US Army Corps of Engineers®
St. Paul District

Main Report

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

Minnesota River: Miles 15-21

St. Paul District

Project Sponsor: U.S. Fish and Wildlife Service

Final Draft, April 2019

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EXECUTIVE SUMMARY

This Feasibility Study Report with Integrated Environmental Assessment investigates the feasibility of alternative measures to address problems and opportunities associated with the Bass Ponds, Marsh, and Wetland Habitat Restoration and Enhancement project (Project), which is part of the Upper Mississippi River Restoration (UMRR) Program. The study area includes three lakes and a marsh, situated southwest of St. Paul, MN and adjacent to the Minnesota River.

The project lies within the Minnesota Valley National Wildlife Refuge (Refuge), established by Congress to provide habitat for a large number of migratory waterfowl, waterbirds, fish, and other wildlife species threatened by commercial and industrial development, as well as to provide educational and recreational opportunities to the public.

The hydrology in the study area has changed significantly, and it is likely that this is driven at least in part by changes in land use and climate. Currently the lakes, wetlands, and marshes experience prolonged full pool conditions with depths of 3 to 4 feet throughout the year. The lack of seasonal variability in water levels has resulted in a degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity, and the availability of quality habitat for migratory waterbirds and waterfowl.

The objectives of the project are to:

1. Increase the diversity and percent cover of desirable emergent aquatic plant species.
2. Increase the diversity and percent cover of desirable submergent aquatic plant species.
3. Provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl.

The Project Delivery Team (PDT) identified a variety of measures that could be taken to achieve project objectives, including water level management structures (single and double bay stoplog structures), earthen ditch plugs, access dredging, and rock-lined overflow channels. The measures were combined in various logical combinations to form alternative project plans.

The Recommended Plan, shown in Figure ES-1, would partially restore the lake and marsh habitats by providing water level management capability to improve emergent and submergent aquatic vegetation, and to improve the habitat for waterfowl and waterbirds. The stoplog structures would utilize a 5-feet wide by 6-feet high concrete bay design that would efficiently increase conveyance to allow for periodic drawdowns following periods when floodwaters have receded. The Recommended Plan addresses all project objectives and would be 100% federally funded. The preliminary cost estimate is $5.9 million, with a 255 average annual habitat unit gain, and a cost of $981 per average annual habitat unit.

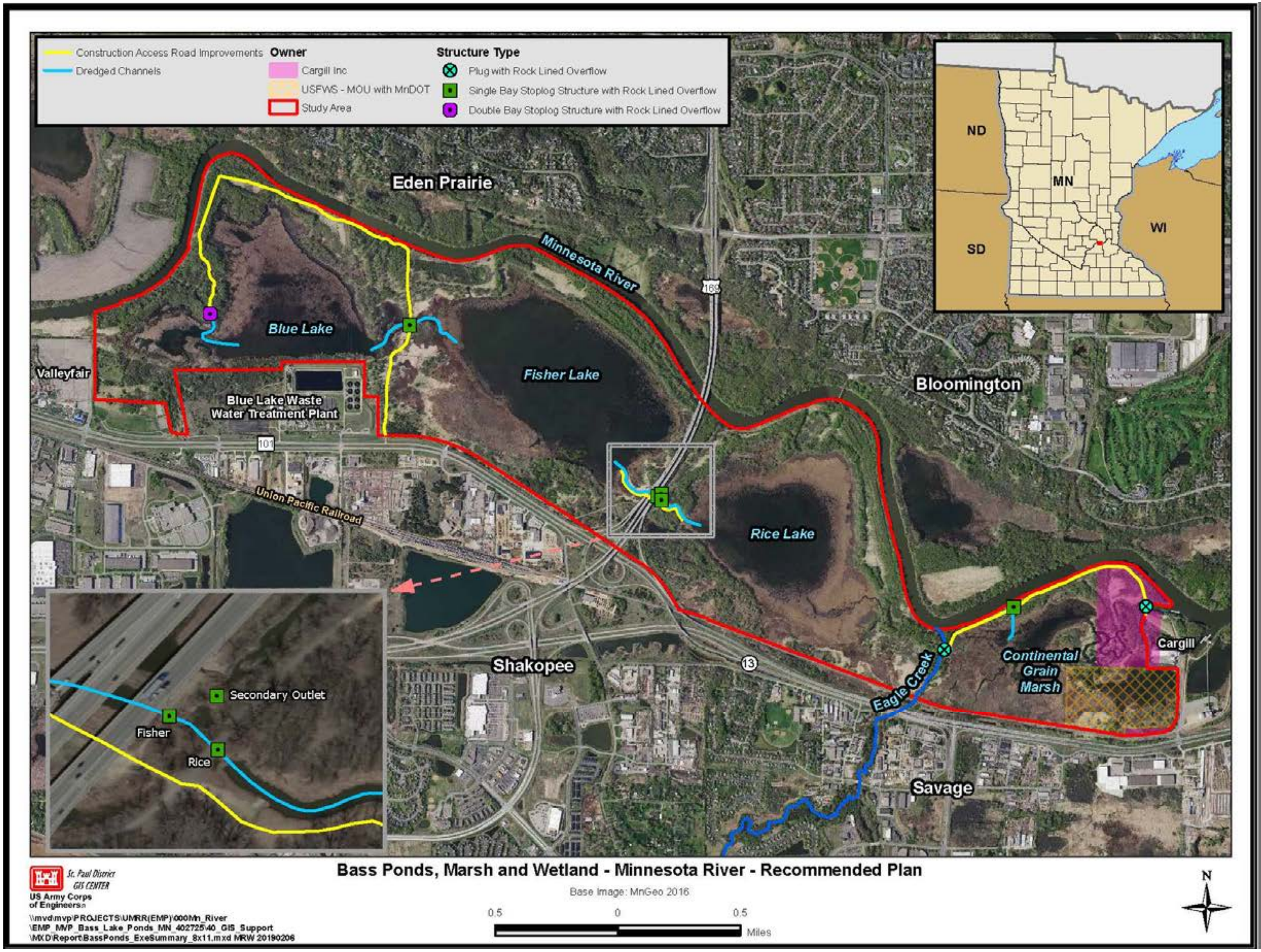

Figure ES-1: Bass Ponds HREP Recommended Plan

FEASIBILITY REPORT AND

INTEGRATED ENVIRONMENTAL ASSESSMENT

BASS PONDS, MARSH, AND WETLAND HABITAT REHABILITATION AND ENHANCEMENT PROJECT

MINNESOTA RIVER

SCOTT COUNTY, MINNESOTA

TABLE OF CONTENTS

EXECUTIVE SUMMARY .... ES-I

1 INTRODUCTION 1

1.1 Study Authority 1

1.2 Study Purpose and Scope 1

1.3 Agency Participants and Coordination 2

1.4 Decisions To Be Made 3

1.4.1 U.S. Army Corps of Engineers 3

1.4.2 U.S. Fish and Wildlife Service 3

1.4.3 State 3

1.5 Project Selection Process 3

1.5.1 Eligibility Criteria 3

1.5.2 Project Selection 4

1.6 Study Area 5

1.6.1 Interconnected Lakes and Marsh Complex 5

1.6.2 Minnesota Valley National Wildlife Refuge 7

1.6.3 Blue Lake Wastewater Treatment Plant 7

1.6.4 Cargill West Grain Elevator and CHS Savage Terminal 7

1.6.5 Flying Cloud Airport 7

1.6.6 Neighboring Residential and Industrial Areas 7

1.7 Existing and Current Studies, Reports, and Water Resources Projects 9

1.7.1 Rice Lake HREP 9
1.7.2 Long Meadow Lake HREP 9
1.7.3 Minnesota River Basin Interagency Study 10
1.7.4 Valleyfair Wetland Mitigation 10
1.8 Resource Significance 10
1.8.1 Institutional Recognition 11
1.8.2 Public Recognition 12
1.8.3 Technical Recognition 12
2 PROBLEM IDENTIFICATION 13
2.1 Factors Influencing Habitat Change 13
2.1.1 Land Use Change 13
2.1.2 Climate Change 15
2.1.3 Altered Hydrology in Study Area 15
2.1.4 Water Management Infrastructure in the Study Area 18
2.2 Problem Summary and Interactions 20
2.3 Estimated Future Without-Project Conditions 20
3 PLAN FORMULATION 21
3.1 Problems and Opportunities 21
3.2 Objectives and Constraints 22
3.2.1 Project Objectives 22
3.2.2 USFWS Management Objectives 22
3.2.3 Constraints 22
3.3 Management Measures and Screening 23
3.4 Formulation of Alternatives 26
3.4.1 Drawdown Analysis for Blue-Fisher-Rice System 26
3.4.2 Drainage Analysis of Continental Grain Marsh 29
3.4.3 Final Array of Alternatives 29
3.5 Evaluation and Comparison of Alternatives 30
3.5.1 Environmental Benefit Analysis 30
3.5.2 Cost Effectiveness & Incremental Cost Analysis 30
3.5.3 Comparison of Best Buy Alternatives 32
3.6 Plan Selection 33

3.6.1 National Ecosystem Restoration Plan ... 33
3.6.2 Resource Agency Support ... 34
3.6.3 Resource Significance ... 34
3.6.4 Risk and Uncertainty ... 34
3.6.5 Consistency with Corps Campaign Plan ... 37
3.6.6 Consistency with Corps Environmental Operating Principles ... 37
4 ASSESSMENT OF EXISTING RESOURCES AND ENVIRONMENTAL CONSEQUENCES OF THE RECOMMENDED PLAN ... 37
4.1 Water Resources ... 38
4.1.1 Water Quality ... 38
4.2 Geology and Soil Substrate ... 38
4.2.1 Hazardous, Toxic, and Radioactive Waste (HTRW) ... 39
4.3 Wetlands ... 39
4.4 Invasive Species ... 40
4.5 Fish and Wildlife ... 41
4.5.1 Federally Threatened and Endangered Species ... 41
4.5.2 Minnesota State Listed Species ... 42
4.6 Air Quality ... 42
4.7 Noise ... 43
4.8 Cultural Resources ... 43
4.9 Socioeconomic Setting ... 44
4.9.1 Recreation and Aesthetics ... 44
4.10 Environmental Justice ... 44
4.11 Greenhouse Gases ... 45
4.12 Summary of Consequences ... 45
5 CUMULATIVE EFFECTS ... 47
5.1 Programmatic Cumulative Effects ... 47
5.2 Cumulative Effects to Wetlands ... 48
6 RECOMMENDED PLAN ... 48
6.1 Plan Features ... 50
6.2 Design Considerations ... 51

6.2.1 Control Structures ... 51
6.2.2 Channel Dredging ... 52
6.2.3 Ditch Plug ... 52
6.2.4 Rock-lined Overflow Structures ... 53
6.2.5 Construction Access Roads ... 53
6.3 Design Quantities ... 53
6.4 Construction Implementation ... 54
6.4.1 Construction Restrictions ... 54
6.4.2 Construction Schedule ... 54
6.4.3 Environmental Compliance and Permitting ... 54
6.5 Operation, Maintenance, Repair, Rehabilitation, and Replacement ... 55
6.6 Project Cost Summary ... 55
6.7 Real Estate Considerations ... 56
6.8 Project Performance (Monitoring and Adaptive Management) ... 57
7 PLAN IMPLEMENTATION ... 57
8 SUMMARY OF ENVIRONMENTAL COMPLIANCE AND PUBLIC INVOLVEMENT ... 57
8.1 Environmental Laws and Regulations. ... 58
8.2 Coordination, Public Views, and Comments ... 60
9 RECOMMENDATION ... 61
10 FINDING OF NO SIGNIFICANT IMPACT ... 62
11 LITERATURE CITED ... 63

List of Figures

Figure 1: Study Area Bathymetry; Depths Relative to the Average Pool Elevation Under the Existing Condition ... 6
Figure 2: Bass Ponds HREP - Real Estate Map ... 8
Figure 3: Long Meadow Lake Water Control Structure During Handrail Construction ... 9
Figure 4: 1896 Topographical Map ... 13
Figure 5: Aerial Photographs of the Study Area: 1957, 2004, 2017 ... 14
Figure 6: Annual Mean Discharge at the Jordan, MN, Gage (1935-2017) ... 16
Figure 7: Major Flood Events in the Study Area, Recorded at the Jordan, MN, Gage (1935-2018) ... 17
Figure 8: Summary of Existing Water Level Management Structures in the Study Area ... 19
Figure 9: Conceptual Model of the Bass Ponds HREP ... 20
Figure 10: Major Flooding & Successful Drawdown Assessment: Period of Record for the Study Area (1935-2018) ... 28
Figure 11: CE/ICA Analysis of All Alternatives ... 31

Figure 12: Incremental Cost and Output Results for the Best Buy Plans 32
Figure 13: Existing Silted Stoplog Structure and Proposed Plug on Cargill Property 36
Figure 14: Bass Ponds HREP Recommended Plan 49
Figure 15: Example of Rock-lined Channel Constructed by USACE for the Long Lake Project . 51

List of Tables

Table 1: Typical Water Level Management Plan within the Refuge 22
Table 2: Screening of Measures (Shaded Measures Were Screened From Further Analysis) .. 25
Table 3: Minimum Time to Drawdown at Maximum Efficacy 27
Table 4: Final Array of Alternatives 29
Table 5: Results of CE/ICA for Best Buy Plans 32
Table 6: Project Features and Impacts 40
Table 7: Environmental Assessment Matrix for Proposed Project 46
Table 8: CEQ's Approach for Assessing Cumulative Effects 47
Table 9: Past, Existing, and Potential Future Ecological Restoration Projects in the Minnesota River 48
Table 10: Summary of Main Project Features 50
Table 11: Top and Bottom Elevations (in feet) of Stoplog Structures in the Recommended Plan 52
Table 12: Recommended Plan: Channel Dredging 52
Table 13: Estimated Quantities (cubic yards) and Footprints (acres) 53
Table 14: Recommended Plan Project First Cost ($000) 56
Table 15: Cost Summary for Recommended Plan 56

Appendices

Appendix A – Correspondence and Coordination
Appendix B – Clean Water Act Compliance
Appendix C – Plan Formulation
Appendix D – Habitat Evaluation Procedure
Appendix E – Geotechnical Analysis and Water Quality
Appendix F – Hydraulics and Hydrology
Appendix G – Cost Engineering
Appendix H – Real Estate Plan
Appendix I – Civil Drawings
Appendix J – Structural Engineering
Appendix K – Monitoring and Adaptive Management
Appendix L – Hazardous, Toxic, and Radioactive Waste
Appendix M – Cultural Resources
Appendix N – Memorandum of Agreement

1 INTRODUCTION

1.1 Study Authority

Congress passed the Upper Mississippi River Management Act in Section 1103 of the 1986 Water Resources Development Act (WRDA) (Public Law 99-662), codified at 33 USC § 652 which authorized the Upper Mississippi River Restoration (UMRR) Program. Over the course of its first 13 years, the UMRR program proved to be one of the Nation's premier ecosystem restoration programs, combining close collaboration between Federal and State partners, an effective planning process, and a built-in monitoring process. This success led Congress to reauthorize the UMRR program in WRDA 1999 (Public Law 106-53). Section 509 of WRDA 1999 adjusted the program and established the following two elements as continuing authorities:

- Planning, construction, and evaluation of fish and wildlife habitat rehabilitation and enhancement projects (also known as Habitat and Restoration and Enhancement Projects, or HREPs).
- Long-term resource monitoring, computerized data inventory and analysis, and applied research (known collectively as Long-Term Resource Monitoring element).

Section 509 of WRDA 1999 provides USACE with the authority to plan, design, and construct HREPs, such as the proposed Project.

1.2 Study Purpose and Scope

The purpose of this Feasibility Report with Integrated Environmental Assessment (EA), including the Finding of No Significant Impact (FONSI), is to evaluate the proposal for the Project within the UMRR program. The Feasibility Report and Integrated EA meets USACE planning guidance and meets National Environmental Protection Act (NEPA) requirements. USACE developed this report with the U.S. Fish and Wildlife Service (USFWS) serving as the Federal project partner. This report provides planning, engineering, and sufficient construction details of the Recommended Plan to allow for final design and construction to proceed subsequent to document approval.

The purpose of the main report is to summarize the multidisciplinary efforts of USACE, USFWS, and the State of Minnesota's Department of Natural Resources (MNDNR) that led to the study recommendation. USACE organized the report to follow a general problem-solving format:

- Review existing conditions and anticipated future conditions;
- Identify project goals and objectives;
- Formulate restoration alternatives to address the goals and objectives;
- Identify costs and benefits of the restoration alternatives;
- Compare the alternatives on the costs and benefits;
- Recommend a single restoration plan for implementation; and
- Present a detailed analysis on the plan.

The detailed analysis includes considerations of design, construction, operations, and maintenance; a detailed cost estimate; a monitoring plan to gage restoration performance; real estate requirements; environmental effects; and a detailed schedule for implementation. Supporting documentation is provided in the appendices of this report.

1.3 Agency Participants and Coordination

Participants in the planning for the Bass Ponds HREP included the USFWS, MNDNR, and USACE. These agencies were involved in project planning because the study area is located within the Refuge and a portion of the Minnesota River in Minnesota. Under Federal regulations governing the implementation of NEPA, USFWS is a cooperating agency.

The following individuals played an active role in the planning of the Bass Ponds project.

U.S. ARMY CORPS OF ENGINEERS		
Tom Novak	Program Manager	Program Manager
Kelli Phillips	Project Manager	Project Manager
Angela Deen	Lead Planner	Study Manager, Plan Formulation
LeeAnn Glomski	Biologist	Environmental/HEP/Adaptive Management
Jon Hendrickson	Hydraulic Engineer	Hydrology/Hydraulics
Kacie Opat	Hydraulic Engineer	Hydrology/Hydraulics
Jeff McGrath	Economist	Economics
Luke Schmidt	Engineer	Geotechnical
Paul Hegre	Engineer	Costs & Specs
Paul Morken	Engineer	Civil/Layout
Brad Perkl	Archaeologist	Cultural Resources
Tony Horacek	Civil Engineer	Construction
Jim Noren	Hydrologist	Water Quality
Steph Dupey	Real Estate	Real Estate
Tony Fares*	Engineer	Structural
Mike Walker	Cartographer	GIS
Eric Hansen	Biologist	Environmental
U.S. FISH AND WILDLIFE SERVICE		
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Eric Mruz	Deputy Refuge Manager	Minnesota Valley National Wildlife Refuge
Gerry Shimek	Supervisory Wildlife Refuge Specialist	Minnesota Valley National Wildlife Refuge
Vicki Sherry	Wildlife Biologist	Minnesota Valley National Wildlife Refuge
Chris Kane	Wildlife Refuge Specialist	Minnesota Valley National Wildlife Refuge
Chad Lawson	Maintenance	Minnesota Valley National Wildlife Refuge
Sam Finney	Project Leader	La Crosse Fish & Wildlife Conservation Office
James Myster	RHPO/Archaeologist	Regional Office
Nick Utrup	Fish and Wildlife Biologist	MI-WI Ecological Services Field Office
MINNESOTA VALLEY NATIONAL WILDLIFE REFUGE TRUST		
Matt Millet	GIS Specialist	
MINNESOTA DEPARTMENT OF NATURAL RESOURCES		
Jennie Skancke	Habitat Projects Coordinator	

*Technical Lead

1.4 Decisions To Be Made

1.4.1 U.S. Army Corps of Engineers

Because the proposed project is funded by USACE, the St. Paul District Commander will select one of the alternatives for implementation. The District Commander will also determine, based on the facts and recommendations contained herein, whether the EA is adequate to support a FONSI or whether an EIS will be prepared. The Mississippi Valley Division (MVD) Commander has the final approval of the Feasibility Report and the Recommended Plan.

1.4.2 U.S. Fish and Wildlife Service

Because the project would be located on land managed by the Minnesota Valley National Wildlife Refuge, the Regional Director of the USFWS, Region 3, will determine whether the project is compatible with Refuge goals and objectives and the Refuge Comprehensive Conservation Plan. The USFWS Regional Director will also determine if the USFWS approves the selected alternative for potential implementation and if the USFWS will assume operation and maintenance responsibilities. The Regional Director will also determine, based on the facts and recommendations contain herein, whether the final integrated Feasibility Report and EA meets the USFWS's obligation under NEPA, the Fish and Wildlife Coordination Act of 1965, the Endangered Species Act of 1973, the Migratory Bird Treaty Act of 1918, and the Bald Eagle Protection Act of 1940. The USFWS has been a cooperating agency in the preparation of this EA and has been integral in the decision making process for the Feasibility Report.

Before any work is commenced under a construction contract, USACE will obtain a Special Use Permit from the Refuge Manager. This permit will be included in the technical specification package and be part of the contract documents.

1.4.3 State

Decisions to be made by the State of Minnesota include permits for dredging, disposal and structures, state threatened and endangered species review, and archeological review. This project would require endorsement by the River Resources Forum (RRF). The RRF is a state and Federal agency partnership for addressing resource issues concerning the Upper Mississippi River system within the St. Paul District's geographic jurisdiction. The State of Minnesota has been a partnering agency in the decision making process for the Feasibility Report.

1.5 Project Selection Process

1.5.1 Eligibility Criteria

In January 1986, prior to enactment of Section 1103 of WRDA 1986, USACE, North Central Division, completed a "General Plan" for implementation of the UMRR Program. The USFWS, Region 3, and the five affected States (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) participated through the Upper Mississippi River Basin Association (UMRBA). Programmatic updates of the General Plan for budget planning and policy development are accomplished through Annual Addenda.

Coordination with the States and USFWS during the preparation of the General Plan and Annual Addenda led to an examination of the Comprehensive Master Plan for the Management of the Upper Mississippi River System (UMRS). The Master Plan, completed by the Upper Mississippi River Basin Commission in 1981, was the basis for the recommendations enacted into law in Section 1103. The Master Plan and General Plan reports identified examples of potential habitat rehabilitation and enhancement techniques. Consideration of the Federal interest and Federal policies has resulted in the following conclusions:

a. From the First Annual Addendum:

   The Master Plan report and the authorizing legislation do not pose explicit constraints on the kinds of projects to be implemented under the UMRR-HREP. "For habitat projects, the main eligibility criterion should be that a direct relationship should exist between the project and the central problem as defined by the Master Plan; i.e., the sedimentation of backwaters and side channels of the Upper Mississippi River. Other criteria include geographic proximity to the river (for erosion control), other agency missions, and whether the condition is the result of deferred maintenance…"

b. From the Second Annual Addendum.

   "(1) The types of projects that are definitely within the realm of Corps of Engineers implementation authorities include the following:

   -backwater dredging
   -dike and levee construction
   -island construction
   -bank stabilization
   -side channel openings/closures
   -wing and closing dam modifications
   -aeration and water control systems
   -waterfowl nesting cover (as a complement to one of the other project types)
   -acquisition of wildlife lands"

   "(2) A number of innovative structural and nonstructural solutions, which address human-induced impacts, particularly those related to navigation traffic and operation and maintenance of the navigation system, could result in significant long-term protection of UMRS habitat. Therefore, proposed projects that include such measures will not be categorically excluded from consideration, but the policy and technical feasibility of each of these measures will be investigated on a case-by-case basis and the measures will be recommended only after consideration of system-wide effects."

1.5.2 Project Selection

Projects are nominated for inclusion in the USACE St. Paul District's habitat restoration program by a State natural resource agency or the USFWS, based on agency management objectives. To assist the District in the selection process, the States and USFWS have agreed to use the expertise of the Fish and Wildlife Work Group (FWWG) of the River Resources Forum (RRF) to consider critical habitat needs along the Mississippi River and sequence nominated projects on a biological basis.

The FWWG consists of river managers responsible for managing the river for their respective agencies. Meetings are held on a regular basis to evaluate and rank nominated projects according to the biological benefits they could provide in relation to the habitat needs of the river system. The ranking is forwarded to the RRF for consideration of the broader policy perspectives of the agencies involved. The RRF submits the coordinated ranking to the District and each agency officially notifies the District of its views on the ranking. The District then formulates and submits a project that is consistent with the overall program guidance as described in the UMRR General Plan and Annual Addenda and supplemental guidance provided by USACE, MVD.

Personnel familiar with the river have screened potential projects. Resource needs and deficiencies have been considered on a pool-by-pool basis to ensure that regional needs are being met and that the best expertise available is being used to optimize the habitat benefits created at the most suitable locations.

The Bass Ponds HREP was first identified in 2006 by the FWWG for consideration in USACE's St. Paul District habitat projects program. The study was funded and began in December 2017. The USFWS submitted an updated list of habitat project priorities for Bass Ponds and included a description of three areas ranked by priority: 1. Fisher Lake area, 2. Continental Grain Marsh Area, and 3. Bass Ponds area. The Factsheet and updated priority list can be referenced in Appendix A – Correspondence and Coordination.

1.6 Study Area

The study area is located in Scott County, MN, between Minnesota River river miles (RM) 15 and 21, at the convergence of the cities of Eden Prairie, Bloomington, Shakopee, and Savage, MN (Figure 2). The study area is approximately 2,085 acres in size and the project features are located entirely within the Refuge, which USFWS manages.

The Minnesota River drains much of west central, southwestern, and south central Minnesota, and flows northeastward into the Twin Cities metropolitan area towards the Minnesota River's confluence with the Mississippi River. Most of the river floodplain is a mosaic of bottomland forest and marsh habitats. In limited areas, portions of the floodplain are farmed. Development in the form of grain terminals, quarries, and landfills are present in the floodplain, and a number of highways and railroads bisect the area. As this reach of the river is within the Twin Cities metropolitan area, much of the upland area bordering the river valley is either already developed or rapidly undergoing development. The 9-foot navigation channel extends to RM 14.7, while a federally authorized 4-foot channel extends to RM 25.6 at Shakopee, MN.

1.6.1 Interconnected Lakes and Marsh Complex

The study area includes three interconnected backwater lakes (Blue, Fisher, and Rice Lakes) and Continental Grain Marsh. The waterbodies in the study area are all relatively shallow; the average depth ranges between only 0-2 feet deep, with the deepest area in the southeast corner of Blue Lake at 3-4 feet deep (depths are relative to the average pool elevation under the existing condition, Figure 1). When flows are greater than 26,600 cubic feet per second (cfs) at the Jordan Gage, the Minnesota River berms are overtopped, resulting in complete inundation of the study area, resulting in average depths increasing up to 4 feet deep. During low flows (less than 10,000 cfs), the lakes are largely isolated from river inputs and water recedes by passing through water level management (WLM) structures. Most often, the flow path throughout the system starts with water entering Blue Lake from the river through the Blue Lake structure. The water then can be directed into Fisher Lake through the Interlake structure and finally through the Fisher Lake structure and out to the river through the Secondary structure. Rice Lake is most often separately managed due to the existing conditions of the surrounding structures. The Blue Lake structure operates both as an inlet and outlet depending on the flow conditions and water management goals. Continental Grain Marsh drains into Eagle Creek which flows into the Minnesota River.

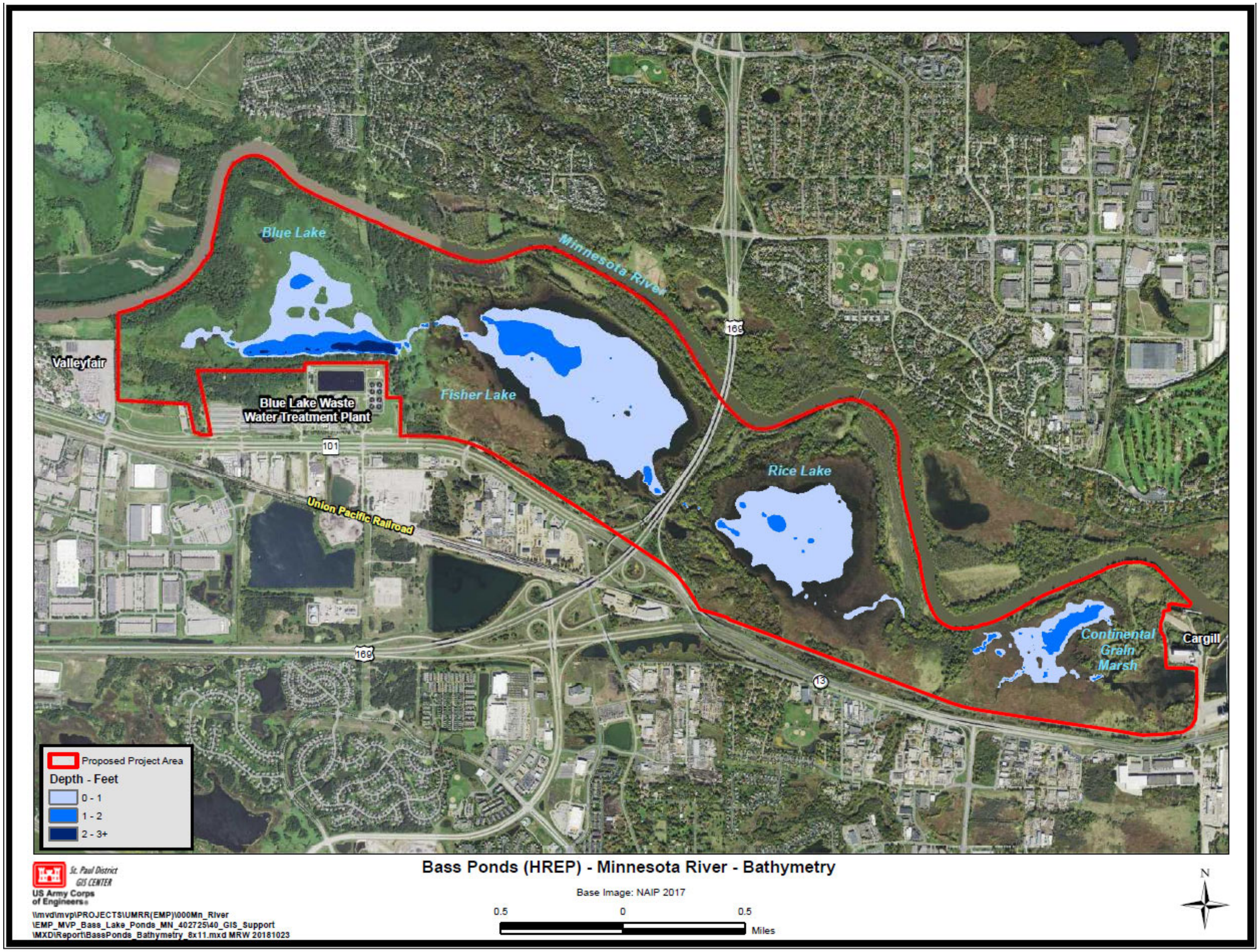


Figure 1: Study Area Bathymetry; Depths Relative to the Average Pool Elevation Under the Existing Condition

1.6.2 Minnesota Valley National Wildlife Refuge

USFWS manages the study area as part of the Refuge. The Refuge as a whole covers over 14,000 acres of the river valley, extending from RM 4 to RM 68 on the Minnesota River. Established in 1976, the Refuge is one of the few national wildlife refuges located within a major metropolitan area. The proposed study area is mostly on Refuge land, with Cargill and Minnesota Department of Transportation (MnDOT) parcels on the east end (Figure 2).

1.6.3 Blue Lake Wastewater Treatment Plant

The Blue Lake Wastewater Treatment Plant (WWTP) is located south of Blue Lake (Figure 2) and is operated by the Metropolitan Council. The WWTP is the fourth largest WWTP in Minnesota (https://metrocouncil.org/Wastewater-Water/Publications-And-Resources/ES_Bluelake2012_combined-pdf.aspx). The Blue Lake WWTP does not discharge its processed wastewater effluent to Blue Lake but instead discharges directly to the Minnesota River upstream of Blue Lake (east of the Valleyfair parking lot).

The only discharge from the plant to Blue Lake is untreated groundwater that the plant pumps as needed to protect underground infrastructure within the facility. The plant added more dewatering capacity in 2008 after record flood events increased groundwater levels higher than targeted. Typical quantities are 1.0 to 1.5 billion gallons per year. This discharge is located in the southeast corner of Blue Lake from a 42-inch storm water outfall.

1.6.4 Cargill West Grain Elevator and CHS Savage Terminal

Cargill is a corporation that trades, purchases, and distributes agricultural commodities among other business endeavors. CHS is a business that performs food processing. Cargill's West Grain Elevator is located on the east side of Continental Grain Marsh (Figure 2). Train and truck traffic enters the Cargill elevator site and the CHS terminal site from the south where the sites meet Minnesota Highway 13.

1.6.5 Flying Cloud Airport

Flying Cloud Airport (FCM) is located less than 1 mile northwest of the project and is one of seven airports owned and operated by the Metropolitan Airports Commission. The airport opened in 1943. FCM is located 14 miles from downtown Minneapolis and is a primary reliever airport for the Minneapolis-St. Paul International Airport.

1.6.6 Neighboring Residential and Industrial Areas

In addition to the noteworthy parts of the project's physical setting, numerous residential and industrial areas neighbor the study area. North of the study area, and on the northern side of the Minnesota River, sits residential housing in Eden Prairie and Bloomington. On the south side runs the Union Pacific railroad as well as OP Rail Systems, which operates a truss swing bridge on the Minnesota River immediately north of the CHS Savage grain elevator.

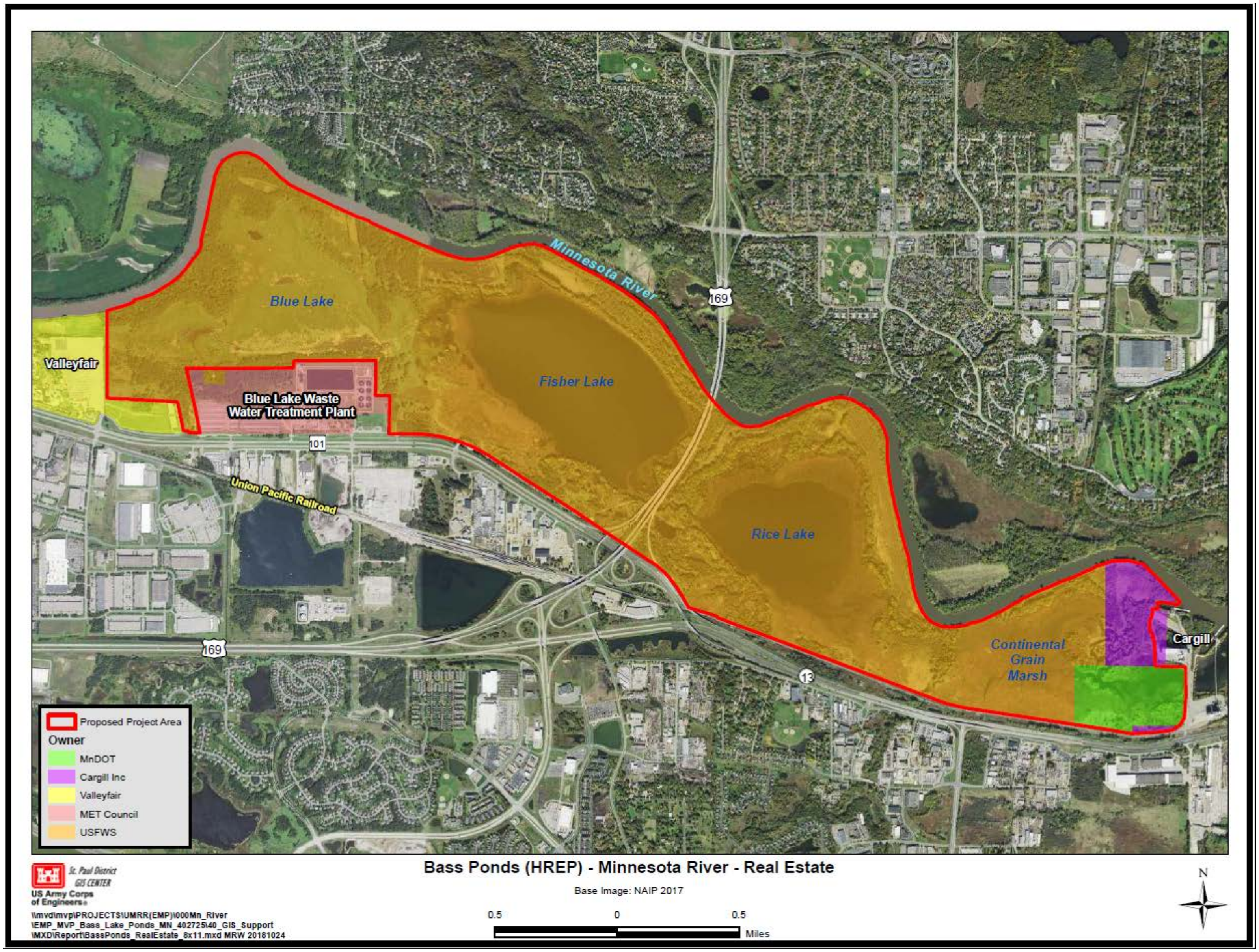


Figure 2: Bass Ponds HREP - Real Estate Map

1.7 Existing and Current Studies, Reports, and Water Resources Projects

1.7.1 Rice Lake HREP

The Rice Lake HREP was constructed in 1998 (USACE 2012a). It consisted of four main strategies: dredging, WLM, bank stabilization, and forest restoration.

The project included an earthen plug in the eastern outlet and a 42-inch culvert and stoplog structure at the western outlet. The purpose of the culvert and stoplog structure was to allow USFWS staff to manage the water levels in Rice Lake and promote optimal growth of aquatic vegetation. The project also included a rock-lined spillway within the Minnesota River berm of Continental Grain Marsh to prevent interior drainage and wetland habitat loss due to riverbank erosion. An additional component was restoration of a 40-acre farm field to bottomland hardwood forest.

The Rice Lake stoplog structure is aging and showing signs of rust damage and deterioration. Section 2.1.4 further discusses the condition of existing infrastructure in the study area.

1.7.2 Long Meadow Lake HREP

The Long Meadow Lake HREP was constructed in 2006 (USACE 2004). Long Meadow Lake is a shallow floodplain lake and marsh located on the left bank of the Minnesota River between RM 5 and RM 10 just downriver of the Bass Ponds HREP study area.

The selected plan for Long Meadow Lake involved the demolition of the existing culvert and concrete attachment, excavation of a channel, installation of a two-bay concrete stoplog control structure, and replacement of the secondary culvert (Figure 3). The two-foot secondary culvert replaced the four-foot culvert that runs under the access road. The replacement culvert includes a slide gate on the upstream end for water level control.

USACE designed the two-bay stoplog control structure to give the USFWS staff the ability to control water levels in Long Meadow Lake when the Minnesota River discharges are below bank full conditions. In addition, the structure decreases inflow frequency to Long Meadow Lake through the channel from the Minnesota River. This structure and proper operation allows USFWS to maintain the lake as a shallow floodplain lake and marsh, providing high quality habitat for migratory birds and aquatic wildlife. Since construction, the USFWS has been successful at achieving drawdowns in this system as designed.

Figure 3: Long Meadow Lake Water Control Structure During Handrail Construction

1.7.3 Minnesota River Basin Interagency Study

The study is in draft form, includes authors and data from numerous Federal, state, and tribal agencies and partners, and has a likely completion date of early 2019. The spatial scope of this study spans 16,770 square miles, roughly 10 million acres, and touches 37 counties. The study examines many different physical and ecological processes using hydrologic and mechanistic modeling tiered to the scale of examination:

- Tier 1 is a basin scale assessment of grassland bird and waterfowl response to alternative landscape scenarios using spatially explicit habitat models.
- Tier 2 is a biological response using Hydrological Simulation Program – FORTRAN output for subbasins to assess fish species richness in response to a tight set of hydrologic metrics.
- Tier 3 is a Gridded Surface Subsurface Hydrologic Analysis limited to flow and sediment with no extension to habitat benefits for the single catchment scale model.

1.7.4 Valleyfair Wetland Mitigation

Valleyfair is an amusement park located to the west of the Bass Ponds HREP project. Recently, the park proposed to expand its facilities, which would result in the loss of 4.52 acres of wetland. To offset wetland impacts associated with its expansion project, Valleyfair has proposed a mitigation plan that includes the creation of 6.38 acres of floodplain forest wetland adjacent to the Minnesota River. An additional 4.64 acres of upland will be preserved and act as buffer to the wetland. The goal of the mitigation plan is to create a backwater wetland system connected to the Minnesota River during flood events that integrates into the Blue, Fisher, and Rice Lake complex.

In order to create the mitigation area, Valleyfair would remove topsoil and subsoil, lowering the ground surface. Following excavation and grading, Valleyfair would place topsoil from adjacent wetlands into the mitigation area and perform seeding using appropriate seed mixes for both floodplain forest and upland buffers. In addition to seeding, Valleyfair would plant trees within the floodplain forest area. Species include silver maple, cottonwood, black willow, green ash, and elms.

The St. Paul District Regulatory office issued a permit and approved the mitigation plan in 2018. Valleyfair will protect the mitigation area by recording a Declaration of Restrictions and Covenants with Scott County. Construction is expected to commence in 2019.

The permit explained that the mitigation site is intended to offset the loss of flood water storage and potential changes in water fluctuations due to the parking lot construction. A short hydraulic discussion between members of the Corps, regulatory and Barr Engineering concluded that a lower bank at the mitigation site is not a concern in regards to frequency of flooding and deposition into Blue Lake because the existing high ground control “saddle” is not breached by the project. Because this high ground will remain intact, the potential for an increase in flood frequency and sediment into Blue Lake is small.

The Valleyfair mitigation plan was not factored into the modelling efforts for this project. However, the hydraulics comments from the issued regulatory permit explained above suggest this should not affect the Bass Ponds HREP features. More information on this topic is included in Section 4.3 of Appendix F, *Hydraulics and Hydrology*.

1.8 Resource Significance

Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Water Resources Council 1983) (P&G) and USACE

Planning Guidance Notebook Engineering Regulation (ER) 1105-2-100 determine the criteria for the significance of resources (USACE 2000).

Protecting and restoring significant resources are in the national interest because of the scarcity of these resources. For ecosystem restoration projects, monetary and non-monetary values also quantify and qualify the resource significance. The resource's contribution to the Nation's economy determines monetary value (e.g., a lake with waterfowl encourages bird-watching tour businesses) whereas technical, institutional, or public recognition of the ecological, cultural, and aesthetic attributes determines non-monetary value (e.g., a lake serves as a historic site with cultural significance).

ER 1105-2-100 illustrates these three forms of significance determining non-monetary value:

> *"Significance of resources and effects will be derived from institutional, public or technical recognition. Institutional recognition of a resource or effect means its importance is recognized and acknowledged in the laws, plans and policies of government and private groups. Technical recognition of a resource or an effect is based upon scientific or other technical criteria that establishes its significance. Public recognition means some segment of the general public considers the resource or effect to be important. Public recognition may be manifest in controversy, support or opposition expressed in any number of formal or informal ways. The scientific community and natural resources management agencies recognize the technical significance of resources."*

1.8.1 Institutional Recognition

Congress established the Refuge in 1976 (PL 94-466) to provide habitat for a large number of migratory waterfowl, waterbirds, fish, and other wildlife species threatened by commercial and industrial development as well as provide educational and recreational opportunities to the public. In addition to Congress, many other governmental entities and agencies as well as non-profit and private organizations have recognized the significance of the Refuge.

Federal, state, and local agencies and institutions have demonstrated tangible support for the restoration of the lake ecosystem. In 1986, Congress designated the UMRS as both a "…nationally significant ecosystem and a nationally significant navigation system…" in Section 1103 of the WRDA 1986. The lower Minnesota River (up to RM 25.4) is included in the UMRS efforts. The National Research Council's Committee on Restoration of Aquatic Ecosystems targeted the Upper Mississippi River for restoration as one of only three large river-floodplain ecosystems so designated. UMRBA is an advocate for restoration on habitat on the Upper Mississippi River. In addition, the Upper Mississippi River Conservation Committee recognized the importance of the floodplain forest to the fish and wildlife of the river.

On September 22, 1992, former Minnesota Governor Arne Carlson said, "Our goal is that within 10 years, our children will be swimming, fishing, picnicking, and recreating in this river." Leading up to this call to action, Minnesota River degradation was well known, and state agencies had collected critical baseline data in an innovative standardized monitoring program to document the river's condition and prioritize critical problems. The Minnesota River Assessment Project assessed water quality, fish, and macro-invertebrates from 1989 to 1994 using a standardized watershed assessment protocol [Minnesota Pollution Control Agency (MPCA) 2011]. The MPCA shared results at public meetings with citizens and interest groups who prioritized issues discovered during the assessment. The state legislature and former Governor Carlson established the county-based Minnesota River Board to coordinate state and Federal activity in the Minnesota River Basin.

Non-profit and private organizations also have recognized the significance of this resource. The Minnesota Valley National Wildlife Refuge Trust, Inc. (MVT) is a 501(c)3 tax-exempt, nonprofit corporation. MVT was created in September 2000 under a settlement agreement with the Metropolitan Airports Commission to mitigate the impact on the Refuge of the new north-south runway at the Minneapolis-St. Paul International Airport. MVT has continued its work in support of the Refuge beyond completion of the Mitigation Plan in 2012. Objectives under the 2019-2023 Strategic Framework including continued strategic land acquisition and habitat restoration, support of special projects and investments to provide a positive, inspiring experience on the Refuge for a diversity of visitors, and investments to connect more people and a diversity of people with the Refuge. MVT is governed by a volunteer board of directors that meets monthly. Nominees from the following partner organizations serve on the MVT board of directors including Audubon Minnesota (state office of the National Audubon Society), Carver County, Friends of the Minnesota Valley, Minnesota Department of Natural Resources, and Minnesota Waterfowl Association. Each of these organizations has recognized the significance of this resource.

1.8.2 Public Recognition

The Refuge also provides environmental education, wildlife recreational opportunities, and interpretive programming for Twin Cities residents and visitors. The public can visit the Refuge at two locations managed by USFWS. The nearest location to the Project is the Bloomington Education and Visitor Center at 3815 American Boulevard East, Bloomington, MN.

Additionally, the Refuge allows the following activities for members of the public:

- Environmental education and interpretation, hiking, cross country skiing, snowshoeing, wildlife observation, and nature photography.
- Biking on designated trails.
- Shore and ice fishing on most Refuge waters according to state and Refuge-specific regulations.
- Hunting in areas designated by Refuge Manager according to state and Refuge-specific regulations.
- Berry, mushroom, and nut picking (not more than one gallon per family, for personal consumption).

Accurate quantification of public activity on the Refuge and, more specifically, at the Project is difficult due to the multiple points of public access and free admission. The public recognizes the Refuge and the Project as a nationally, regionally, and locally significant resource. In general, there is a wide range of uses for the Refuge and the Project, which extends beyond the ecological health of the Minnesota River watershed and the larger Upper Mississippi River watershed and directly impacts public welfare and the long-term ecological health of the region.

1.8.3 Technical Recognition

A great deal of technical and historical information has been published in the literature, as well as webpages (e.g., Lower Minnesota River Watershed District website and Draft Report 2018), documenting the social and economic vulnerabilities and environmental stresses related to the Minnesota River. According to a study conducted by the MPCA, "Overall, the Minnesota River is unhealthy. Sediment clouds the water, phosphorus causes algae, nitrogen poses risks to humans and fish, and bacteria make the water unsafe for swimming. Too much water flowing into the river plays a big part in all these problems. There's more rain, more artificial drainage, and not enough places to store this water" (https://www.pca.state.mn.us/water/mn-river-study).

2 PROBLEM IDENTIFICATION

2.1 Factors Influencing Habitat Change

Changes in land use and climate are likely the main drivers of habitat change in the study area. Land use changes at the site have resulted from actions relating to flood control, agriculture, industry, and transportation.

2.1.1 Land Use Change

Prior to settlers moving into the Midwest, Native American populations hunted, fished, and lived in the Minnesota River valley, including areas of the Refuge. Substantial land-use change occurred following European settlement, primarily in the form of conversion of native prairie and wetland into agricultural use. Historic maps and aerial imagery of the study area reveal this trend in the landscape.

Late 1800s: The 1896 topographical map portrays conditions prior to agricultural development when the majority of this area was wetland (Figure 4). In 1849, the Bloomington Ferry shuttled people across the Minnesota River. In 1889, the Bloomington Ferry Bridge was built, ending the Bloomington Ferry business. While the shape of the three lakes remains largely unchanged from the 1896 topo, Continental Grain Marsh appears to have drained easterly.

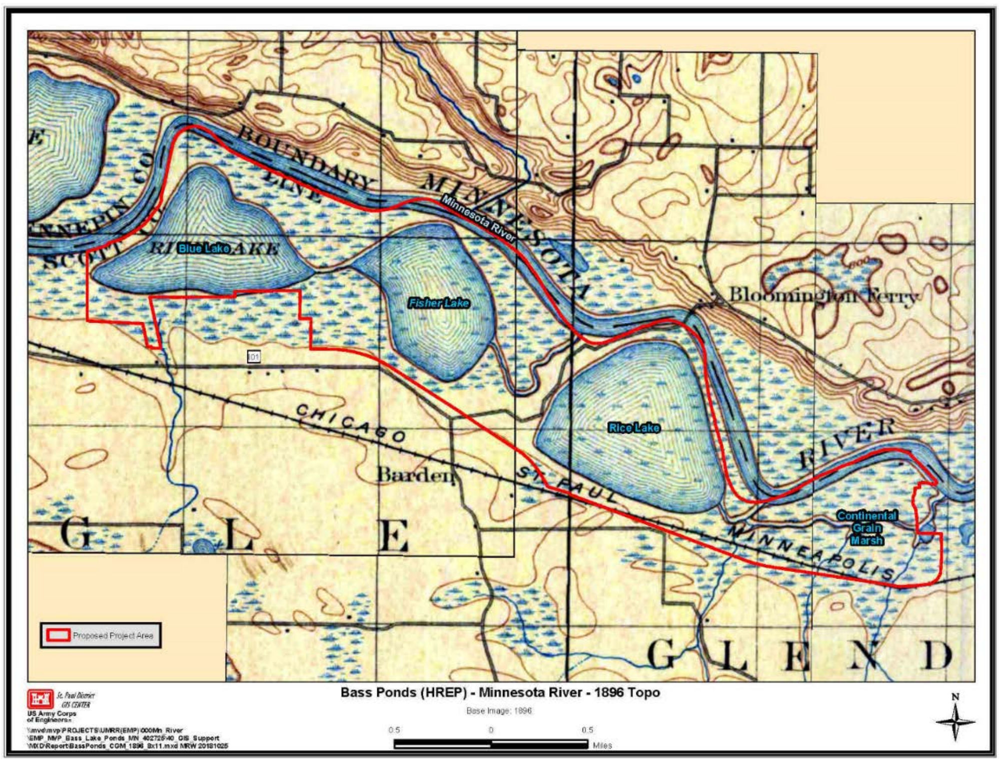


Figure 4: 1896 Topographical Map

Mid-1900s: An image from 1957 illustrates that the wetlands were converted to agricultural fields and grain companies connected by rail lines were constructed across Minnesota and Wisconsin (http://www.soyinfocenter.com/HSS/cargill.php) (Figure 5). With the formation of the Refuge, some of the agricultural fields were acquired and converted back to floodplain forest and wetland habitat. During this period, the hydrology of Continental Grain Marsh was altered to reverse flows westward.

Today: One of the most dramatic changes to the study area in the final aerial image is the new Bloomington Ferry Bridge (Hwy 169), which was completed in 1996 (Figure 5). Hwy 169 is the main artery connecting Shakopee to Bloomington and runs directly between Fisher Lake and Rice Lake. In the mid-1990s loss of a beaver dam on the west end of Continental Grain Marsh resulted in the formation of a new side-channel. The newly formed channel continues to widen, and has directed flows into Eagle Creek and significantly reduced water levels in the marsh. Since formation of the new side channel, its width has increased significantly due to floodwater events (from less than 5 feet to over 20 feet today).

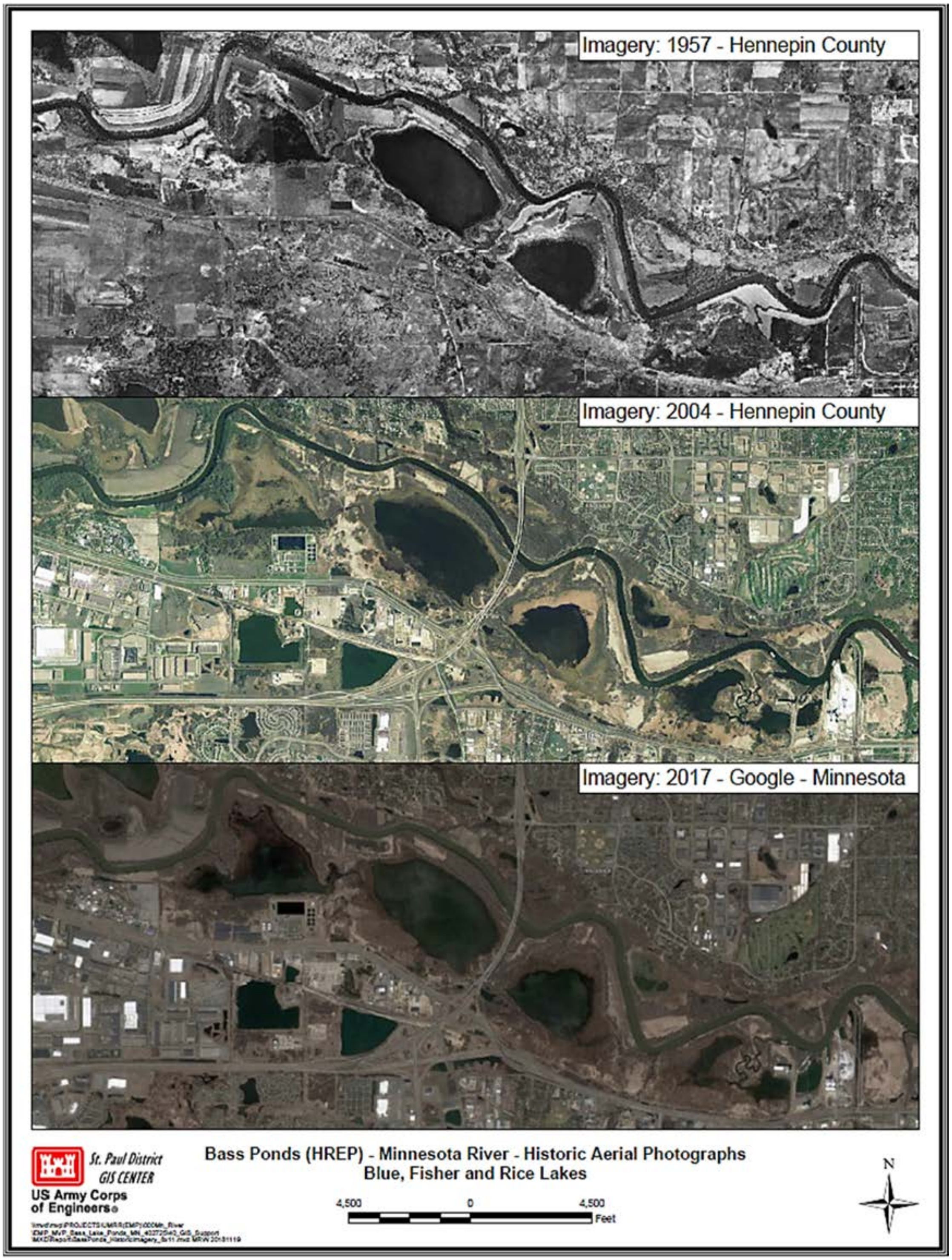


Figure 5: Aerial Photographs of the Study Area: 1957, 2004, 2017

2.1.2 Climate Change

Engineering Construction Bulletin (ECB) No. 2018-14 (USACE 2018) provides guidance for incorporating climate change information in hydrologic analyses in accordance with USACE overarching climate change adaptation policy. It calls for a qualitative analysis and provides links to online tools that can be used in this qualitative analysis. The goal of a qualitative analysis of potential climate threats and impacts to USACE hydrology-related projects and operations is to describe the observed present and possible future climate threats, vulnerabilities, and impacts specific to the study goals or engineering designs. This includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant climatic and hydrologic variables. For additional details on the climate change analysis completed for this study please see Appendix F, *Hydraulics and Hydrology*.

The U.S. Global Research Program completed its Third National Climate Assessment in 2014. It states:

> *"[I]n the Upper Midwest extreme heat, heavy downpours, and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress, flooding, drought, and late spring freezes. Climate change also alters pests and disease prevalence, competition from non-native or opportunistic native species, ecosystem disturbances, land-use change, landscape fragmentation, atmospheric and watershed pollutants, and economic shocks such as crop failures, reduced yields, or toxic blooms of algae due to extreme weather events. These added stresses, together with the direct effects of climate change, are projected to alter ecosystem and socioeconomic patterns and processes in ways that most people in the region would consider detrimental."*

Specific to the study area, historic discharge data at the USGS Gage at Jordan, MN indicates statistically significant trends of increasing average and peak annual discharge ($p<0.05$) with strong nonstationarities detected in the years 1981 and 1990, respectively. ECB 2018-14 also requires an analysis of other climatic variables. The relevant variables for this study were chosen to be total annual precipitation and average annual air temperature. Historical observed data was compiled from the National Oceanic and Atmospheric Administration's National Climactic Data Center station at the Minneapolis-St. Paul International Airport. The total annual precipitation and average annual air temperature variables also indicate a statistically significant, increasing trend over the period of record and strong evidence of a statistically significant nonstationarity detected in the years 1976 and 1997, respectively. For additional details on the climate change analysis completed for this study please see Appendix F, *Hydraulics and Hydrology*.

Studies on the Minnesota River Basin, as well as analyses on this study area support the U.S. Global Research program's findings of wetter and warmer climate in the future.

2.1.3 Altered Hydrology in Study Area

It is likely that the trends detected within observed streamflows in the Minnesota River Basin are at least in part driven by changes in land use and climate. The Lower Minnesota River Watershed District found that annual runoff, total phosphorus, and total suspended solids have all significantly increased in the last 50-60 years (Draft Report, 2018). Since 1935, the average annual discharge has almost quadrupled from 2,500 cfs to 8,000 cfs (depicted by the trend line in Figure 6).

An analysis conducted by USACE on the period of record in the study area (1935-2018) found a greater number of overbank flood events. The results for the 1935-2018 timeframe indicate that there has been a statistically significant increase in the number of days each year that a bankfull flood event occurs in the study area (flows greater than 26,600 cfs). These events result in the study area lakes filling up with turbid water that reduces the quantity and quality of aquatic vegetation and degrades habitat.

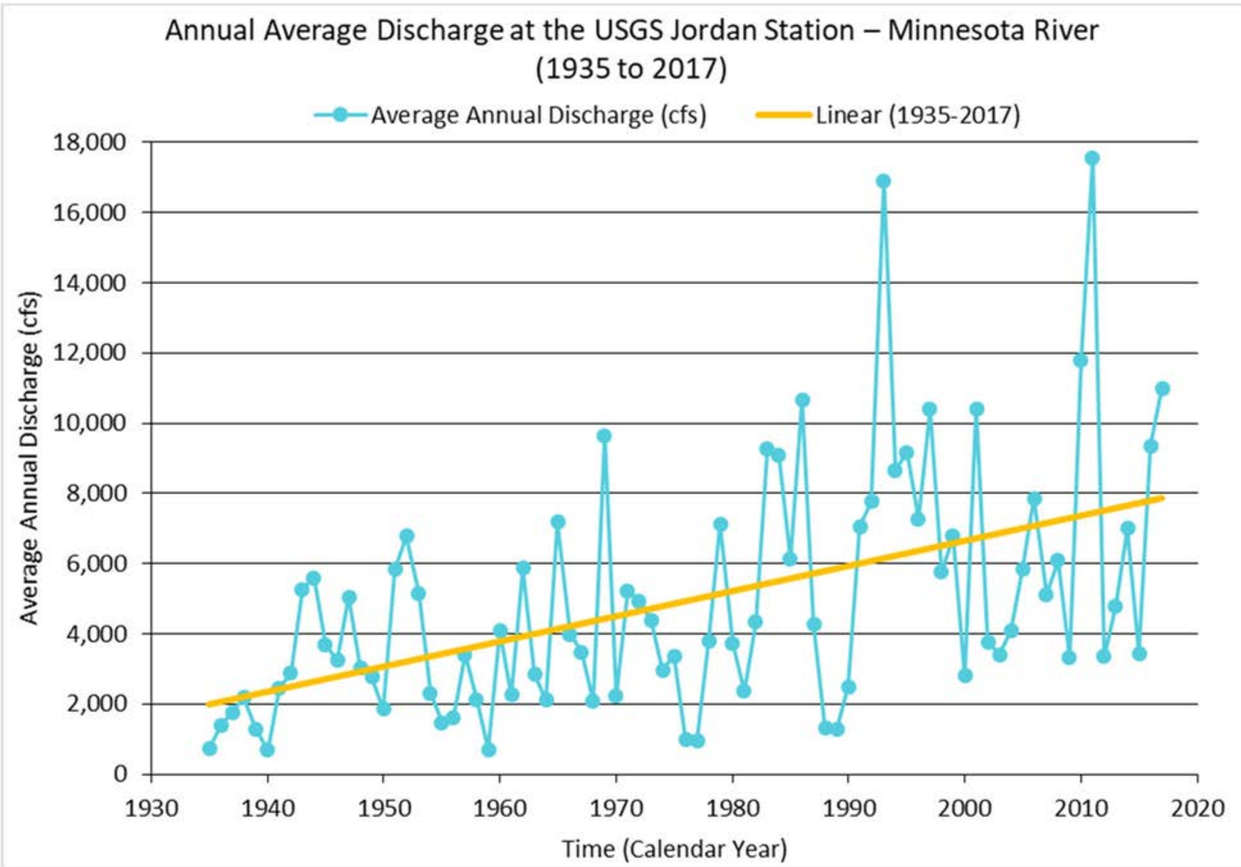


Figure 6: Annual Mean Discharge at the Jordan, MN, Gage (1935-2017)

Furthermore, the 8 years with the greatest number of days of bankfull flood events have all occurred since 1980 (Figure 7 and Appendix F, *Hydraulics & Hydrology*). For example, in 2018 there were 4 major flooding events in the study area, where discharge of 26,600 cfs was met or exceeded 4 different times that year.

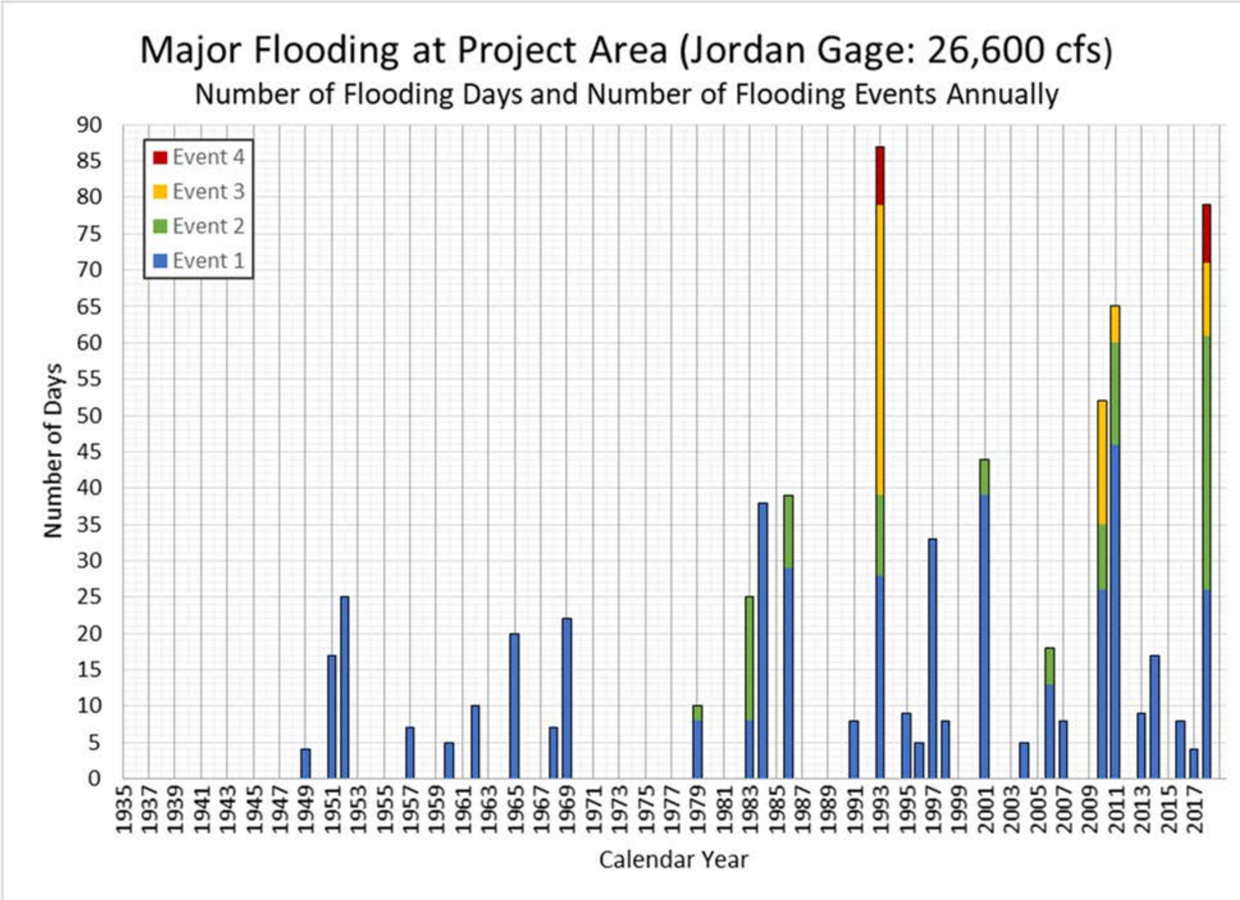


Figure 7: Major Flood Events in the Study Area, Recorded at the Jordan, MN, Gage (1935-2018)

The duration of high or low flows has ecological and engineering significance. Ecologically, the number of days of high flow per year can affect vegetation communities, aquatic organisms, sediment transport, nutrient cycling, and other ecological components and processes. Extended periods of low flows can result in longer residence times in aquatic areas causing increased water temperatures, changes in dissolved oxygen, and higher incidence of algae blooms. From an engineering perspective, longer durations of high flows that overtop ecosystem restoration project features could become detrimental to these structures by causing erosion, increased sediment deposition, and affecting the establishment of riparian vegetative communities. Low flows, if associated with drought conditions, can also affect the establishment of the planted vegetation used to stabilize ecosystem restoration project features.

Many aquatic vegetation and wetland plants life cycles and habitat requirements depend on water level fluctuations. Lower water levels in the summer or fall allow for seed beds to be exposed for germination, consolidate sediments, and oxidize nutrients making them readily available to plants.

Wetland habitat quality has gone down as a result of sustained high water in the three lakes. Sustained high pool has reduced the diversity of aquatic plants within the lakes, and the shorelines are dominated by river bulrush and cattails. Not only does the altered hydrology reduce the quality of wetland habitat and aquatic plant diversity, it also impacts the ability for migrating waterfowl and waterbirds to utilize quality nesting and resting habitat.

2.1.4 Water Management Infrastructure in the Study Area

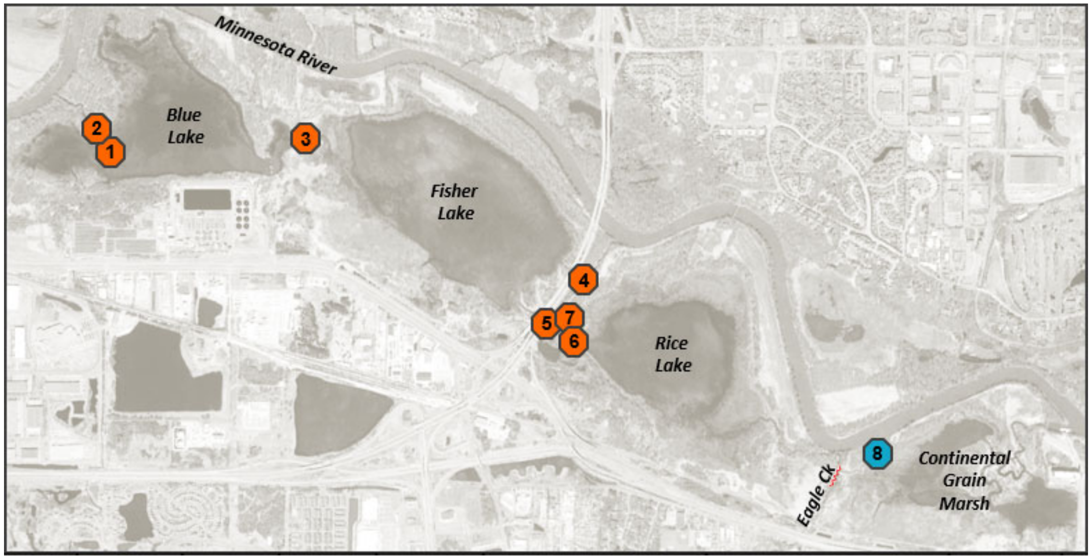
The increasing trend in the number of overbank flood events has negatively impacted the habitat in the study area. Blue, Fisher, and Rice Lakes consistently experience full pool elevations. Compounding the impacts from prolonged high water and peak flow events, is the inability of water in the study area lakes to recede, even after the Minnesota River has gone down.

The primary impedance of flow between these connected systems are the condition of the existing connecting channels and the existing structures located within. There are eight existing structures within the study area, seven of which are not expected to last for the 50-year period of analysis (Figure 8). The existing structures no longer function as intended and/or do not operate holistically for the current desired management of the system for a number of reasons:

- **Deteriorating –** All of the stoplog structures on the Refuge are constructed out of corrugated metal pipe (CMP) and are round culverts. Current structure design approaches are going away from using CMP as this material does not typically last more than 20 years. The CMP stoplog structure at Rice Lake is 20 years old and rusting. Road salt from Hwy 169 may be a contributing factor, as it appears that the structures with the closest proximity to the highway have the most rust damage.

- **No Longer Functional** –The stoplog structure at the Fisher Lake outflow is completely collapsed, preventing drawdowns of Fisher Lake. At Continental Grain Marsh, the failure of a beaver dam has resulted in the formation of a new side channel that has significantly eroded over a short period of time draining the west side of the marsh (See 2017 image, Figure 5). Consequently, the marsh spillway (constructed as a part of the Rice Lake HREP) is no longer functional as the hydrology of the system has further changed and now drains into the adjacent Eagle Creek trout stream.

- **High Operation and Maintenance (O&M)** – Many outlets are too small to allow effective drawdowns and easily become clogged with debris. Existing culverts are 42 inches or less in diameter, and the drawdown rate is twice as long compared to more recently designed structures that can handle the increased flows observed in the more recent hydrologic regime. Debris and sediment has filled in some of the outflowing channels, constricting flows. Beavers have also contributed to the clogging of outlet channels and the existing structures. Currently, the Blue Lake structure requires the most O&M in the study area.



	Structure Location	Structure Name	Type	Size	Material	Year Built	Structure Objective	Condition	Currently Meets Objective	Projected To Meet Objective Over 50-year Project Life
1	Blue Lake	Blue Lake	Gated Stoplog	10x8 ft	Metal	1985[1]	Drawdown Blue Lake	High O&M, design difficulties	Partial	No
2	Blue Lake	Blue Lake	Culvert	84 in	Metal	1985[1]	Road crossing for O&M	Rusting, high debris	Yes	No
3	Blue Lake-Fisher Lake	Interlake	Stoplog	30 in	Metal	1985[1]	Move water from Blue to Fisher Lake	Unable to fill Fisher or Rice (invert 3ft higher), undersized	No	No
4	Fisher Lake	North Fisher Lake	Stoplog	36 in	Metal	1985[1]	Move water from Fisher to Minnesota River	Silted in, does not pass flows	No	No
5	Fisher Lake	South Fisher Lake	Stoplog	36 in	Metal	Unknown	Drawdown Fisher, Fill Rice Lake	Collapsed, undersized	No	No
6	Rice Lake	Rice Lake	Stoplog	42 in	Metal	1998	Drawdown/Fill Rice Lake	Rusting, undersized	Yes	No
7	Secondary Pond	Secondary Outlet	Stoplog	48 in	Metal	Unknown	Move water from Fisher to Rice Lake	Rusting, clogged with debris, undersized	Yes	No
8	Continental Grain Marsh[2]	Con Grain Marsh	Overflow	30x100 ft	Rock	1998	Maximum level of marsh	Silted, does not impact functionality	Yes	Yes

[1]MNDNR Permit #85-6039; [2]Rice Lake HREP feature

Figure 8: Summary of Existing Water Level Management Structures in the Study Area

2.2 Problem Summary and Interactions

Each of the historic changes and problems identified above has influenced the resulting habitat conditions present today in the study area. The problems were combined and summarized in a conceptual model to show how they may be interacting with one another (Figure 9).

In summary, changes in climate and land-use are likely the main drivers that have altered the hydrology in the study area. As a result, the existing habitat experiences prolonged periods of high water, degrading wetland habitat, reducing aquatic plant diversity, and ultimately reducing the habitat quality for waterbirds and waterfowl (nesting, resting, and food habitat). Several WLM actions have been taken in the past, but are no longer functioning in a way that holistically address the current habitat improvement objectives.

The desired new endpoint is providing WLM capabilities that increase the ability of managers to draw floodwaters off lakes and increase the number of days of low water conditions during the growing season.

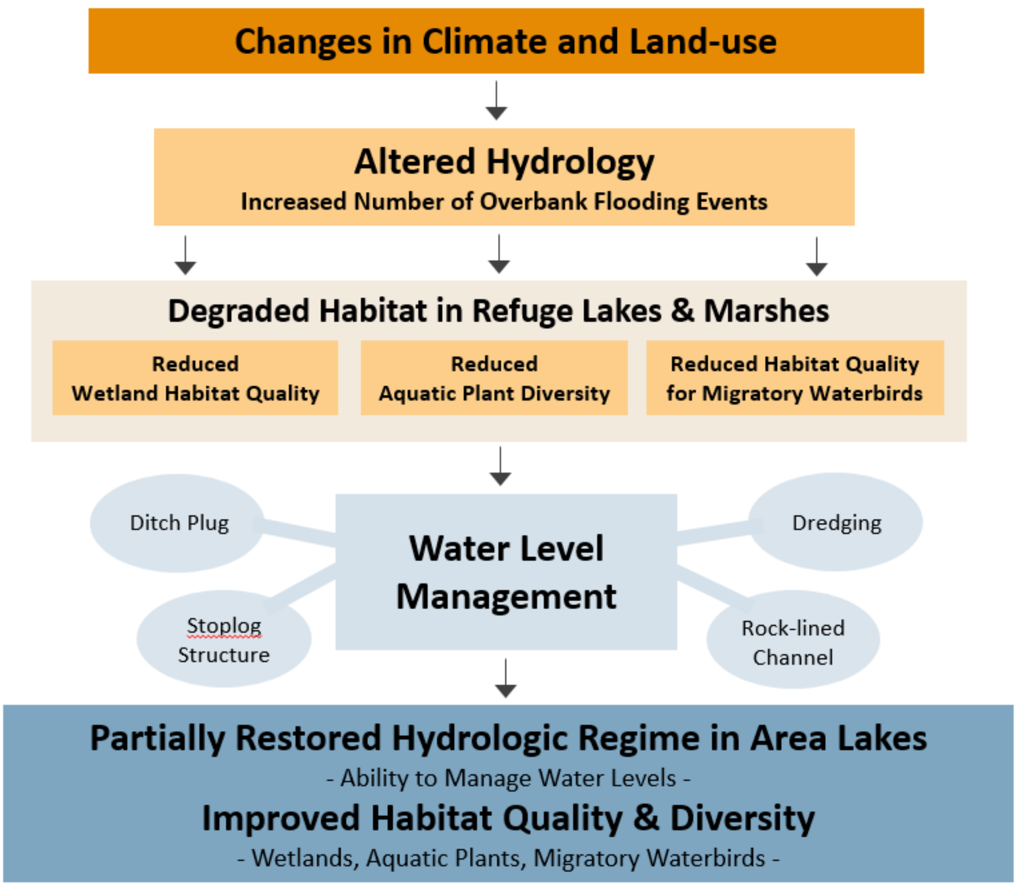


Figure 9: Conceptual Model of the Bass Ponds HREP

2.3 Estimated Future Without-Project Conditions

The Future Without Project condition is the forecasted condition of the study area for the next 50 years assuming that no significant action is taken to address the resource problems identified.

Based on the information discussed above, conditions for a variety of wetland plant species and migratory birds expected to occur in the type of habitat in the study area would generally be considered marginal in many areas. The lake's overall shallow average depth combined with nearly annual flood events limit the ability of the system to have naturally occurring low-level conditions.

The increased number of flood events combined with the increased duration of full lake levels would likely continue to occur more often based on the trends detected within the Minnesota River Basin. Prolonged periods where lakes are experiencing high water conditions can result in poor emergent and submergent habitat for migratory birds.

Furthermore, if no action is taken, deterioration and failure of existing structures is expected to continue. The existing corrugated metal pipe culverts are expected to continue to rust and eventually collapse within the next 50 years. The Fisher Lake outlet structure is already collapsed which has caused erosion of an adjacent berm and has altered the flow path through the highway holding pond.

3 PLAN FORMULATION

Plan formulation for the Bass Ponds HREP has been conducted in accordance with the six-step planning process described in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983) and the *Planning Guidance Notebook* (ER 1105-2-100). The six steps in the iterative plan formulation process are: 1) Specify the water and related land resources problems and opportunities of the study area; 2) Inventory and forecast existing conditions; 3) Formulate alternative plans; 4) Evaluate alternative plans; 5) Compare alternative plans; and 6) Select the recommended plan.

The basis for selection of the Recommended Plan is fully documented below, including the logic used in the plan formulation and selection process.

3.1 Problems and Opportunities

USACE's planning process starts with identifying problems and associated opportunities within the geographic scope of the study area. From the list of problems and opportunities, and in collaboration with agency partners, USACE drafts specific objectives for the project. USACE determines the success of the project planning by the fulfillment of the objectives through identified measures.

Problem Statements

- Reduced wetland habitat quality
- Reduced aquatic plant diversity
- Reduced habitat quality for migratory waterbirds and waterfowl
- Degradation of wetland habitat within Continental Grain Marsh

Opportunities

- Increase bird feeding and nesting habitat
- Increase recreational opportunities where compatible with overall project goals and objectives

3.2 Objectives and Constraints

3.2.1 Project Objectives

Based on the project's problems and opportunities, USACE listed specific objectives below. USACE planning guidance ER 1105-2-100 provides guidance for developing objectives and specifies that objectives must be clearly defined and provide the effect desired, the subject of the objective, the location where the effect will occur and the timing and duration of the effect. For the purpose of this report, the timing or duration of the objectives is assumed to be the 50 year period of analysis. The performance targets to measure the success of each objective are discussed in Appendix K, *Monitoring and Adaptive Management*. The Bass Ponds HREP Objectives are:

1. Increase the diversity and percent cover of desirable emergent aquatic plant species.
2. Increase the diversity and percent cover of desirable submergent aquatic plant species.
3. Provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl.

3.2.2 USFWS Management Objectives

The project objectives are consistent with the overall objectives of the Refuge, which are to "manage and enhance permanent/semi-permanent wetland systems throughout the Minnesota Valley National Wildlife Refuge to provide habitat for waterfowl, shorebirds and other waterbirds. Provide diverse habitat for other wetland-dependent wildlife while preserving the ecological integrity of the wetland in the Eastern Broadleaf Forest Province" (USFWS 2018a).

In order to successfully achieve the management objectives of the Refuge, the Refuge manager's goals are to be able to adjust water levels throughout the season (full, partial, optimal pool elevations), and when scheduled, to be able to drawdown water quickly (less than 10 days) in order to have the best chance at achieving a beneficial habitat response. Another goal is to manage each lake independently, storing and supplementing water from upstream to downstream sources depending on conditions.

The Refuge's typical WLM plan by season is outlined below in Table 1. Depending on habitat conditions, Refuge managers would target a full drawdown every 5 to 7 years. Desired surface water elevation goals for the Refuge were defined by the total percent of study area with surface water present (see Section 8.2.1 of Appendix F, *Hydraulics and Hydrology*).

A successful full drawdown was defined as achieving a full drawdown (less than 10% inundation) by mid-July for a duration of at least 30 days.

Table 1: Typical Water Level Management Plan within the Refuge

Month	Action
May – Jun	Gradually decrease water levels
Jul – Aug	Maintain water levels
Sept – Nov	Gradually increase water levels
Dec – Apr	Maintain water levels

3.2.3 Constraints

Planning constraints are temporary or permanent limits imposed on the scope of the planning process and the choice of solutions. These limits can be related to the ecological, economic, engineering, legal, and administrative aspects of a project. Some constraints are states of nature, whereas others are based on the design of built structures and other engineering considerations. Legislation and decision makers can impose other constraints and such human-imposed constraints are possible to change. USACE established the following planning constraints to guide and set boundaries on the formulation and evaluation of alternatives.

- Institutional constraints: Avoid or minimize impacts to flood stages and navigation.
  - Restoration measures should not increase flood heights or adversely affect private property or infrastructure.
- Environmental constraints: Construct measures consistent with Federal, state, and local laws. Compliance and coordination under NEPA emphasizes the importance of environmental impacts to be minimized and avoided, as much as possible. Therefore, the following constraints are considered when analyzing alternatives:
  - Avoid impacts to adjacent trout stream, Eagle Creek.
  - Avoid impacts to threatened and endangered species (the northern long eared bat, and the rusty patch bumblebee, respectively).
  - Minimize waterbird and migratory bird impacts
  - Avoid adverse impacts to cultural resources

3.3 Management Measures and Screening

A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measures to form alternative plans. Management measures were developed to address study area problems, meet study objectives, and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including prior studies, the NEPA public scoping process, and the multidisciplinary, interagency Project Delivery Team (PDT).

Screening of measures is a process whereby various criteria are evaluated to better characterize a specific measure and the likelihood that it can achieve project objectives and cost effective restoration. The evaluation criteria identified in the P&G were used to identify the alternative management measures retained for further consideration. The purpose of this preliminary screening is to narrow down the number of alternatives to be subjected to detailed further analysis; however, it will not preclude resurrecting a measure at a future date if it becomes apparent that a measure was screened out based on incomplete data or an invalid assumption. The measures that are retained for further consideration must derive from the planning objectives for the project, must be feasible within the project constraints, and must be considered to best meet the screening criteria within the range of alternatives considered.

Alternative plans are developed from the measures carried forward; if a measure is not justified and not carried forward, the measure will not be further developed into an alternative plan. Alternative plans are different combinations of various sizes and scales of measures that would contribute to attaining the planning objectives. A measure may stand alone as an alternative plan that can be implemented independently of other measures, resulting in some achievement of the planning objectives. Measures are screened against selected criteria in the first iteration of the planning process and alternative plans are developed and screened against the same criteria in a later iteration of the planning process. Review of the four formulation criteria suggested by the P&G (completeness, effectiveness, efficiency, and acceptability, defined below) and resource significance (institutional, public, and technical, described in Section 1.8) were used to aide in the selection of the Recommended Plan.

- **Completeness -** Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planned effects.
- **Effectiveness -** Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified objectives.
- **Efficiency -** Efficiency refers to cost-effectiveness and the most efficient allocation of other resources. Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and achieving the specified objectives.
- **Acceptability -** Acceptability refers to the workability and viability of the alternative with respect to acceptance by state and local entities and the public compatibility with existing laws.

The first step taken in this study was to identify general locations and categories of potential improvements that would satisfy the study objectives. The process began with several discussions concerning the management goals and objectives discussed in the previous section, as well as the USFWS three priority areas: Fisher Lake, Continental Grain Marsh, and Bass Ponds. Based on site visits and interagency discussions, it was agreed to screen out the third priority area (Bass Ponds) from further consideration; It was determined that restoration and enhancement measures to improve this area would jeopardize the adjacent trout stream (Ike's Creek), which the Refuge and the PDT decided was not worth the risk. In addition, early in the planning process it was determined that no action would be taken at Hogback Ridge Dike south of Bass Ponds as clear problems or opportunities for habitat restoration were not identified for that location. Additional discussion and maps of the priority areas can be found in Appendix C, *Plan Formulation*.

An array of general measures was developed for the remaining study area from which alternative plans were developed, and is summarized in Table 2.

- **No Action -** The no action measure is defined as no implementation of a project to modify habitat conditions in the study area. The No Action Alternative is required under NEPA for comparison of proposed actions to a baseline condition.

- **Water Level Management** – Water level management (WLM) of the water elevation within the study area could enhance aquatic habitat. Common designs for WLM include stoplog structures, pump stations, gated structures, rock-lined overflows, and plugging existing undesirable outlets (USACE 2012b). A full or partial drawdown could consolidate sediments and expose the seedbed to stimulate plant germination and growth. A drawdown could be conducted during the growing season (June – August) to best promote aquatic plant growth. In the fall, WLM structures could be used to hold water to optimize seasonal habitat for waterbirds and waterfowl (e.g., feeding, nesting, resting). WLM structures can also be used to drawdown water from one system to fill another; thereby reducing impacts during drought conditions. As an example, the USFWS has found the Long Meadow Lake stoplog structure to be the most reliable, functional, and easily maintainable water control structure on the Refuge. The 5 feet wide by 6 feet high concrete bay design with aluminum stoplogs has resulted in low O&M and the structure has held up well over time. A disadvantage of this measure can be annual O&M, as stoplogs require manual adjustment and monitoring, culverts can clog with debris or by beaver activity, and the size and complexity of some designs can be costly. However, given the numerous advantages of this measure, the PDT retained it for further evaluation.

- **Habitat Dredging -** Habitat dredging is a measure often used to improve overwintering centrarchid habitat. When designed correctly, the increased water depth from habitat dredging creates a larger volume of water with the proper levels of dissolved oxygen and temperature greatly improving winter habitat conditions for centrarchids. Habitat dredging was primarily considered for Blue Lake due to the known shallow water depths in Fisher and Rice Lake. However, after receiving the bathymetry data it was found that Blue Lake was predominantly shallow as well, therefore significant dredging and disposal of material would need to occur in order for this measure to be effective. Additionally, this measure did not meet the project objectives of enhancing habitat for aquatic vegetation and migratory birds and was therefore screened from further consideration.

- **Access Dredging -** Access dredging is accomplished to facilitate access to areas to construct project features or to facilitate flow to WLM structures. While determined not necessary for habitat dredging or access to other features, it was determined that access dredging would need to be evaluated further in combination with WLM in order to allow flow to reach and pass through structures successfully.

- **Floodplain Forest Creation/Enhancement -** Floodplain forest creation or enhancement could serve a variety of habitat purposes in the study area. Floodplain forests increase habitat diversity and provide habitat niches that have been lost in the Minnesota River. In the study area, some agricultural land has already been converted back to floodplain forest. However, within the study area, no opportunities for floodplain forest restoration were identified. The lake, marsh, and wetland environments are the only habitat types considered forward for restoration; this measure was screened from further consideration.

Table 2: Screening of Measures (Shaded Measures Were Screened From Further Analysis)

Measure	Location	Retained	Justification for Elimination or Retention
No Action		Yes	All alternative plans must be compared to No Action Alternative.
Water Level Management *Stoplog Structure* *Rock-lined Channel* *Access Dredging* *Plug* *Pump Station*	 All Sites All Sites All Sites CGM Blue & CGM	Yes	Complete, Effective, Efficient, and Acceptable. Would improve wetland habitat quality and diversity of aquatic vegetation, and habitat for migratory waterbirds and waterfowl.
T-structure *Dikes* *Gated Structure* *CMP Culverts*	Rice-Fisher Bass Ponds Blue Lake All Sites	No	Not Acceptable; Safety concerns No clear problems identified (Hogback Ridge Dike). Does not meet objectives; Not cost-effective. Not Effective or Efficient
Habitat Dredging	Blue Lake	No	Does not meet objectives; Does not meet P&G criteria
Floodplain Forest	All Sites	No	Does not meet objectives; Does not meet P&G criteria

CGM = Continental Grain Marsh

The measures retained for further consideration (no action, stoplog structures, rock-lined channels, access dredging, plugs, and pump stations) were derived from the planning objectives for the project, and are considered to be the most complete, effective, efficient, and acceptable within the range of measures considered. Increments and scales of the retained measures were developed and combinations of the different scales and increments of the measures were used to formulate alternative plans.

3.4 Formulation of Alternatives

Alternatives are combinations of measures that would contribute to attaining the planning objectives. A measure may stand alone as an alternative plan that can be implemented independently of other measures, resulting in some achievement of the planning objectives. Measures that were deemed feasible were carried forward for consideration in the development of alternatives.

Some of the important factors that led to the development of the final array of alternatives for this project are described below. Alternative development is a complex, iterative process with many inputs, and the hydrologic analysis of the study area was the most influential in the development of alternatives leading up to the Recommended Plan.

3.4.1 Drawdown Analysis for Blue-Fisher-Rice System

To evaluate the effectiveness of WLM measures in the Blue-Fisher-Rice Lake system, several iterations of hydraulic modeling and analyses were conducted. A 2D HEC-RAS model was used to analyze and optimize WLM of the interconnected Blue-Fisher-and Rice Lake. The analysis used the existing hydrologic record for the Minnesota River at the nearby Jordan, MN, gage, and incorporated inputs from the Blue Lake WWTP and precipitation. The hydraulic model showed that the existing 42-inch culverts are currently too small to achieve the desired water level conditions throughout the year. To make matters worse, the outlet for Fisher Lake has collapsed and flows are eroding below the highway bridge. Furthermore, the findings of the climate change assessment (Section 2.1.2) and the USFWS management objectives (Section 3.2.2) emphasized the need to design efficient and robust structures that are both tolerant to high flows as well as able to drawdown these systems efficiently. The analysis explored several different scales of culvert sizes and materials to determine efficient drawdown rates (e.g., ability to complete a drawdown in at least 10 days). Initial model runs using standard round culvert sizes of 42 inch, 60 inch, and 72 inch required almost twice as many days to drawdown the system as the newer design of 5 feet wide by 6 feet high rectangular bays (as used in the Long Meadow Lake HREP). Additionally, anecdotal information from the USFWS suggested that the round culverts experienced more debris build-up than the rectangular culverts. The corrugated metal pipe material was also a downside to the existing structures in the study area – as they are susceptible to rusting, and likely need to be replaced within the 50-year period of analysis. More recent WLM projects, like Long Meadow Lake, have moved toward using concrete over CMP for this reason. See Appendix F, *Hydraulics and Hydrology,* for additional details on the drawdown analysis. The results of the preliminary drawdown analysis are summarized below:

Culvert Sizing – 5-feet wide by 6-feet high rectangular concrete box culverts were the best balance between drawdown rates and structure operation and maintenance. The USFWS has experience with a similar size structure at Long Meadow Lake HREP and considers this a desirable size.

Major Flooding – Major flooding at the study area begins at an assumed elevation of 704.5 feet at RM 20 (NAVD 88). At this elevation, the berms between the lakes and marsh as well as the berms between the project and the Minnesota River are beginning to be overtopped. This overtopping elevation correlates to approximately 26,600 cfs at the USGS Gage at Jordan, MN, which is reflected as a red line in Figure 10. When the historic, observed, mean daily flow at Jordan exceeds the line the study area likely experienced major flooding.

Drawdowns – WLM through replacing the existing structures with new 5-feet wide by 6-feet high bays resulted in the most efficient successful drawdown that could be maintained throughout the growing season. The quickest, most efficient full drawdown can be achieved once the Jordan Gage decreases to a discharge of 10,000 cfs or lower. This discharge value at Jordan correlates to the approximate full drawdown elevation of the lakes (Blue, Fisher, and Rice) and Continental Grain Marsh (see Appendix F for more detailed information). The full drawdown elevation is necessary to provide the variation in pool/water levels necessary to encourage waterfowl and waterbird nesting and the establishment of aquatic plant communities.

A successful drawdown is defined as a full drawdown occurring for a minimum duration of 30 days by mid-July. The time it takes to drawdown the lakes (Blue, Fisher, and Rice) and Continental Grain Marsh when conditions are sufficiently low (<10,000 cfs at Jordan) is listed in Table 3.

Table 3: Minimum Time to Drawdown at Maximum Efficacy
(Minnesota River Receded to 10,000 cfs at Jordan)

Location	Drawdown Time (days)
Blue Lake	0.5
Fisher Lake	3
Rice Lake	4
Continental Grain Marsh	0.2

A period of record analysis from 1935-2018 indicates that if the proposed project structures had been in place, a successful drawdown could have been achieved 86% of the years. The years where a successful drawdown would have been feasible, historically are indicated by the green circles in Figure 10.

Based on the results of the climate assessment presented in Appendix F, there is an abrupt nonstationarity in the mean annual discharge record collected at Jordan, MN, occurring circa 1981. The record collected post-1981 consists of higher flows, relative to the pre-1981 portion of the record. Therefore, the more recent “wetter” period from 1981-2018 was also analyzed, and it was found that a successful drawdown still could be achieved 79% of the years.

Dependencies – WLM structures would be required between Blue, Fisher, and Rice Lakes in order for the interconnected lake system to have successful drawdowns as well as filling capabilities. For example, in order to fill Rice Lake, structures are required between Blue and Fisher (the Interlake structure), as well as between Fisher and Rice (the Secondary Outlet structure) in order to redirect and hold flows in Rice Lake.

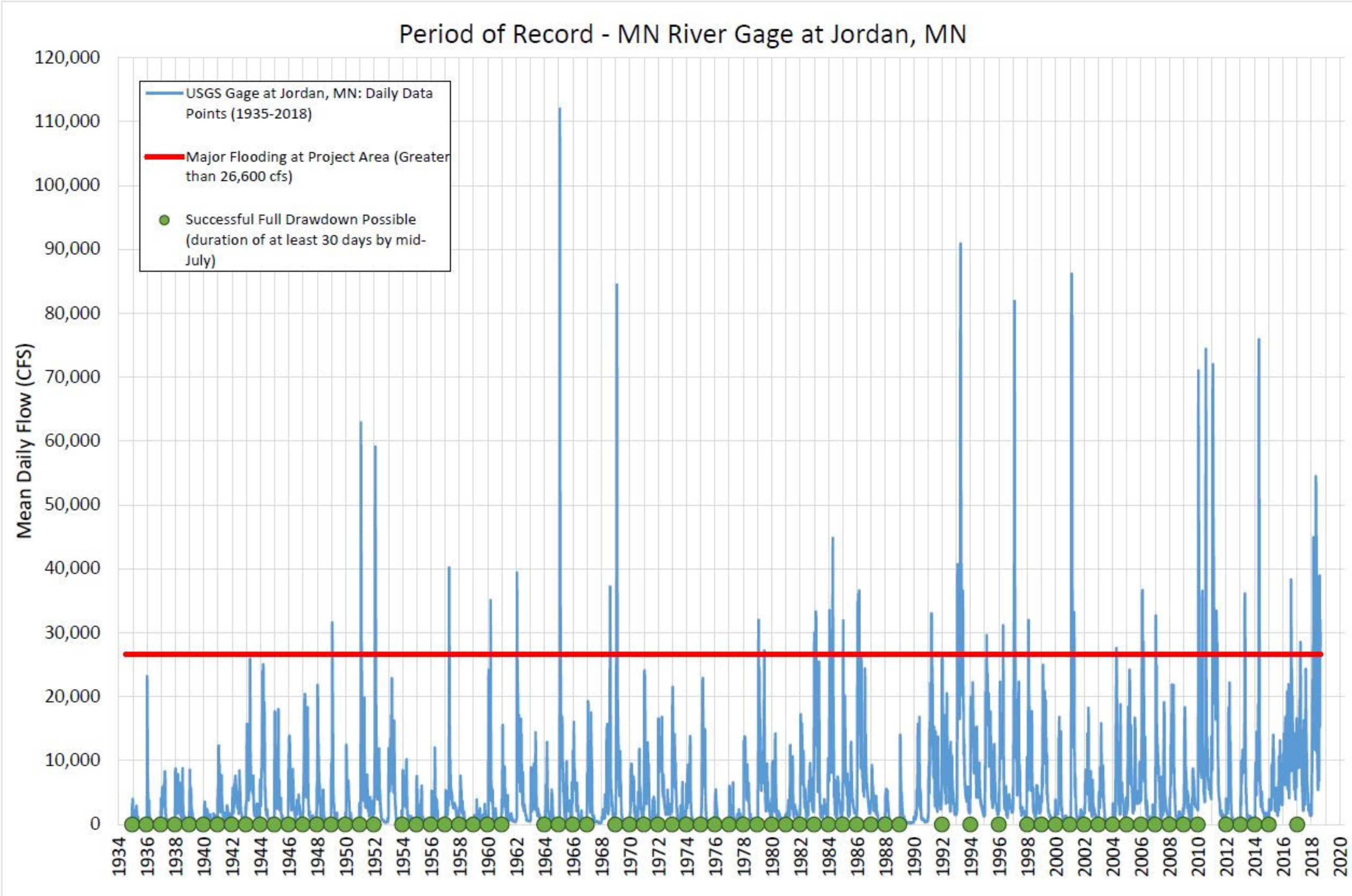


Figure 10: Major Flooding & Successful Drawdown Assessment: Period of Record for the Study Area (1935-2018)

3.4.2 Drainage Analysis of Continental Grain Marsh

A drainage analysis was conducted for Continental Grain Marsh to evaluate the location of low elevation points along the natural levee separating the marsh from the Minnesota River and determine locations where modifications could be made to hold more water within the marsh. Using LIDAR and HEC-RAS modeling, the lowest elevation along the Continental Grain Marsh levee is no longer the Rice Lake HREP rock spillway. The new primary outlet is a channel on the west side of the marsh where a former beaver dam was lost.

3.4.3 Final Array of Alternatives

The drawdown analysis of the Blue-Fisher-Rice Lake system, as well as a drainage analysis of the Continental Grain Marsh site, was conducted during the initial development of alternatives (see Appendix F, *Hydraulics and Hydrology,* and Appendix C, *Plan Formulatio*n, for further details on initial alternatives). The final array of alternatives is summarized in Table 4.

Table 4: Final Array of Alternatives

		Blue-Fisher-Rice Lake System				Con Grain Marsh	
Site	**Feature**	**BFR 1**	**BFR 4**	**BFR 5**	**BFR 6**	**M1**	**M2**
Blue Lake	Stoplog	4	4	2	1		
Interlake	Stoplog	2	1	1	1		
Fisher Lake	Stoplog	1	1	1	1		
Secondary Outlet	Stoplog	2	1	1	1		
Rice Lake	Stoplog	1	1	1	1		
Con Grain Marsh	Plug					x	x
Con Grain Marsh	Stoplog						1

As a result of the drawdown and drainage analyses of the study area, three standalone alternative groupings were formed, each with different WLM capacities:

- **BFR Alternative** (Blue-Fisher-Rice Alternatives): Consisting of a stoplog structure with a rock-lined overflow at each of the lake sites. Different combinations of this alternative included an analysis of a range of maximum and minimum numbers of stoplog structures at each lake outlet to determine the most effective design to achieve an effective drawdown rate. (BFR1 was the largest with a maximum of four bays at Blue Lake to BFR6 with only one bay at each outlet).

- **M1 Alternative** (Continental Grain Marsh Alternative #1); consisting of an earthen plug at Continental Grain Marsh.

- **M2 Alternative** (Continental Grain Marsh Alternative #2): consisting of an earthen plug and a stoplog structure for WLM at Continental Grain Marsh.

In addition to these standalone alternative groups, a pump station increment was also considered for the BFR Alternatives as well as for the Marsh Alternatives:

- **Cp** (Continental Grain Marsh Pump): an increment that could be added to M1 or M2 that included adding a pump station to Continental Grain Marsh that could fill the marsh during low-water (drought) conditions.

- **Bp** (Blue Lake Pump): an increment that could be added to any BFR alternative that consists of a pump station at Blue Lake to fill the BFR system during low-water (drought) conditions.

The various combinations of these alternatives amounted to 45 different alternatives, including the No Action Alternative (Appendix C, *Plan Formulation*).

3.5 Evaluation and Comparison of Alternatives

This section describes the final array of alternatives that were evaluated. It also documents the process used to determine the potential costs and habitat benefits of each alternative.

3.5.1 Environmental Benefit Analysis

To quantify habitat benefits of the proposed alternatives for the Bass Ponds HREP, the USFWS Habitat Evaluation Procedure (HEP) was used (USFWS 1980). The HEP methodology utilizes Habitat Suitability Index (HSI) models to rate quality of habitat on a scale of 0 to 1 (1 being optimal). The HSI value is multiplied by the number of acres of available habitat to obtain Habitat Units (HUs); the HSIs and acreages are then projected into the future. One HU is equivalent to 1 acre of optimum habitat. HUs are then averaged annually across the project's 50-year period of analysis, referred to as Average Annualized Habitat Units (AAHUs). By comparing the AAHUs of the No-Action Alternative to each of the action alternatives, the benefits can be quantified (net gain in AAHUs).

Based on the management objectives of the resource agencies in this portion of the river, wildlife "bluebook" models were used to quantify habitat benefits and evaluate effectiveness of the proposed measures. To quantify the changes in aquatic habitat, the dabbling duck HSI model (Devendorf 2013) was used. This model has been applied to other HREPs in the UMR and is certified by the USACE Ecosystem Planning Center of Expertise. For a detailed discussion of the HEP conducted for this study, see Appendix D, *Habitat Evaluation Procedure*.

3.5.2 Cost Effectiveness & Incremental Cost Analysis

USACE guidance requires a cost effectiveness analysis and incremental cost analysis (CE/ICA) for determining what project features and design alternatives should be built based on a comparison of quantified habitat benefits (outputs) and estimated costs of alternative designs (ER 1105-2-100, Appendix E, paragraph 36). This process identifies which alternatives or combinations of features fully or partially meet the objectives of the project and are the most cost effective. A cost effective analysis is conducted to ensure that the least cost alternatives have been identified. Subsequent incremental cost analysis is conducted to evaluate changes in cost for increasing levels of environmental output.

CE/ICA is a three-step process: (1) calculate the environmental outputs for each alternative; (2) determine a cost estimate for each alternative; (3) compare and evaluate the alternatives based on habitat benefits and costs.

Costs were annualized (AACost) over a 50-year period of analysis at an interest rate of 2.875% for Fiscal Year 2019. These costs included initial construction with mobilization and demobilization, contingency (32%), planning, engineering, and design (15%), and construction management (8%) above the actual estimated cost for construction. Additionally, operation and maintenance (ranging approximately $2,000 to almost $60,000 per year for 50 years), adaptive management (3%), and interest during construction (2 years of construction was assumed for all alternatives) were included in each alternative.

The incremental analysis for each alternative was accomplished using the USACE Institute for Water Resources Planning Suite II. The results of the CE/ICA analysis is displayed in Figure 11.

The incremental cost per unit of output for Best Buy plans are displayed in Figure 12. Refer to Appendix C, *Plan Formulation*, for the detailed table and results of the analysis.

Of the 45 generated plans, 6 plans were considered Cost Effective, 5 of which were considered Best Buys, including the No-Action Alternative. “Cost Effective” means that for a given level of non-monetary output, no other plan costs less, and no other plans yields more output for less money. From the set of Cost Effective plans, “Best Buy” plans are the most efficient and give the greatest increases in output for the least increase in cost.

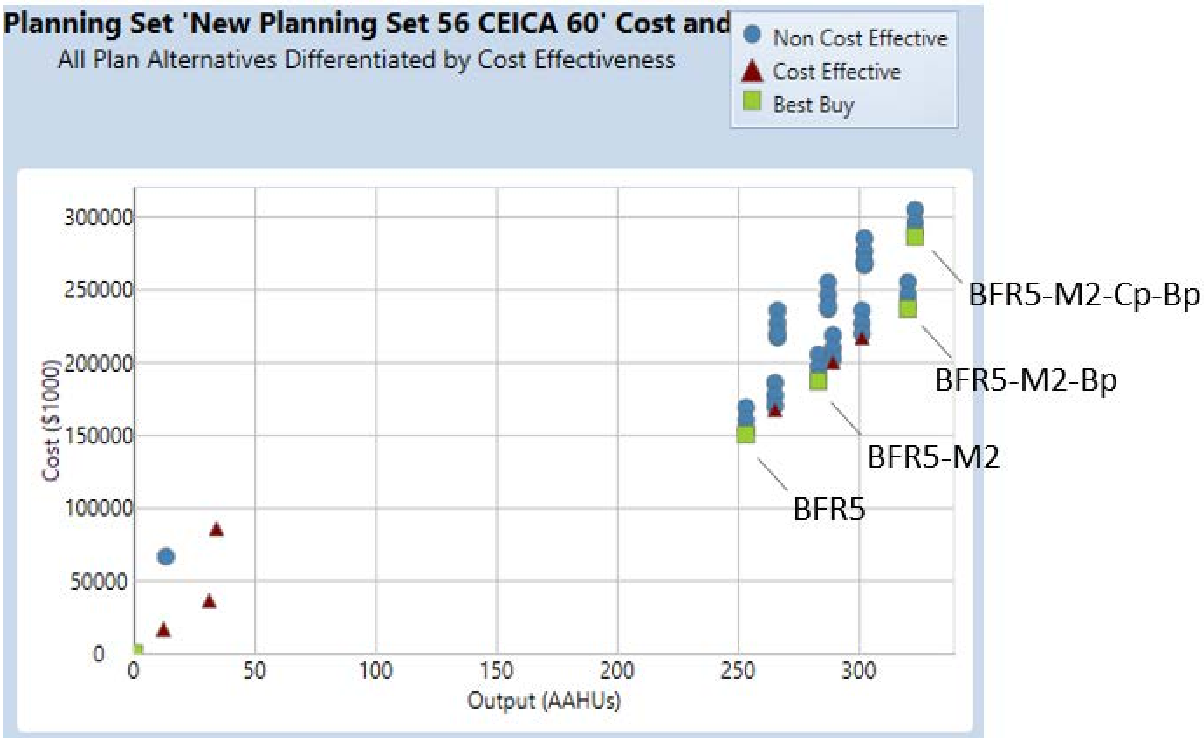


Figure 11: CE/ICA Analysis of All Alternatives

The Best Buy plans presented provide the information necessary to make well-informed decisions regarding desired project scale and features. Progressing through the increasing levels of output for the alternatives helps determine whether the increase in output is worth the additional cost. As long as decision makers consider a level of output to be “worth it”, subsequent levels of output are considered. When a level of output is determined to be “not worth it”, then subsequent levels of output will also likely be “not worth it”, and the final decision regarding desired project scale and features for environmental restoration will be reached.

Typically in the evaluation of Best Buy plans, “break points” are identified in either the second-to-last column in Table 5, or in the stair-step progression from left to right in Figure 12. Break points are defined as significant increases or jumps in incremental cost per output, such that subsequent levels of output may not be considered “worth it”. Identification of such break points can be subjective. For this study, break points were identified between each of the five Best Buy plans (No Action, Alternatives 3, 11, 35, and 43).

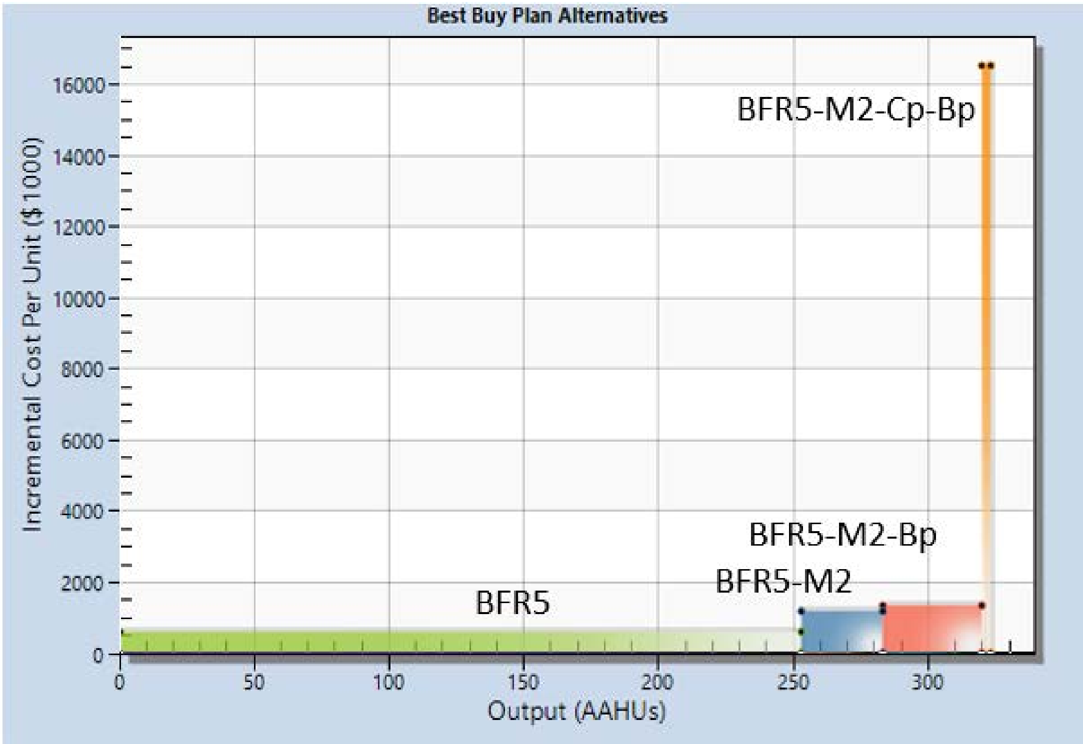


Figure 12: Incremental Cost and Output Results for the Best Buy Plans

Table 5: Results of CE/ICA for Best Buy Plans

Alternative	Feature Groups	Net AAHUs	Total Project Cost	Incremental AACost	AAHU Incremental Output	Incremental AACost/AAHU	$/AAHU
No Action	No Action	0	$0	$0	NA	NA	$0
3	BFR5	225	$3,635,000	$152,700	225	$679	$679
11	BFR5-M2	255	$4,518,000	$36,900	30	$1,230	$774
35	BFR5-M2-Bp	288	$5,388,000	$50,200	33	$1521	$833
43	BFR5-M2-Bp-Cp	291	$6,257,000	$50,100	3	$16,700	$996

3.5.3 Comparison of Best Buy Alternatives

No-Action Alternative – This alternative was not chosen because it does not improve or maintain the ecosystem resources within the study area. This alternative would cost $0. The continued high water events would continue to reduce the habitat value provided in the study area. The existing study area provides 590 HUs, and is assumed to remain at this level over the next 50 years. This alternative does not meet any of the project objectives.

Alternative 3 (BFR5) – This alternative improves the aquatic ecosystem in Blue, Fisher, and Rice Lakes. While this alternative has a low cost per AAHU of $679, it failed to address study objectives in Continental Grain Marsh. Without a plug in the marsh, the system would continue to degrade, and it is likely that the new outlet channel would continue to widen and erode into Eagle Creek. For these reasons, Alternative 3 was deemed as not effective by USACE and the USFWS, and this alternative was eliminated.

Alternative 11 (BFR5-M2) – This alternative meets all of the project objectives and addresses problems in the entire study area, including Continental Grain Marsh. This alternative would cost approximately $4.5 million to construct and would result in a net gain of 255 AAHUs, at an average annual cost per average annual habitat unit of $744/AAHU. The incremental output is 30 habitat units and the incremental average annual cost per average annual habitat unit is $1,230. Alternative 11 was considered worth the investment as it met all project objectives and maximizes habitat benefits at a reasonable cost.

Alternative 35 (BFR5-M2-Bp) – Similar to Alternative 11 with the addition of a pump station at Blue Lake. This alternative meets the project objectives and provides a gain of 33 AAHU above Alternative 11. However, the additional habitat benefits provided by the Blue Lake pump station are minimal compared to the increase in annual O&M costs ($35K/yr) for USFWS. For these reasons, this alternative was eliminated.

Alterative 43 (BFR5-M2-Cp-Bp) – This alternative meets the project objectives and provides similar benefits as Alternative 11 and 35 with the addition of a pump station at Continental Grain Marsh. However, there were several downsides to this alternative. The cost of this alternative was also higher than other alternatives for only minimal benefits achieved; the 3 additional habitat units for this increment cost approximately $16K each. USFWS felt that this large increase O&M costs to maintain and operate two pump stations ($52K/yr) could be better utilized in a different area and therefore was not worth the investment. This small increase in habitat units, at a much larger cost, was deemed not worth it, and this alternative was eliminated.

3.6 Plan Selection

The Bass Ponds, Marsh, and Wetland PDT determined that Alternative 11 (BFR-M2) is the plan that best meets the goals and objectives of the involved agencies and the UMRR program and was chosen as the Recommended Plan. Selecting the National Ecosystem Restoration (NER) plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, completeness, effectiveness, efficiency, and acceptability. The remainder of this section details the considerations made in selection of the Recommended Plan.

3.6.1 National Ecosystem Restoration Plan

The alternative plan that reasonably maximizes the benefits in relation to cost and meets the overall planning objectives is Alternative 11 (BFR5-M2), tentatively selected as the NER plan. The $744 per AAHU created by Alternative 11 is efficient in achieving the ecosystem restoration objectives and has been considered reasonable. For reference, HREPs yielding an average annual cost per AAHU of $2,000-$3,000 have generally been accepted as justified, with over $5,000 per AAHU accepted in some circumstances. These numbers have not been adjusted for inflation since they were developed in the early 1990s. These criteria have been used to justify construction of over $59 million in habitat projects within the St. Paul District since the program began. Alternative 11 is also consistent with regional and State planning for the area.

The Federal objective for water and related land resources planning is to contribute to national economic development consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements. Achievement of the Federal objective is measured in terms of contribution to Federal accounts intended to track the overall benefits of a given project.

3.6.2 Resource Agency Support

USFWS and the State of Minnesota support Alternative 11 (BFR5-M2) over other alternatives (Appendix A, *Correspondence & Coordinatio*n). The USFWS supports this plan over the other Best Buy plans as it meets all the project objectives, addresses the problems across the entire study area, and does not include the additional annual O&M costs of pump stations.

3.6.3 Resource Significance

All of the action Best Buy alternatives demonstrate institutional and public significance as they meet goals and objectives of the Minnesota Valley National Wildlife Refuge and the multi-agency coordination effort in maintaining a high quality ecosystem while avoiding adverse impacts.

Review of technical importance for the Best Buy alternatives considered to be worth the investment, supported the selection of Alternative 11. Technical importance can best be described in terms of one of more of the following criteria: scarcity, representativeness, status and trends, connectivity, limiting habitat, and biodiversity. In terms of status and trends, resource agencies have documented an increase in flows in the Minnesota River, especially over the last two decades. Increased major flood events and duration of inundation have resulted in degradation of habitat for aquatic vegetation and migratory waterbirds and waterfowl. Alternative 11 would increase the likelihood of the ability to have a successful drawdown, targeting the recruitment of aquatic plants and habitat conditions for wildlife. In terms of biodiversity, Alternative 11 would likely increase the species richness of aquatic plants and wetland habitat.

The larger alternatives (Alternatives 35 and 43) would not likely result in a distinguishable difference in biodiversity or status and trends. The smaller alternative (Alternative 3) would not include a quarter of the study area by omitting Continental Grain Marsh, and would therefore limit the ability of WLM to address these criteria in the study area.

3.6.4 Risk and Uncertainty

Areas of risk and uncertainty have been analyzed and were defined so that decisions could be made with some knowledge of the degree of reliability of the estimated benefits and costs of alternative plans. Risk depends on the probability or likelihood for an outcome and the consequences of that outcome. Uncertainty refers to a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes.

The team worked to manage risk during plan formulation. One way this was done was by using experience from past projects to identify potential risks and reduce uncertainty during the development of potential measures. The team referenced successful similar WLM work in the UMR (especially Long Meadow Lake, MN and Long Lake, WI), the *UMRR Design Handbook* (USACE, 2012), and used best professional judgment. The team also had several meetings to conduct an Abbreviated Risk Analysis during which project risks were factored into project costs (Appendix G, *Cost Engineering*).

The primary risks identified for the Bass Ponds, Wetland, and Marsh study area included constructability risks and risks associated with climate change impacts to flow discharges.

Constructability – During the planning process it was discovered that two utilities (a 12 inch natural gas pipeline and a fiber optic conduit) were a potential risk due to the proximity to proposed structures (see utility map in Appendix H, *Real Estate Plan*). The team revised the dredging plan to avoid the pipeline at the Interlake structure by only dredging on the eastern side and staying outside the 80 ft right of way. To manage risk with the fiber optic cable, the team had several meetings with USFWS and MnDOT to discuss a path forward. In order to manage construction of the Fisher Lake outlet structure, the team included costs associated with relocating the conduit within the Lands, Easements, Right-of-Way, Relocation, and Disposal (LERRDs) component of the cost estimate.

Flow Risks – Hydraulic and hydrology analyses were done to evaluate the existing flow regime and the probability of drawdown success. Since water levels cannot be managed successfully in the current condition, a with-project 80% chance for a 30-day drawdown is considered a very good outcome by the USFWS.

During the flow analysis, the team identified a WLM structure on the east end of Continental Grain Marsh, located on Cargill property (Figure 13). The Cargill structure was constructed in 1985 by the USFWS, which was before the loss of the beaver dam on the western end of the marsh and throughout the lifespan of the Continental Grain Marsh overflow structure that was installed as a part of the Rice Lake HREP. Throughout this time, this structure did not affect the marsh water levels and has been acting as a plug. Inspection of the structure indicated that it was silted in and functioning as a plug. There was also significant erosion observed around the failed structure. If this structure were to pass flow or fail completely, a new outlet would exist. This new outlet would decrease the effectiveness of the proposed project plug and WLM structure significantly.

The proposed solution for this structure includes the construction of a plug/rock overflow structure at the current location of the Cargill culvert road crossing (Figure 13). The real estate requirements for both the construction access road as well as the plug would total 1.8 acres (see Appendix H, *Real Estate Plan*).

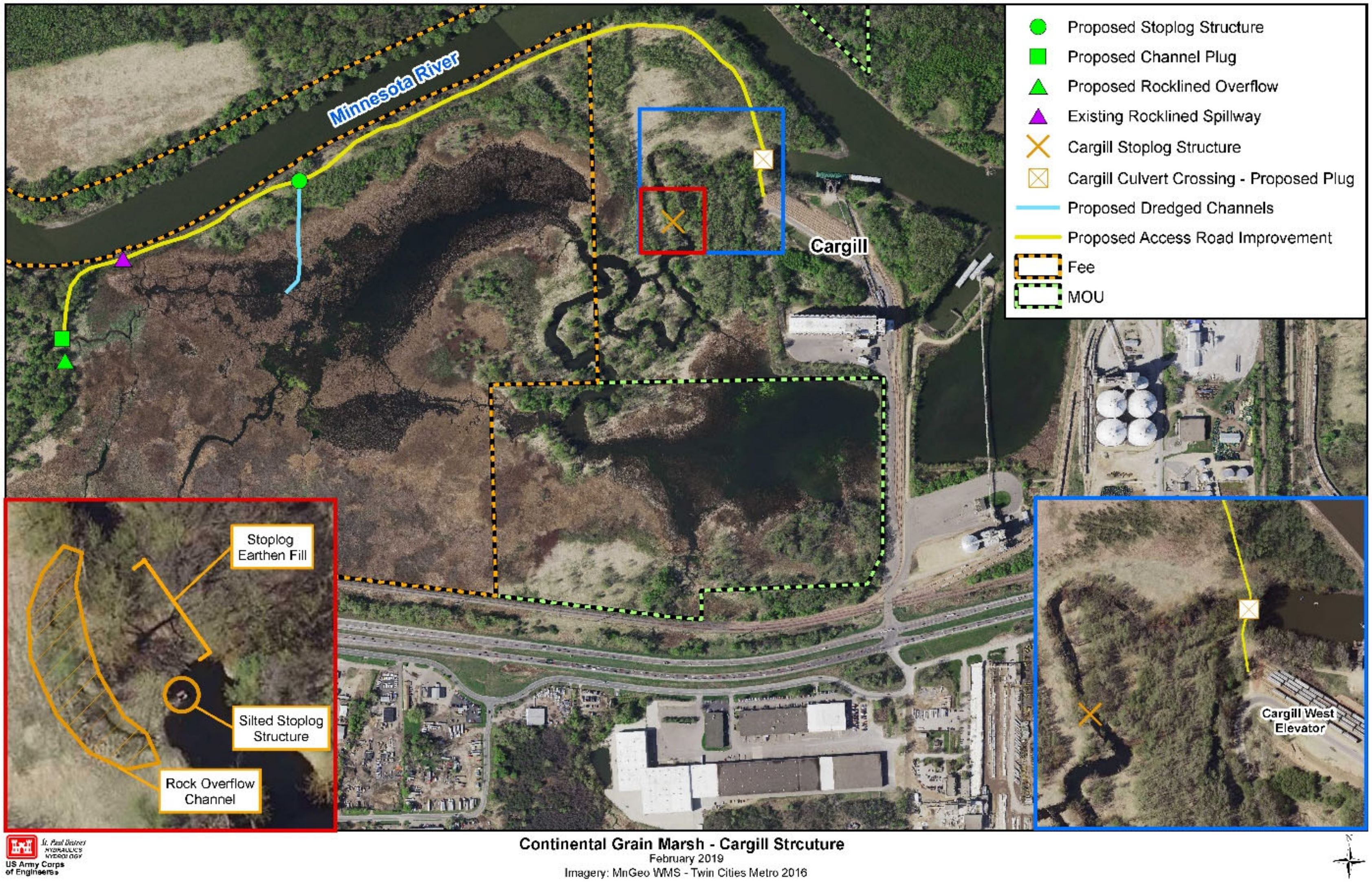


Figure 13: Existing Silted Stoplog Structure and Proposed Plug on Cargill Property

Given that the adjacent Minnesota River is a dynamic system, post-construction monitoring and adaptive management would be used to address any unplanned outcomes of the Recommended Plan. None of the project measures (WLM structures) are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed habitat.

3.6.5 Consistency with Corps Campaign Plan

USACE has developed a Campaign Plan with a mission to "provide vital public engineering services in peace and war to strengthen our Nation's security, energize the economy, and reduce risk from disasters." This study is consistent with the Corps Campaign Plan by producing lasting benefits for the Nation, by optimizing agency coordination, and by using innovative solutions in pursuit of a sustainable, environmentally beneficial, and cost-effective ecosystem restoration design.

3.6.6 Consistency with Corps Environmental Operating Principles

USACE has reaffirmed its commitment to the environment by formalizing a set of Environmental Operating Principles (EOP) applicable to all of its decision-making and programs. The formulation of alternatives considered for implementation met all of the EOP principles.

The EOPs are:

- foster sustainability as a way of life throughout the organization;
- proactively consider environmental consequences of all USACE activities and act accordingly;
- create mutually supporting economic and environmentally sustainable solutions;
- continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments;
- consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs;
- leverage scientific, economic and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner; and
- employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

The EOPs were considered during the plan formulation and the Recommended Plan is consistent with the EOPs. The Recommended Plan promotes sustainability and economically sound measures by incorporating the most natural and least cost methods for restoring habitat for aquatic plants and bird species.

4 ASSESSMENT OF EXISTING RESOURCES AND ENVIRONMENTAL CONSEQUENCES OF THE RECOMMENDED PLAN

This chapter identifies the existing conditions of the resources for the Bass Ponds HREP study area and describes the environmental consequences of the alternatives considered compared to the no-action Future Without Project condition. The depth of analysis of the alternatives corresponds to the scope and magnitude of the potential environmental impact. This chapter provides the scientific and analytic basis for the comparison of alternatives and describes the probable consequences (impacts and effects) of each alternative on the selected environmental resources. The purpose of characterizing the environmental consequences is to determine whether the resources, ecosystems, and human communities of concern are approaching conditions where additional stresses will have an important direct, indirect, or cumulative effect (CEQ 1997).

The Recommended Plan (Alternative 11) and No-Action Alternative are the primary actions evaluated and discussed in this section. The full array of Best Buy alternatives presented in Section 4 (No-Action Alternative and Alternatives 3, 11, 35, and 43) were also considered for environmental consequences. However, these action alternatives involve many of the same restoration measures and the type and degree of the adverse impacts and would not be appreciably different from those associated with the Recommended Plan. Due to the integrated format of this document, the benefits of the alternatives were assessed in the previous section (Section 3) through the development, evaluation, and selection process. Therefore, only the effects of the Recommended Plan and No-Action Alternative are discussed in detail below.

4.1 Water Resources

4.1.1 Water Quality

Water quality in the Lower Minnesota River Watershed has persistent problems with excess phosphorus, sediment, bacteria, and other contaminants, according to a 2017 report by the MPCA (MPCA 2017). The watershed covers 1,835 square miles of south-central Minnesota and includes 87 miles of the Minnesota River, from north of St. Peter, to its confluence with the Mississippi River. The watershed includes the Minnesota Valley National Wildlife Refuge, 133 lakes larger than 10 acres, 2,482 miles of tributaries to the Minnesota River, and the many metropolitan cities including, but not limited to, Bloomington, Prior Lake, Winthrop, Waconia, New Prague, and Le Sueur.

Land use is a major factor affecting water quality. In this watershed, land use ranges from row-crop agriculture in the west to residential suburbs and urban industry in the northeast. More than 90% of the wetlands present prior to European settlement have been drained to accommodate cropland. The lack of wetlands prevents water retention on the landscape and leads to increased storm water runoff and discharges that can destabilize stream banks and increase sediment into the water. Similarly, in urban and suburban environments, impervious surfaces send huge volumes of water into storm drains and nearby bodies of water.

Impacts of the No-Action Alternative – No major changes to water quality would be expected.

Impacts of the Recommended Plan – The Recommended Plan would have temporary, short-term adverse impacts to water quality by increasing turbidity in the immediate study area where construction and excavation occur. There could also be the potential for oil spills from construction equipment; however, Best Management Practices (BMPs) would be used to minimize impacts to water quality during construction. Overall, the Recommended Plan would have a long-term, beneficial effect on water quality by increasing the overall percent coverage of aquatic vegetation. Aquatic vegetation can slow the velocity of flood waters entering the study area, allowing suspended materials to settle to the sediment surface. Excess nutrient or toxic chemicals entering the system, can be taken up by aquatic vegetation, trapped with settled soil particles or converted to less harmful chemical forms by biological processes.

4.2 Geology and Soil Substrate

The region surrounding the Bass Ponds area was glaciated extensively during the Pleistocene Epoch. Advancing and retreating glaciers laid down thick deposits of unsorted till and outwash sand that today form a hummocky, poorly-drained plain dotted with numerous marshes and small lakes. The glacial drift can reach a thickness of between 200 and 250 feet, and it overlies dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations.

The Glacial River Warren carved the wide valley of the present Minnesota River. Glacial River Warren carried large volumes of water discharging from the now-extinct Glacial Lake Agassiz located in western Minnesota and eastern North Dakota. Glacial River Warren cut deeply into bedrock, scouring and reworking an earlier valley filled with outwash, stratified drift, and till.

Episodic increases in flow caused Glacial River Warren to cut lower into the older valley, leaving remnants of higher channel bottoms as terraces. When Lake Agassiz eventually ceased to drain to the south, local drainage formed the Minnesota River and established its present floodplain in the valley.

Three alluvial and bedrock terraces rise above the Minnesota River floodplain and form regionally prominent benches paralleling the river valley. The lower terrace is 30 to 50 feet above the floodplain, the middle terrace is 75 to 115 feet above the floodplain, and the upper terrace is between 120 and 180 feet above the floodplain. The walls of the river valley form a bluff that grades into a hummocky, poorly drained regional highland.

Impacts of the No-Action Alternative – No major impacts to geology and soils would be expected.

Impacts of the Recommended Plan – Minor impacts to geology and soils would be expected due to construction of project features. Construction of the water control structure and ditch plug at Continental Grain Marsh would replace native soils with impervious materials such as concrete and clay. These features would also impact the existing topography in relatively small areas within the study area. Replacement of existing water control structures at Blue, Fisher and Rice Lakes would have a minor impact on soils as they will mainly be constructed in existing footprints. Dredging channels near control structures will remove accumulated soils but leave the native soils in place. Construction of the access roads would replace native soils with aggregate material.

4.2.1 Hazardous, Toxic, and Radioactive Waste (HTRW)

A Phase I HTRW analysis was conducted in June 2018, in accordance with ER-1165-2-132, Water Resource Policies and Authorities HTRW Guidance for Civil Works Projects (see Appendix L, *Hazardous, Toxic, and Radioactive Waste*, for the full report). Based on the desktop search and on-site inspection, this assessment revealed that there were no recognized environmental conditions. Therefore, USACE does not recommend a Phase II assessment.

There are no known HTRW sites at the study area; therefore, there are no HTRW concerns with either the No-Action Alternative or the Recommended Plan.

4.3 Wetlands

The Palustrine System in the Cowardin Classification Scheme (Cowardin et al. 1979) includes all non-tidal wetlands dominated by trees, shrubs, persistent emergent vegetation and emergent mosses or lichens. The Palustrine System includes vegetated wetlands that are traditionally called marsh, swamp, bog, etc., but can also include water bodies often called ponds and wetlands on river floodplains. Also included in this group are shallow lakes, as defined by the MNDNR (2016), which have permanent or semi-permanent water regimes and are typically dominated by wetland habitat. Shallow lakes are a critical habitat component for Minnesota's wildlife and are characterized by aquatic plants and are generally < 15 feet deep (MNDNR 2016). The habitat type that is dominated by persistent vegetation are permanent/semi- permanent wetlands. The Refuge contains approximately 4,376 acres of permanent/semi-permanent wetlands across all the management units except the Round Lake Unit. The Wilkie Unit, which includes Blue, Fisher and Rice Lakes and Continental Grain Marsh, has approximately 1,832 acres of permanent/semi-permanent wetlands (USFWS 2018).

Per the Habitat Management Plan (HMP) for the Refuge, the goals for permanent/semi-permanent wetlands are to manage and enhance permanent/semi-permanent wetland systems to provide habitat for waterfowl, shorebirds and other waterbirds. And, to provide diverse habitat for other wetland-dependent wildlife while preserving the ecological integrity of the wetlands in the Eastern Broadleaf Forest Province (USFWS 2018).

Project impacts are summarized in Table 6. Fill material would be discharged into 3.43 acres of forested/shrub wetland and 2.15 acres of emergent wetlands. With the exception of the water control structure and western plug at Continental Grain Marsh, all project features are being constructed in previously disturbed areas.

Table 6: Project Features and Impacts

Project Feature	Permanent Impact (Acres)	Temporary Impact (Acres)
1 2-bay water control structure with associated excavator pads	0.07	0.09
5 1-bay water control structures with associated excavator pads	0.30	0.25
2 earthen plugs	0.24	
Access roads	4.67	
Channel dredging	3.55	
Rock-lined overflow channels	0.30	
Coffer dams (if needed)		0.20
Total Fill	**5.58**	**0.54**
Total Dredging	**3.55**	

Impacts of the No-Action Alternative – The aquatic resources in the study area have been adversely affected by the increased frequency and duration of high water events. These conditions have led to reduced aquatic plant diversity and habitat quality for migrating waterbirds and waterfowl. Wetlands in the study area would remain in a degraded state throughout the 50-year planning timeframe under the No-Action Alternative.

Impacts of the Recommended Plan – Short-term negative impacts to aquatic resources, primarily associated with increased water turbidity and sedimentation would occur due to construction activities. BMPs would be used to minimize effects on aquatic resources. Long-term beneficial impacts to aquatic vegetation would occur in the study area. The Recommended Plan would allow the Refuge to quickly remove flood waters from the area each spring and conduct yearly drawdowns to increase the density and distribution of aquatic plant species, ultimately improving habitat for migrating waterbirds and waterfowl.

4.4 Invasive Species

According to the HMP, the primary invasive species within the permanent/semi-permanent wetlands include: purple loosestrife, reed canary grass, non-native cattail and phragmites (USFWS 2018). Vegetation data collected on Blue Lake in 2012 and Fisher Lake in 2011 also indicated the presence of curly-leaf pondweed.

Impacts of the No-Action Alternative – Habitat in the study area will remain in a degraded state due to the frequency and duration of high water events and the failure of existing water control structures. As a result, the diversity of both native emergent and submergent aquatic vegetation will remain degraded or may decline slightly over the 50-year planning timeframe. As native vegetation declines, non-native invasive species may become dominant. High water events also make the area difficult to access which would hinder any management activities that could take place. Invasive species identified in the Minnesota River include Asian carp and zebra mussels. Due to connectivity to the Minnesota River, Asian carp and zebra mussels could enter the study area.

Impacts of the Recommended Plan – The Recommended Plan would allow the refuge to conduct yearly drawdowns which would increase the density and distribution of native aquatic plant species. With a dense and robust native plant community, invasive species are less likely to establish or spread within the study area. Similar to the No-Action Alternative, Asian carp and zebra mussels, which are present in the Minnesota River, could enter the study area. The Recommended Plan has no measures to prevent these species from entering the study area.

4.5 Fish and Wildlife

The permanent/semi-permanent wetlands on the Refuge are important to spring and fall migratory waterfowl, waterbirds and shorebirds. The Refuge is a part of the Mississippi River Flyway, which is used by millions of birds as a migration corridor. Based on unpublished Refuge data collected annually, approximately 14 species of ducks (including mallard, wood duck, American coot, hooded merganser, ring-necked duck, green-winged teal, northern shoveler, and northern pintail) along with Canada geese and trumpeter swans are observed annually on a consistent basis. White pelicans, great blue herons and great egrets are also seen in large numbers during migration. Between three to eight species of shorebirds, depending on the water conditions (not consistently), are seen each year.

The Refuge is also home to forty-nine species of fish. Species that have been identified within the study area include crappie, bluegill, bowfin, shiners, drum, shad, sunfish, perch and bass and several minnow species. However, many of the lakes adjacent to the Minnesota River, including Blue, Fisher and Rice, have water depths less than 5 feet which limits their fishery potential.

There are seven eagle nests in the study area. Currently two are active: one is located on the southeast portion of Fisher Lake, and the other is located on the southeast corner of Continental Grain Marsh.

According to the HMP, resources of concern utilizing permanent/semi-permanent wetlands on the Refuge include: American white pelican, blue-winged teal, greater and lesser yellowlegs, mallards, pied-billed grebes, ring-necked ducks, short-billed dowitcher, trumpeter swan and Blanding's turtle (USFWS 2018a).

Impacts of the No-Action Alternative – Wetland wildlife would be negatively impacted through the continued degraded state of ecosystem structure and function within the study area. The continued frequency and duration of high water conditions would result in a less diverse aquatic plant community which would result in fewer waterfowl and other wildlife utilizing the area.

Impacts of the Recommended Plan – Fish and wildlife species are likely to avoid areas under construction; however, this effect would be minor and temporary. Following construction, the project will have a positive long-term effect on wildlife such as waterfowl, shorebirds, turtles, beavers, fish, muskrats and other wildlife species that would utilize the study area by improving habitat.

4.5.1 Federally Threatened and Endangered Species

USACE consulted the USFWS Information for Planning and Consultation (IPaC) website on 19 September 2018 to identify the potential presence of federally listed threatened and endangered species within the defined project action area. USFWS listed the northern long-eared bat

(*Myotis septentrionalis*; NLEB) and rusty patched bumblebee (*Bombus affinis*; RPBB) for the action area.

NLEB is a medium-sized bat that hibernates in caves and mines in the winter and in the summer roosts singly or in colonies under the bark or in cracks and crevices of trees. NLEB is relatively widespread, and USFWS lists NLEB as a threatened species because a fungal pathogen causing white-nose syndrome is sharply reducing populations. There are no known NLEB maternity roost trees or hibernacula in the study area (USFWS 2018b).

RPBB inhabit grasslands with flowering plants from April through October and use underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites and undisturbed soil for hibernating queens to overwinter. The study area consists of saturated soils that RPBB would not use for nesting or overwintering. Vegetation in the study area does consist of flowering wetland plants that RPBB could use as a food source; however, the study area is in the "low potential" area for RPBB (USFWS 2018c).

Impacts of the No-Action Alternative – No impacts to NLEB or RPBB would be expected.

Impacts of the Recommended Plan – USACE has initially determined that the proposed project may affect NLEB. Trees will need to be removed to allow construction equipment access to the project features. Anticipated effects to the species from tree removal were consulted with USFWS under Section 7 of the Endangered Species Act,16 U.S.C. §1533(d), through a Section 4(d) Rule Streamlined Consultation Form. Consultation began on January 26, 2018. USFWS did not respond within the 30 days; therefore, no further consultation is required. To reduce potential impacts, no tree clearing will occur between late May and late July.

There will likely be no effect to RPBB. The RPBB likely uses the study area for foraging only and no removal of floral resources is anticipated. Construction will likely occur in the winter when RPBB is hibernating and flowering plants have senesced.

4.5.2 Minnesota State Listed Species

A number of species that are listed by the State of Minnesota as endangered, threatened or special concern have been historically documented in the vicinity of the project area. A review of the MNDNR Natural Heritage Information System Rare Features Database was conducted. Natural Heritage Database information was obtained from the MNDNR Division of Ecological and Water Resources through an inter-agency cooperative licensing agreement and includes the most recent July 14, 2017 update. The search included a one-mile buffer around the project area to ensure that any listed species would be included. There are a total of 36 species listed by the state of Minnesota as endangered, threatened, or of special concern that may occur within or near the project area: 15 freshwater mussels, 1 insect, 1 fish, 4 reptiles and amphibians, 2 rodents, 3 birds and 10 plants.

The project area does not provide suitable habitat for the listed mussel and plant species. Construction will take place during the winter months when any potentially listed species would be dormant. Construction restrictions (Section 6.4.1) have also been applied to the project to avoid any potential impacts.

No major impact to Minnesota state-listed species would be expected for the No-Action Alternative or Recommended Plan.

4.6 Air Quality

The U.S. Environmental Protection Agency is required by the Clean Air Act to establish air quality standards that primarily protect human health. These National Ambient Air Quality Standards regulate six major air contaminants across the U.S. When an area meets criteria for each of the six contaminants, it is called an “attainment area” for the contaminant; those areas that do not meet the criteria are called “nonattainment areas.” Scott County is classified as an attainment area for each of the six contaminants and is therefore not a region of impaired ambient air quality (EPA 2018). This designation means that the study area has relatively few air pollution sources of concern.

Impacts of the No-Action Alternative – The No-Action Alternative would have no impacts to air quality.

Impacts of the Recommended Plan – Minor, temporary increases in airborne particulates are anticipated as a result of mobilization and use of construction equipment. Frequent inspections of construction equipment will be made during construction to ensure they are properly functioning and do not release unnecessary amounts of emissions.

4.7 Noise

The Refuge is located in an urban area and existing noise levels are consistent with urban areas. The most significant producers of noise in the area are Highways 101 and 169, Valleyfair and Cargill. Construction would require heavy equipment to operate in the area which would generate noise during construction. This effect would only occur during construction and is anticipated to be temporary and minor. There are no sensitive receptors in the immediate vicinity; therefore, noise is not anticipated to impact quality of life.

Impacts of the No-Action Alternative – No change in noise levels would be expected.

Impacts of the Recommended Plan – The construction of the project would generate a temporary increase in noise levels associated with heavy equipment. This may lead to temporary displacement of some wildlife species and decreased recreational use; however, no long-term impacts would be expected.

4.8 Cultural Resources

The Minnesota River has been a focus of human use and occupation for thousands of years as evidenced by the many archaeological sites associated with the diverse landscape settings of the river valley. Twenty-four historic properties are recorded within 1 mile of the study area, however, no historic properties have been identified within the study area.

USACE conducted preliminary deep soil testing at Continental Grain Marsh (see Appendix M for details). USACE has also sought information from appropriate Native American groups pertaining to any properties of cultural or religious importance that may exist within the area of potential effects for the project (see Appendix A for pertinent correspondence). The preliminary survey as well as the tribes contacted have not identified any historic properties. See Appendix M, *Cultural Resources*, for additional discussion.

Impacts of the No-Action Alternative – No impact to cultural resources would be expected.

Impacts of the Recommended Plan – Preliminary surface reconnaissance and limited deep site testing within the study area indicate that the project would likely have no impacts to historic properties. There would be no permanent indirect effects to proximal recorded historic properties. Additional cultural surveys will be conducted prior to construction to verify the preliminary information. If significant archaeological phenomena are identified, steps would be taken to avoid, minimize, or mitigate adverse effects. Section 106 coordination and cultural resources management plans will be developed in consultation with various partners, such as the Native American Groups, the Minnesota State Historic Preservation Office, the USFWS, and others.

4.9 Socioeconomic Setting

The study area is located within Scott County, MN. As of the 2010 U.S. Census, the population of Scott County was 129,928, and the Census expects the county to have grown to 145,827 by July 2017 (https://www.census.gov/quickfacts/scottcountyminnesota). The largest racial/ethnic groups are White (85.6 percent) followed by Black (4.5 percent) and Native American (1.1 percent). In 2014, the median household income of Scott County residents was $90,198; however, 5.5 percent of Scott County residents live in poverty.

Impacts of the No-Action Alternative – Minor long-term adverse effects to socioeconomic resources would be expected. Human use of the study area would likely continue to decline due to the degraded state of ecosystem resources. Low aquatic plant diversity would affect the number and diversity of waterfowl utilizing the area which would impact the number of hunters using the area.

Impacts of the Recommended Plan – The project would have no measurable impacts on community cohesion, property values, industrial growth, or privately owned farms. The increase in recreational use would likely increase community, regional, and business growth, and tax revenues. In the long-term, habitat improvement would increase wetland wildlife and aquatic plant diversity. This would, in turn, increase outdoor recreational opportunities including bird watching, hunting, and fishing. In the short-term, construction activities would likely disturb recreational activities, but would also create employment opportunities.

4.9.1 Recreation and Aesthetics

The natural character of this area within the Refuge contributes to its recreational and aesthetic desirability. Blue, Fisher and Rice Lakes are located in an area of the Refuge that is open to the public. Recreational activities include wildlife viewing, hiking, biking, cross-country skiing, shore fishing and hunting (waterfowl, deer and other upland game). Continental Grain Marsh is not open to the public.

Impacts of the No-Action Alternative – A long-term decline in recreation and aesthetics may occur due to the continued degraded state of habitat and wildlife populations resulting in minor adverse landscape changes. High water events also make the study area inaccessible which would limit the number of visitors to the study area each year.

Impacts of the Recommended Plan – Short-term impacts to the aesthetic resources would occur with construction equipment and soil disturbance. In the long-term, recreational and aesthetic resources would improve as a result of a more diverse aquatic plant community (emergent and submergent) and increased populations of waterfowl and waterbirds utilizing the area during fall migration.

4.10 Environmental Justice

An evaluation of environmental justice impacts is mandated by Executive Order (E.O.) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994). This E.O. directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse health or environmental effects of its programs, policies, and activities on minority and low-income populations.

For the Bass Ponds HREP, there are no communities in the study area that would be impacted by the project. Therefore, there are no concerns with environmental justice for either the No-Action Alternative or the Recommended Plan.

4.11 Greenhouse Gases

Carbon dioxide (CO_2) is the primary greenhouse gas emitted from human activities, chiefly through combustion of fossil fuels (EPA 2015). Greenhouse gases absorb reflected energy from the sun and warm Earth's atmosphere. Increases in greenhouse gases have resulted in measurable warming of the Earth's surfaces and ultimately changes to some ecosystems. Wetlands are able to reduce the amount of CO_2 in the atmosphere by sequestering the gas during photosynthesis and returning oxygen to the atmosphere as a byproduct.

Neither the No-Action Alternative nor the Recommended Plan would impact greenhouse gases.

4.12 Summary of Consequences

The Recommended Plan would result in positive long-term benefits to waterfowl and waterbirds and submergent and emergent aquatic vegetation in and around the Bass Ponds study area. No federally protected species would be negatively affected. Construction of the project would cause short-term adverse effects to water quality, air quality, aesthetics, wildlife habitat, and public use. However, long-term benefits to the study area would far outweigh the short-term impacts. No negative social or economic impacts would result from the project. Environmental consequences of the proposed action are discussed below and summarized in Table 7.

Table 7: Environmental Assessment Matrix for Proposed Project

Alternative	No Action							Recommended Plan (Alt 11)						
	BENEFICIAL[a]				ADVERSE[b]			BENEFICIAL[a]				ADVERSE[b]		
PARAMETER	+++	++	+	0	-	--	---	+++	++	+	0	-	--	---
A. SOCIAL EFFECTS														
1. Noise Levels				X								ST		
2. Aesthetic Values						X			X			ST		
3. Recreational Opportunities					X				X			ST		
4. Transportation				X							X			
5. Public Health and Safety				X							X			
6. Community Cohesion (Sense of Unity)				X							X			
7. Community Growth & Development				X							X			
8. Business and Home Relocations				X							X			
9. Existing/Potential Land Use				X							X			
10. Controversy				X							X			
B. ECONOMIC EFFECTS														
1. Property Values				X							X			
2. Tax Revenue				X							X			
3. Public Facilities and Services				X							X			
4. Regional Growth				X							X			
5. Employment				X						ST				
6. Business Activity				X							X			
7. Farmland/Food Supply				X							X			
8. Commercial Navigation				X							X			
9. Flooding Effects				X							X			
10. Energy Needs and Resources				X							X			
C. NATURAL RESOURCE EFFECTS														
1. Air Quality				X								ST		
2. Terrestrial Habitat						X					X	ST		
3. Wetlands						X			X			ST		
4. Aquatic Habitat						X			X			ST		
5. Habitat Diversity and Interspersion						X			X			ST		
6. Biological Productivity				X					X			ST		
7. Surface Water Quality				X					X			ST		
8. Water Supply				X							X			
9. Groundwater				X							X			
10. Soils				X								ST		
11. Threatened or Endangered Species				X							X			
D. CULTURAL RESOURCE EFFECTS														
1. Historic Architectural Values				X							TBD			
2. Pre- & Historic Archeological Values				X							TBD			

[a] Beneficial: '+++' = significant; '++' = substantial; '+' = minor. [b] Adverse: '---'= significant; '--' = substantial; '-' = minor. '0' = No effect. X = Long-term effects; ST = Short-term effects, TBD = to be determined.

5 CUMULATIVE EFFECTS

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present, and reasonably foreseeable actions. The actions evaluated for cumulative effects in this section include those associated with the No-Action Alternative and the Recommended Plan. Cumulative effects are studied to enable the public, decision–makers, and project proponents to consider the "big picture" effects of a project on the community and the environment. In a broad sense, all impacts on affected resources are probably cumulative; however, the role of the analyst is to narrow the focus of the cumulative effects analysis to important issues of national, regional, or local significance (CEQ 1997).

The Council on Environmental Quality (CEQ) issued a manual entitled "Considering Cumulative Effects Under the National Environmental Policy Act" (1997) which presents an 11-step process for addressing cumulative impact analysis. The cumulative effects analysis for the Bass Ponds HREP followed these 11 steps (Table 88).

Table 8: CEQ's Approach for Assessing Cumulative Effects

Component	Steps
Scoping	1. Identify resources
	2. Define the study area for each resource
	3. Define the time frame for analysis
	4. Identify other actions affecting the resource
Describing the Affected Environment	5. Characterize resource in terms of its response to change and capacity to withstand stress
	6. Characterize stresses in relation to thresholds
	7. Define baseline conditions
Determining the Environmental Consequences	8. Identify cause-and-effect relationships
	9. Determine magnitude and significance of cumulative effects
	10. Access the need for mitigation of significant cumulative effects
	11. Monitor and adapt management accordingly

An environmental evaluation in accordance with NEPA (42 U.S.C. § 4331) has been conducted for the No-Action Alternative and the Recommended Plan. To maintain brevity, the cumulative effects discussion does not include those parameters where the broad-scale impacts are negligible.

As specified by 33 C.F.R. § 320.4(a)-(r), the categories of impacts in Table 7 were reviewed and considered in arriving at the final determination. In accordance with USACE regulations (33 C.F.R. § 323.4(a)(2)), a Clean Water Act Section 404(b)(1) evaluation has been prepared and is included in Appendix B of this report. A FONSI is attached at the end of the report. If determined appropriate, the FONSI will be signed by the District Commander after the MVD Commander approves the Final Report.

The primary natural resources of the study area and its surroundings are described in Section 4 of this report. Additional descriptions of the ecological effects and benefits associated with the No-Action Alternative and the Recommended Plan can be found in Section 4 and Appendix D, *Habitat Evaluation Procedure*, of this report.

5.1 Programmatic Cumulative Effects

Table 9 shows the only two UMRR HREP projects previously constructed in the Minnesota River.

Table 9: Past, Existing, and Potential Future Ecological Restoration Projects in the Minnesota River

Project	Year Construction Completed/Proposed For Construction	Acres Affected (est)
Long Meadow Lake	2006	2340
Rice Lake	1998	807
Total		**3147**

5.2 Cumulative Effects to Wetlands

The Refuge contains many wetlands which range from wet meadows and calcareous fens to permanently flooded, mixed vegetation marshes. Water control structures have been installed on many of the Refuge's wetlands allowing water levels to be manipulated to improve wetland vegetation and productivity. Previous UMRR projects on the Refuge include Long Meadow Lake and Rice Lake. The Long Meadow Lake HREP included the installation of a water control structure which enhanced vegetation in a 1,500 acre wetland. The project also restored 45 acres of farm field to floodplain forest. The Rice Lake HREP water control structure was installed for the purpose of enhancing 288 acres of wetland. The project also included the restoration of a 40-acre farm field to bottomland hardwood forest. Overall, both previous UMRR projects restored over 1,800 acres of wetland

No-Action Alternative – The cumulative impact to wetlands in the area would be relatively minimal with the no-action alternative. The wetlands would likely remain in a degraded state within this area of the Refuge resulting in fewer waterfowl and waterbirds utilizing the area.

Recommended Plan – The Recommended Plan would enhance approximately 1,000 acres of wetland within the Refuge. By installing water control structures, water levels within the study area will be able to be managed long-term to off-set the negative impacts associated with observed increases in stream flows. Having high quality wetland habitat is beneficial for plant and animal communities, especially in a large, metropolitan area of the state.

6 RECOMMENDED PLAN

The results of the NEPA analysis, incremental cost analysis, P&G criteria evaluation, and habitat evaluation were all considered in the decision-making process along with other factors including physical features on the site, management objectives, critical needs of the region, and ecosystem needs. The Bass Ponds PDT concluded that the alternative plan that best meets the objectives is Alternative 11 (BFR5-M2). This alternative is cost-effective and justified as a "Best Buy" plan.

Alternative 11 was identified by the PDT as the NER Plan and is the Recommended Plan, and is supported by the Project Sponsor, USFWS (Appendix A, *Correspondence & Coordination*). The plan would enhance a complex of three lakes and a marsh through six WLM structures and an earthen plug (Figure 14).

Construction, operation, maintenance, repairs, rehabilitation, and replacement considerations are discussed in this section. The project schedule and initial cost estimates are provided. The project has been developed to a detailed feasibility level of design. Further details will continue to be refined in the Plans & Specifications (P&S) Stage.

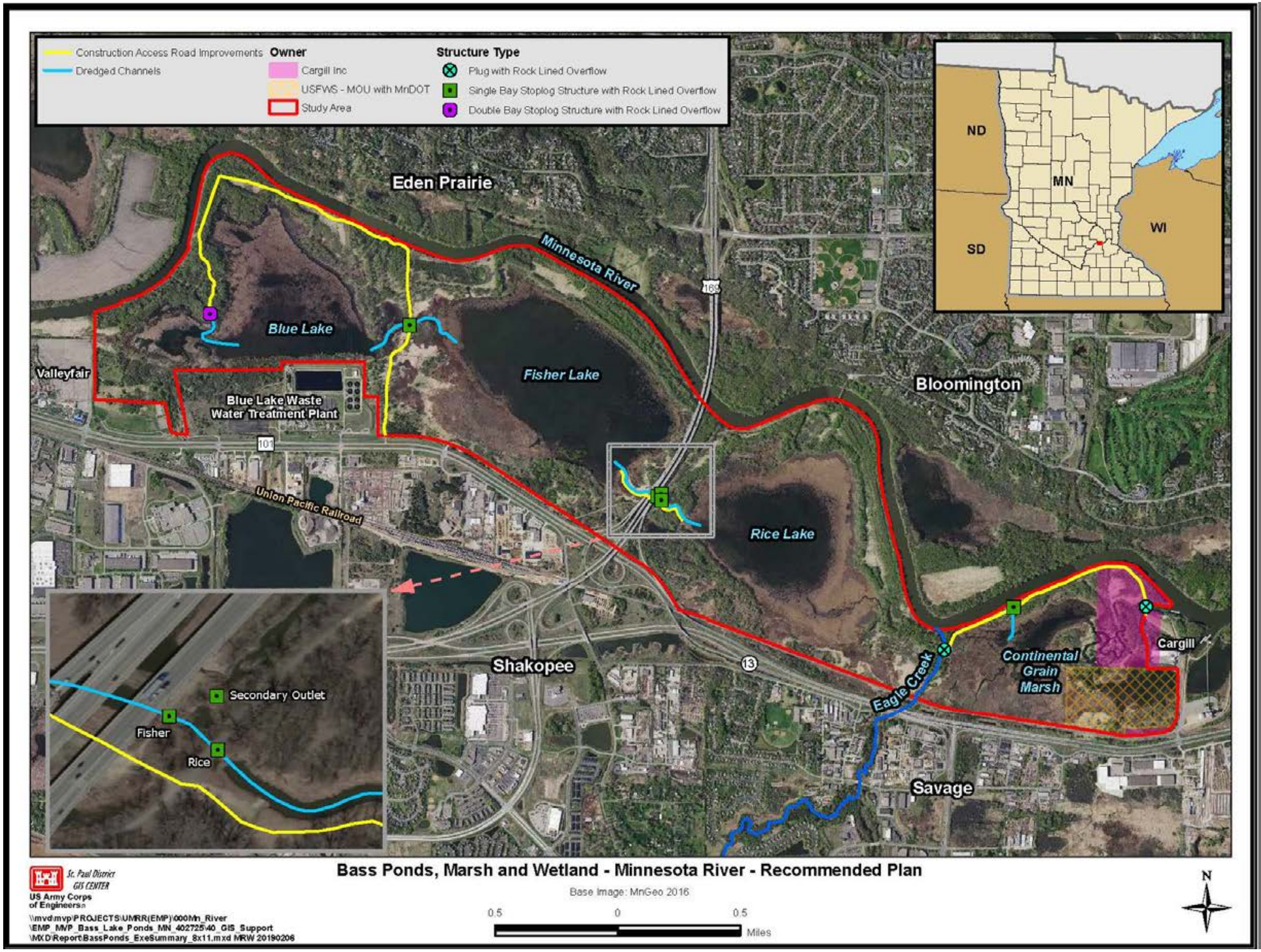


Figure 14: Bass Ponds HREP Recommended Plan

6.1 Plan Features

Each of the proposed project features are related to WLM and contribute to meeting all three of the study objectives (increasing diversity of emergent and submergent aquatic plant species and providing habitat for waterbirds and waterfowl) and are described in Table 1010.

Table 10: Summary of Main Project Features

Features	Description
Stoplog Structures - 1 Double Bay (Blue Lake) - 5 Single Bay (All other sites)	The stoplog structures improve habitat conditions by providing the ability and capacity to drawdown all three lakes and marsh, as well as fill Fisher and Rice Lakes from upstream sources. The structures consist of 5 feet wide by 6 feet high concrete bays with road crossings overtop.
Rock-lined Overflow Structure	The rock-lined overflow feature would be built around the stoplog structures and the western ditch plug. During high-flows, water would pass through the overflow channel first, preventing scour/damage to the structure itself.
Ditch Plug - 2 (Continental Grain Marsh)	Ditch plugs will be constructed of compacted soil and armored by engineered rock at two locations in Continental Grain Marsh: at the eroded channel on the west side, and at the culvert on the east side.
Access Dredging	Access dredging up- and downstream of the stoplog structures would improve hydraulic conveyance to and from the structures to provide control of water elevations between the lakes and marsh. Dredged soil will be hauled to the adjacent landfill.
Construction Access Roads	Construction access roads would provide improved, maintainable access to the stoplog structures and ditch plug. Roads would be excavated and constructed to existing topography.

USACE has constructed many water level improvement structures to improve habitat on the Upper Mississippi over the past few decades. Many of the features and recommendations have been denoted in the *Upper Mississippi River Restoration Program - Environmental Design Handbook, December 2012*. This document was used to ensure structure dimensions and design criteria were in general agreement with currently accepted design characteristics. Figure 15 is an aerial image taken in Pool 7 that shows a stoplog structure with a rock-lined overflow constructed by the USACE as part of a habitat improvement project.

The proposed rock-lined overflows for the Bass Ponds HREP would be similar. See Appendix I, *Civil Drawings,* for details.

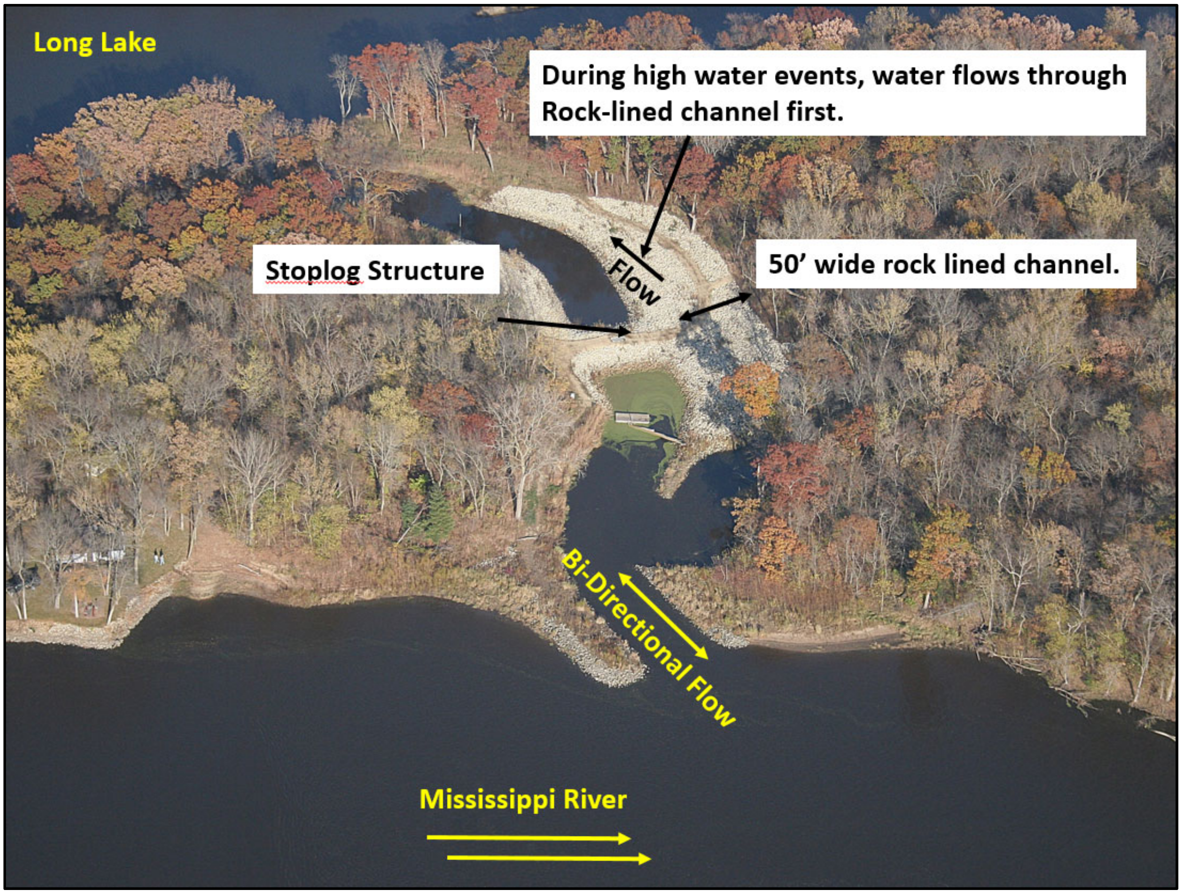


Figure 15: Example of Rock-lined Channel Constructed by USACE for the Long Lake Project

6.2 Design Considerations

The Project has been developed to a feasibility level of design (Table 1111, Table 1312). Design details are included in Appendix I, *Civil Drawings* and Appendix J, *Structural Engineering*. As with all feasibility level studies, these details will be refined in the Plans and Specifications (P&S) Stage.

6.2.1 Control Structures

The control structures would improve habitat conditions by providing the ability to raise, lower and/or maintain the Blue, Fisher and Rice Lake water levels. Analysis indicated that it would be more feasible to replace the existing metal structures with rectangular concrete stop log structures. Hydraulic analysis indicated that one rectangular culvert would suffice to meet requirements to allow floodwaters out of the lakes in a timely manner. The structure at Blue Lake was designed as a double-bay largely due to the high O&M at this location. The structures were designed as a 5-foot wide by 6-foot tall concrete box culvert with aluminum stoplogs (Appendix J, *Structural Engineering*). Setting the control structure invert elevation 693.00 feet (NAVD 88) would allow for opportunities to better manage water levels in the three lakes.

The marsh will also have a control structure constructed to provide the ability to raise, lower and/or maintain the Continental Grain Marsh water levels. This control structure will be located at an existing swale/crossing (Figure 14). Hydraulic analysis indicated that one rectangular culvert would suffice to meet requirements to allow floodwaters out of the marsh in a timely manner. Setting the control structure invert elevation 693.00 feet (NAVD 88) would allow for opportunities to better manage water levels in the marsh (Table 1111).

Table 11: Top and Bottom Elevations (in feet) of Stoplog Structures in the Recommended Plan (NAVD 88)

Structure Location	From	To	Top Elevation	Bottom Elevation	Invert Elevation
Blue Lake	Blue Lake	Minnesota River	700.00	691.75	693.00
Interlake	Blue Lake	Fisher Lake	702.00	691.75	693.00
Fisher lake	Fisher lake	Channel	701.00	691.75	693.00
Rice Lake	Rice Lake	Channel	704.60	691.75	693.00
Secondary Outlet	Channel	Minnesota River	701.00	691.75	693.00
Con Grain Marsh	Con Grain Marsh	Minnesota River	701.50	691.75	693.00

6.2.2 Channel Dredging

To permit the drawdown of the lakes, channel dredging would extend from the control structure to a low point of each lake/marsh. The channel will be dredged on the upstream sides of the structures with the exception of the Interlake structure. The Interlake structure will be dredged on both the upstream and downstream sides. The channel would have a 10-foot bottom width, with 1V:4H side slopes. The channel would be excavated to a depth of 692.5 feet (NAVD 88). The dredge locations and approximate lengths of the dredged channels are listed in Table 1212. No dredging is needed on the downstream sides of the Blue and Secondary structure due to the sufficient existing channel depth of 692.5 feet or lower.

Dredged soil will be hauled to the adjacent Burnsville Landfill which is less than 2 miles east of the study area. Beneficial reuse was not pursued as the material in these channels is very soft and saturated which would not meet the requirements for suitable backfill for the structures. Other measures where this material could have been used (e.g., islands, floodplain forest) were screened out earlier in the formulation process (Section 3.3). Furthermore, due to the urban location, the material may contain contaminates which would limit reuse; soil samples will be tested for contamination to determine placement within the landfill.

Future channel dredging is not anticipated and was not included in project costs (see Section 6.5 OMRR&R for additional discussion).

Table 12: Recommended Plan: Channel Dredging

Location	Dredge Location	Dredged Channel Length (ft.)
Blue	Upstream	662
Interlake	Upstream and Downstream	2240
Fisher	Upstream	1374
Rice	Upstream	1184
Continental Grain	Upstream	717

6.2.3 Ditch Plug

Ditch plugs will be constructed of compacted soil and armored by engineered rock at two locations in Continental Grain Marsh; the eroded channel on the west side and the culvert at the road crossing on the east side. The top of the ditch plug will be set at 700.5 feet which makes the plug flush with the existing adjacent land. The side slopes for the ditch plug are 1V:4H on the upstream and downstream sides, respectively.

6.2.4 Rock-lined Overflow Structures

The rock-lined overflow feature would be built around each stoplog structure and the western ditch plug in Continental Grain Marsh. During high-flows, water would pass through the overflow channel first, minimizing the chance of scour/damage to the structure itself. The overflow channels will be approximately 50 feet wide with 24 inches of R80 riprap. The size and depth of the rock was determined using the potential average velocities over the rock overflow channel.

6.2.5 Construction Access Roads

Construction access roads would provide improved, maintainable access to the WLM structures and ditch plug (Figure 14). Roads would be graded so that drainage occurs with minimal encroachment in the floodway and would be excavated and constructed to existing topography. This would be done by excavating approximately 12 inches of material to be replaced with aggregate. The excavation depth may be reduced after soil borings are completed. The approximate length of construction access road improvements throughout the study area is 18,500 feet.

6.3 Design Quantities

Design quantities are based on topographical and bathymetry surveys performed by USACE in June, 2018. The surveys were performed for the study areas near Blue Lake, Fisher Lake, Rice Lake, and Continental Grain Marsh. Vertical Datum for the surveys is NAVD 88 and Horizontal Datum is NAD 83-MN SPCS-South Zone, U.S. Survey Feet). Estimated quantities for the Recommended Plan are summarized in Table 13.

Table 13: Estimated Quantities (cubic yards) and Footprints (acres) of Material for the Recommended Plan

Feature Type	Location	Feature Name	Fill Quantity (yd^3)	Dredged Quantity (wet) (yd^3)	Top Elevation (msl ft)
Channel Dredging	Blue Lake	BD	N/A	810	N/A
Water Level Control Structure	Blue Lake	WLC-B	N/A	N/A	699.0
Access Road	Blue Lake	AR-B	6,240	N/A	VARIES
Channel Dredging	Fisher Lake	FD	N/A	2,745	N/A
Water Level Control Structure	Fisher Lake	WLC-F	N/A	N/A	699.0
Access Road	Fisher Lake	AR-F	650	N/A	VARIES
Channel Dredging	Rice Lake	RD	N/A	1,545	N/A
Water Level Control Structure	Rice Lake	WLC-R	N/A	N/A	699.0
Access Road	Rice Lake	AR-R	650	N/A	VARIES
Channel Dredging	Interlake	ID	N/A	3,808	N/A
Water Level Control Structure	Interlake	WLC-I	N/A	N/A	699.0
Access Road	Interlake	AR-I	1,560	N/A	VARIES
Channel Dredging	Con Grain Marsh	CD	N/A	1,094	N/A
Water Level Control Structure	Con Grain Marsh	WLC-C	N/A	N/A	699.0
Ditch Plug	Con Grain Marsh	DP-C	937	N/A	700.5
Access Road	Con Grain Marsh	AR-C	3,640	N/A	VARIES
Total			**13,677**	**10,002**	

6.4 Construction Implementation

How structures are constructed is generally left to the discretion of the contractor. The contractor is responsible for providing the finished product (the structures as designed) in a manner best suited to their operation, and without causing environmental damage.

The contractor would be allowed to use available technologies, so long as they are able to meet all the other conditions, including any necessary State permits and/or water quality certifications.

Rock and fill material utilized for the rock-lined overflows can be trucked to the sites.

Generally, a balance must be struck to provide reasonable access for the construction while minimizing the environmental disturbances associated with the dredging and construction. Contractors are allowed to request alternate access routes. These requests would be evaluated on a case-by-case basis for approval and may require additional environmental review.

6.4.1 Construction Restrictions

Construction restrictions could be applied for any number of reasons. Restrictions are generally applied in the construction of habitat projects to minimize the adverse effects of construction and to protect valuable habitats. The following are the basic construction restrictions that would likely be applied in the construction of the project features.

Access Dredging – Preliminary analysis has indicated that access dredging to the Interlake Structure is limited to only the east side due to a 12” natural gas pipeline. Access dredging would be stay outside of the 80 foot right of way to avoid the pipeline.

Bald Eagles – In general, project activities will not be allowed within 660 feet of an active bald eagle nest during the nesting season. If construction activities would involve loud noises, a ½ mile buffer zone would be required during this period.

Fish – No work can be conducted in wetlands where fish may occur between April 1 and June 30.

Non-game wildlife exclusion (reptiles and amphibians, including Blanding’s turtle) – If a drawdown is needed for construction, it must be completed prior to October 1.

Northern long-eared bat – No tree clearing can take place between late May and late July.

Drawdowns – At least one lake must contain water as a sanctuary for migratory birds and wildlife during project construction.

6.4.2 Construction Schedule

The length of the schedule was determined to allow the contractor to construct during low water conditions and/or winter construction starting in 2019/2020. The project duration is assumed to be two years to complete the construction.

6.4.3 Environmental Compliance and Permitting

This document will be distributed for public review and comment in compliance with NEPA. Scott County, the Responsible Governmental Unit, will concurrently ensure compliance with the Minnesota Environmental Protection Act. This will be accomplished by distributing the report for review as an EA Worksheet.

- An application for a Public Waters Work Permit from the MNDNR will be submitted. USFWS will issue a Special Use Permit for the construction work.

- The MPCA is the administering agency for Section 401 water quality certification in the State of Minnesota. MPCA issued a Clean Water Act Section 401 water quality certification waiver on March 5, 2019. A copy of the waiver can be found in Appendix B, *Clean Water Act*.

- The St. Paul District has determined that the proposed activity is in compliance with all environmental laws and regulations, including the Endangered Species Act, Clean Water Act, NEPA, and Bald and Golden Eagle Protection Act.

6.5 Operation, Maintenance, Repair, Rehabilitation, and Replacement

The estimated annual maintenance costs are $18,200 annually (see Section 6.6). Repair, rehabilitation, and replacement considerations may extend outside the 50-year period of analysis. The USFWS is expected to operate and maintain the project per the terms outlined in the Memorandum of Agreement (Appendix N).

Upon completion of construction, the USFWS would accept responsibility for the project in accordance with Section 107(b) of the WRDA of 1992, Pub. L. 102-580, 33 U.S.C. § 652(e)(7)(A). The operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) responsibilities of the USFWS will be addressed in the proposed Memorandum of Agreement for the project (Appendix N).

The purpose of assigning OMRR&R costs is to ensure commitment and accountability by the project sponsor. The project features require regular attention in order to manage water levels. The present value and estimated average annual OMRR&R costs for USFWS are estimated to be $18,200 annually. USFWS would be responsible for 100 percent of the operation and maintenance of the project features.

Operation and maintenance would be similar to that undertaken by the Refuge for day-to-day management of wildlife areas and other public use areas. The maintenance actions anticipated would be wildlife management activities such as inspections, monitoring water levels, cleaning structures, maintaining riprap, maintaining roads, and management of stoplogs. The Refuge may need to coordinate proposed maintenance activities with nearby stakeholders such as the MnDOT and the Blue Lake WWTP.

Future channel dredging is not anticipated to be necessary. Sediment deposition estimates range from 0.07 - 0.55 inches/year with an average value of 0.33 inches/year. Using the conservative deposition rate of 0.55 inches/year, a 50-year project life results in approximately 28 inches. Dredged channels post-deposition elevations would then increase to 694.8 feet (initially designed at 692.5 feet). This elevation is less than the full drawdown elevations (695-696.2) which do not result in impeding flow through culverts.

6.6 Project Cost Summary

After a Tentatively Selected Plan (TSP) was identified using preliminary costs, a more detailed cost estimate was completed for the final Recommended Plan. The detailed estimate of the project design and construction costs is provided in Appendix G, *Cost Estimat*e; however due to the sensitivity of providing this detailed cost information which could bias construction contract bidding, this material will be omitted in the public document. Quantities and costs may vary during final design.

Table 14 14 shows the estimated cost by account. The costs are expressed as Project First Costs and include construction, contingencies, engineering, planning, design, and construction management. The Project First Costs are the project costs at the effective price level of October 2018.

Table 14: Recommended Plan Project First Cost ($000)

Account	Item	Cost ($)	Contingency (%)	Contingency ($)	Project First Cost ($)
1	LERRDs	$61	25	$15	$76
2	Relocations (Utilities)	$40	25	$10	$50
6	Construction	$3,257	31	$994	$4,251
30	Planning, Engineering, and Design	$695	31	$212	$907
30	Adaptive Mgmt and Monitoring	$98	31	$30	$128
31	Construction Mgmt	$407	31	$124	$531
	Total	**$4,558**	**30**	**$1,385**	**$5,943**

*Numbers have been rounded to nearest thousand; Totals may not add due to rounding.

A cost summary is included in Table 1515. Annual O&M costs are estimated at $18,200 per year. Annual O&M costs for the WLM structures include adjusting stoplogs, debris removal, and maintenance.

A more refined cost estimate will be done on the final Recommended Plan using the Micro-Computer Aided Cost Estimating System), and Total Project Cost System to determine Present Value costs.

Table 15: Cost Summary for Recommended Plan

Item	Cost
Total Project First Cost	$5,943,000
IDC (2 year construction)	$171,500
Total Project Cost	$6,114,000
Average Annual Project Cost	$232,000
Annual O&M	$18,200
Total Average Annual Cost	$250,200
AAHU Gain	255
Total AA Cost / AAHU	$981

6.7 Real Estate Considerations

The land surrounding Blue, Fisher, and Rice Lakes is owned by the sponsor, USFWS (see Figure 2). The east end of Continental Grain Marsh is owned by Cargill. Although all project features will be constructed on Refuge lands owned by USFWS, a perpetual road easement will be required from Cargill in order to access the Continental Grain Marsh for construction and future maintenance (Appendix H, *Real Estate Plan*).

The Recommended Plan also accounts for the potential relocation of a fiber optic cable located at the proposed Fisher Lake outlet structure.

The exact staging area for construction will be determined during development of plans and specifications.

6.8 Project Performance (Monitoring and Adaptive Management)

The project performance assessment will allow measurement of differences from baseline conditions for key biological factors. This should allow a quantitative determination of improvement and assessment of whether features are functioning as intended. Adaptive management allows for the modification of drawdowns regimes, vegetation management features and/or documentation of the lessons learned when the functionality of the project is determined insufficient. Monitoring and adaptive management may extend for up to ten years following project completion and will be 100% federally funded. Monitoring activities to evaluate each of the projects goals and objectives are described in Appendix K, *Monitoring and Adaptive Management*, along with any documentation or adjustments required for underperforming features through adaptive management.

USACE will be responsible for determining ecological success for the ecosystem restoration projects it constructs, and will draft the final performance evaluation report (PER). USACE will also be responsible for vegetation monitoring and data analysis.

USFWS will be responsible for periodically inspecting the project features and documenting the inspection findings. USFWS will be responsible for bird monitoring and data analysis, and will provide USACE with a write-up of the bird monitoring methods and results for incorporation into the PER.

7 PLAN IMPLEMENTATION

The schedule for the feasibility study is documented in Table . After the feasibility report is approved, and an MOA is executed with USFWS, the PDT will initiate Plans & Specifications. The Preconstruction Engineering and Design phase is pending funding and will include refinements to the design of the Recommended Plan. This schedule assumes that funds will be available when needed to prepare plans and specifications and undertake construction.

Project construction would be completed in 2 years and commence in the winter of 2019/2020.

Table 16: Estimated Project Schedule

Requirement	Scheduled Date
Submit draft Feasibility Report and EA to MVD, USACE	January 2019
Submit final Feasibility Report and EA to MVD, USACE	April 2019
Obtain construction approval by MVD, USACE	May 2019
Begin Plans and Specifications	May 2019
Complete Plans and Specifications	August 2019
Advertise for Bids	August 2019
Award Contract (FY19)	September 2019
Begin Construction	December 2019
Complete Construction	Winter 2021
Complete Adaptive Management and Monitoring (10 years)	2031

8 SUMMARY OF ENVIRONMENTAL COMPLIANCE AND PUBLIC INVOLVEMENT

The planning for the Bass Ponds HREP has been an interagency effort involving the St. Paul District, the USFWS, and the MNDNR. Interagency meetings and site visits were held on a periodic basis throughout the study. In addition to the meetings, information and coordination took place on an as-needed basis to address specific problems, issues, and ideas.

The draft Feasibility Report and EA was sent to congressional interests, Federal, state, and local agencies; Native American groups; special interest groups; interested citizens; and others listed in Appendix A, *Correspondence and Coordination*.

8.1 Environmental Laws and Regulations.

This document is an integrated environmental assessment with a Clean Water Act Section 404(b)(1) Evaluation. MPCA issued a Section 401 water quality certification waiver on March 5, 2019. See Appendix B, *Clean Water Act Compliance*, for additional information.

A highlight of compliance with the major environmental laws and regulations follows and is summarized in Table 17.

USACE will need to obtain a Special Use Permit for construction activities from the Refuge. Discussions with permitting agencies have not indicated any major obstacles with the issuance of permits that would be critical for construction of the project at this time.

Archaeological and Historic Preservation Act: The St. Paul District contacted the Shakopee Mdewakanton Sioux community in Scott County as part of the planning process. The cultural resources director for the Shakopee Mdewakanton Sioux participated in a site visit to the study area 20 November 2018.

USACE also conducted two site visits of the study area in the fall of 2018 to conduct preliminary shovel testing. Cultural surveys, to include deep soil testing, will be conducted in 2019 before a compliance determination can be made regarding the project.

Bald and Golden Eagle Protection Act: The Bald and Golden Eagle Protection Act prohibits anyone from taking, possessing, or transporting an eagle, or the parts, nests, or eggs of such birds without prior authorization. Disturbing an eagle to a degree that causes, or is likely to cause injury to an eagle, decrease productivity, or cause nest abandonment are considered forms of take. Activities that directly or indirectly lead to take are prohibited without a permit.

Two active bald eagle nests are located in the study area. The nest closest to project features is located adjacent to the proposed Fisher Lake structure. The USFWS recommends maintaining a buffer of at least 660 feet between project activities and active eagle nests. However, the location of access dredging through the Fisher Lake outlet is within the 660 feet of a nest. Alternate routes over 660 feet from the nest are not practicable. Construction in this area will be scheduled outside of the nesting timeframe (nesting typically occurs between February 1 – July 15). Assistance from USFWS staff would be used to monitor eagle behavior at this nest during construction activities.

Clean Water Act: The Clean Water Act (CWA; 33 USC §1251 *et seq.*) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the United States and is administered by USACE. A Section 404(b)(1) Evaluation has been prepared for the project and is available in Appendix B, *Clean Water Act Compliance*.

Section 401 water quality certification is required for actions that may result in a discharge of a pollutant into waters of the United States to ensure that the discharge complies with applicable water quality standards. MPCA issued a Section 401 water quality certification waiver which can be found in Appendix B, *Clean Water Act Compliance*.

Endangered Species Act: There are two federally-listed species that are believed or known to occur within the study area, (see Section 4.5.1). A no effect determination was made for the RPBB and a may affect, not likely to adversely affect determination was made for the NLEB.

USACE implemented the USFWS Section 4(d) Rule streamline consultation process for NLEB. FWS did not respond within 30 days, therefore no further consultation is required.

Fish and Wildlife Coordination Act: In compliance with the Fish and Wildlife Coordination Act, project plans have been coordinated with the USFWS and the MNDNR.

National Environmental Policy Act (NEPA): This document has integrated the content required of a NEPA environmental compliance document. A range of alternatives have been presented and the significance of the projects impacts have been evaluated. The document will be distributed to agencies, the public, and other interested parties to gather any comments or concerns. If no substantial effects to the environment are found during the comment period or moving forward with the project design, a FONSI will be signed by the St. Paul District Commander.

Table 17: Compliance Review With All Applicable Environmental Regulations and Guidelines

Environmental Requirement	**Compliance[1]**
Federal Statutes	
Archaeological and Historic Preservation Act	TBD
Bald and Golden Eagle Protection Act of 1940, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act, as amended	Full
Coastal Zone Management Act, as amended	N/A
Endangered Species Act of 1973, as amended	Full
Federal Water Project Recreation Act, as amended	Full
Fish and Wildlife Coordination Act, as amended	Full
Land and Water Conservation Fund Act of 1965, as amended	Full
Migratory Bird Treaty Act of 1918, as amended	Full
National Environmental Policy Act of 1969, as amended	Full
National Historic Preservation Act of 1966, as amended	TBD
National Wildlife Refuge Administration Act of 1966	Full
Noise Pollution and Abatement Act of 1972	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic Rivers Act of 1968, as amended	N/A
Farmland Protection Policy Act of 1981	N/A
Executive Orders, Memoranda	
Floodplain Management (E.O. 11988)	Full
Safeguarding the Nation from the Impacts of Invasive Species (E.O. 13112)	Full
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full
Protection and Enhancement of the Cultural Environment (E.O. 11593)	Full
Protection of Wetlands (E.O. 11990)	Full
Analysis of Impacts on Prime and Unique Farmland (CEQ Memorandum, 30 Aug 1976)	Full
Environmental Justice (E.O. 12898)	Full

[1] The compliance categories used in this table were assigned according to the following definitions:
a. Full - All requirements of the statute, E.O., or other policy and related regulations have been met for the current stage of planning.
b. Partial - Some requirements of the statute, E.O., or other policy and related regulations remain to be met for the current stage of planning.
c. Noncompliance (NC) - Violation of a requirement of the statute, E.O., or other policy and related regulations.
d. Not Applicable (N/A) - Statute, E.O., or other policy and related regulations not applicable for the current stage of planning.
[2] 401 water quality certification required.
[3] Full compliance to be achieved with the District Engineer's signing of the Finding of No Significant Impact.

8.2 Coordination, Public Views, and Comments

USACE distributed a Communication Flyer to potentially interested stakeholders and agencies in the summer of 2018 regarding the beginning of a feasibility study in the area (a copy can be viewed in Appendix A, *Correspondence and Coordination*).

The USFWS, the project sponsor, supports the Recommended Plan. Letters of support for the project can be found in Appendix A, *Correspondence and Coordination*.

USACE released the draft feasibility report and integrated environmental assessment for the project for public review in February 2019. Overall, no comments were received during the comment period that would impact plan selection; a summary is included in Appendix A, *Correspondence & Coordination*.

A public meeting was held in Bloomington, MN, at the Minnesota Valley National Wildlife Refuge Visitor on February 12, 2019 to present the TSP and field questions from the public. Three members of the public attended the meeting. No significant concerns with the project were raised at the meeting.

9 RECOMMENDATION

The Recommended Plan is Alternative 11, which includes one double bay stoplog structure (Blue Lake), five single bay stoplog structures (Interlake, Fisher Lake, Rice Lake, Secondary Outlet, and Continental Grain Marsh), a plug at Continental Grain Marsh, and access dredging and construction road improvements to each structure.

Because the project is located on national wildlife refuge lands, project costs would be 100-percent Federal in accordance with Section 906(e) of the WRDA of 1986, Pub. L. 99-662, 33 U.S.C. § 2283(e). The estimated project first cost at current price levels is $5,943,000 (including sunk general design costs). Upon completion, the USFWS would be responsible for OMRR&R at an estimated annual cost of $18,200. The Recommended Plan also includes monitoring and adaptive management, which could total up to $128,000, for which USACE would be responsible. Total average annual project costs amount to $250,000.

The expected outputs of the Recommended Plan include the enhancement of 2,000 acres of lake and wetland habitat. The Recommended Plan will contribute 255 average annual habitat units for fish and wildlife over the 50-year period of analysis to the National Environmental Quality Account at an average annual cost of $981 per average annual habitat unit.

I have weighed the accomplishments to be obtained from the Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project against the cost and have considered the alternatives, impacts, and scope of the proposed project. Therefore, I recommend that the Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project for habitat restoration and enhancement in the Minnesota Valley National Wildlife Refuge be approved for construction.

The recommendations contained herein reflect the information available at this time and current department policies governing formulation of individual projects under the continuing authorities UMRR Program. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works continuing authorities program nor the perspective of higher review levels within the Executive Branch.

Samuel L. Calkins
Colonel, Corps of Engineers
District Commander

10 FINDING OF NO SIGNIFICANT IMPACT

Regional Planning and

Environment Division North

FINDING OF NO SIGNIFICANT IMPACT

In accordance with the National Environmental Policy Act, Endangered Species Act, Clean Water Act, National Historic Preservation Act, Executive Orders, and other environmental laws and regulations, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following project.

BASS PONDS, MARSH, AND WETLAND HABITAT REHABILITATION AND ENHANCEMENT PROJECT

MINNESOTA RIVER, MINNESOTA

Congress authorized the UMRR Program in Section 1103 of the WRDA of 1986, as amended in the WRDA of 1999 (Public Law 106-53), 33 U.S.C. § 652, for planning, construction, and evaluation of fish and wildlife HREPs.

The Bass Ponds, Marsh, and Wetland HREP evaluated 45 alternatives in detail, including the No-Action Alternative, to find a cost effective plan that best met the project goals and objectives. The proposed project alternative, at a first cost of approximately $5,943,000, includes the construction of 6 WLM structures, associated rock-lined overflow channels, 1 earthen ditch plug, access dredging, and access road improvements to the structures. This plan would improve submergent and emergent aquatic vegetation on approximately 1,000 acres of aquatic and wetland habitat, and improve habitat for migratory waterbirds and waterfowl.

An integrated Feasibility Report and EA and 404(b)1 Evaluation was prepared and sent out for agency and public review. A public meeting will also be held to solicit input. No major issues are expected.

This FONSI is based on the following factors: the proposed project would have long-term beneficial impacts on the aquatic and wetland environment, as well as recreational opportunities; short-term minor adverse impacts on the aquatic and terrestrial environment, recreation, noise, air, and water quality during construction; minor beneficial impacts to the economic and social environment; and may affect the federally listed northern long-earned bat, but will not result in prohibited take.

The environmental review process indicated that the proposed action does not constitute a major Federal action significantly affecting the quality of the human environment. Therefore, an environmental impact statement will not be prepared.

11 June 2019

Date

SAMUEL L. CALKINS
Colonel, Corps of Engineers
District Commander

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US Army Corps of Engineers ®
St. Paul District

Appendix A: Correspondence & Coordination

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix A: Correspondence & Coordination

TABLE OF CONTENTS

1 Factsheet 2

2 USFWS Priorities Submitted to USACE in 2017 8

3 Public Outreach 9
3.1 Communication Flyer 9
3.2 Public Meeting 10

4 Coordination with Native American Groups 22
4.1 Informal Notification 22
4.2 Formal Consultation Letter 22

5 Letter of Support from the Sponsor 26

1 Factsheet

7 September 2010

FACT SHEET

BASS PONDS, MARSH, & WETLAND HABITAT RESTORATION PROJECT
MINNESOTA VALLEY NATIONAL WILDLIFE REFUGE, MINNESOTA
ENVIRONMENTAL MANAGEMENT PROGRAM

LOCATION
Three areas located on the Minnesota Valley National Wildlife Refuge in urban floodplain areas near Bloomington, Minnesota, are included in the project area. The "**Bass Ponds**" floodplain marsh area is located in the Long Meadow Lake Unit at Minnesota River mile 7. It is bounded by Bloomington on the north and west and Lower Long Meadow Lake on the south and east. The "**Marsh**" area includes two lakes, Continental Grain Marsh and Fisher Lake at Minnesota River miles 17 to 18. It is bounded by the Minnesota River on the north and east, State Highway 13 on the south, and Blue Lake on the west. The "**Wetlands**" area is located in the Long Meadow Lake, Wilkie, and Bloomington Ferry Units at Minnesota River miles 5 to 11 and 14 to 21. It is bounded by Interstate 494 and Bloomington on the north and by the Minnesota River or State Highway 13 on the south.

EXISTING RESOURCES
Originally created for a private hatchery, the Bass Ponds consists of three small wetlands in the floodplain area of the Minnesota River (Minnow, Little Bass, and Big Bass). The wetlands once supported a variety of wetland dependent species such as dabbling ducks, wading birds and rails, in addition to a variety of emergent and submergent vegetation. These ponds are used for environmental education.

The Marsh area within the floodplain supports waterfowl and other wetland dependent species such as the bald eagle, great blue heron and white pelican. Water levels in these lakes are periodically drawn down through water control structures to promote the growth of emergent marsh vegetation such as cattail, bulrush and moist soil plants.

The Wetlands area of the floodplain is converted agriculture land now managed for wildlife and native plant communities, including bottomland hardwoods, wet meadow, permanent wetlands, and associated wildlife species.

PROBLEM IDENTIFICATION
In the Bass Ponds area, Minnow Pond has silted in due to drainage from an urban area. Prior to degradation, Minnow Pond functioned as a filter for a tremendous amount of silt from the bluff in a continuously running spring that flows through the complex, into Long Meadow Lake, and out to the Minnesota River. Siltation is preventing water from entering the Bass Ponds system. The Little and Big Bass Ponds control structures were old and failing when the Refuge was acquired in 1976, so provide very limited operational capability to manage water levels. Overall, the wetlands are degraded and provide little or no wildlife or water quality benefit.

In the Marsh area, the wetland habitat is declining in both lakes because of siltation from high flow conditions on the Minnesota River. As the wetland habitat is reduced, the area will be able to support less and less waterfowl and other wetland dependent species. At Continental Grain

1
USACE-MVP-0000123932

7 September 2010

Marsh, the riverward side of dike is eroding and the effectiveness of this important marsh area will be eliminated if the dike is breached. Efforts are currently underway to determine the main cause of dike erosion (groundwater movement or river flows). The marsh is also draining from the west side into a designated trout stream (Eagle Creek) and may be causing degradation of the stream.

In the Wetlands area, it is estimated that there were hundreds of small, temporary (ephemeral) wetlands along the Minnesota River between the natural levee and the toe of the bluffs before the floodplain area was settled and farmed. Due to farming in the floodplain and river deposition, most of the ephemeral wetlands which historically existed have been eliminated. These temporary wetlands provided habitat for a wide variety of wetland-dependent wildlife, including dabbling ducks, shorebirds and migratory song birds, as well as amphibians and invertebrates that are not typically found in permanent wetlands. They also improve water quality by slowing down runoff from the bluffs and filtering the water before it enters the Minnesota River.

PROJECT GOALS

Project goals are derived from the Environmental Pool Plans (EPPs), Pools 1 through 10. As described in the EPPs, the desired future for this area is to maintain an interspersion of high quality habitat. The project goals are as follow:

Maintain/protect/enhance/restore quality wetland habitat for all native and desirable plant, wildlife, and fish species.

- Protect, enhance, and restore 15 acres of wetland habitat. This will, in turn, protect the 1,500 acre Long Meadow Lake wetland complex
- Protect, enhance, and restore 569 acres of emergent marsh and riparian habitat (206 acres in Continental Grain Marsh and 363 acres in Fisher Lake)
- Protect, enhance, and restore 100 acres of ephemeral wetland habitat

These goals are consistent with identified needs in the Habitat Needs Assessment for impounded and isolated backwater habitat.

PROPOSED PROJECT

Proposed project actions in the Bass Ponds area include dredging Minnow Pond to remove silt and increase sediment trap capability, replacing existing water control structures on Big Bass Pond, Little Bass Pond and Minnow Pond, and installing a new water control structure between Big and Little Bass Pond on Minnow Pond Creek. The proposed project features are shown in Figure 1.

Proposed project actions for the Marsh area include rehabilitating the dike at the Continental Grain Marsh with riprap or widening the dike to keep it from breaching, reevaluating and adjusting the spillway elevation to keep water from draining into Eagle Creek and to provide more water management capability, rehabilitating the outlet control structure, and dredging channels in Continental Grain Marsh and Fisher Lake to remove silt and increase drawdown capabilities. The proposed project features are shown in Figures 2 and 3.

Proposed project actions in the Wetland area include surveying the floodplain to determine where wetlands could be restored or created, restoring or creating over 100 wetland areas

2

USACE-MVP-0000123932

7 September 2010

ranging in size from 0.1 to 5 acres, and wetland management. The proposed project features are shown in Figure 4.

The authority for this study and potential project construction is provided by Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662), as amended.

PROJECT OUTPUTS

The proposed project would result in the protection, enhancement, and restoration of almost 700 acres of year-round and temporary wetland habitat. It would also protect the 1,500-acre Long Meadow Lake from the effects of Minnesota River flows. Dredging would remove silt deposits and open watercourses. Replacing and building water control structures would provide for more water level management capabilities. Optimal habitat conditions could be provided for both long- and short-term wildlife residents.

IMPLEMENTATION CONSIDERATIONS

Material from project dredging and wetland excavations could be used for topography enhancements in the Bass Ponds, Continental Grain Marsh, and Wetland areas. Material from project dredging and from navigation channel maintenance activities could be used for the Continental Grain Marsh dike rehabilitation. Rehabilitating the Rice Lake dike should be performed prior to construction in the Marsh area. Surveys of the floodplain would be needed prior to construction of the ephemeral wetlands to determine the appropriate actions.

Constraints include construction restrictions in eagle nesting areas. Also, access to the Continental Grain Marsh outlet control structure is via private land and may require a special agreement to access the structure.

FINANCIAL DATA

The project would be located entirely on lands managed as a national wildlife refuge. Therefore, in accordance with Section 906(e) of the Water Resources Development Act of 1986, the project cost would be 100% Federal. The estimated cost for the planning, design, and construction in the Bass Ponds area is $500,000; in the Marsh area the estimated cost is $1,000,000; and in the Wetlands area the estimated cost is $500,000. Total project cost is estimated to be $2,000,000.

The project lands are managed by the U.S. Fish and Wildlife Service (USFWS). Therefore, in accordance with Section 107(b) of the Water Resources Development Act of 1992, all costs for operation, maintenance, and rehabilitation of project features would be the responsibility of the USFWS, including periodic dredging of material from the Minnow Pond sediment trap and other areas. These costs are estimated to be about $1,000 annually for each of the areas.

STATUS OF PROJECT

The Fish & Wildlife Workgroup, the River Resources Forum, and the System Ecological Team (SET) have endorsed this project.

Two other EMP habitat projects have been completed in the project area. The Rice Lake Habitat Rehabilitation and Enhancement Project was completed in 1998 and included excavating a

3

USACE-MVP-0000123932

7 September 2010

2,500-foot-long channel into Rice Lake and installing a stoplog water control structure in the channel to provide for water level management of the lake. The project optimizes aquatic vegetation growth in the lake for migratory waterfowl and other wildlife and has a water connection to the Fisher Lake area. The Long Meadow Lake Habitat Rehabilitation and Enhancement Project was completed in 2006 and included replacing and upgrading an outlet structure that controls both inflow to and outflow from the lake. This provides for water level management of the lake and keeps poor water quality water from the Minnesota River from entering the lake. The project allows optimum lake water levels to promote aquatic vegetation growth for migratory waterfowl and other wildlife. The Long Meadow Lake habitat project is located within the Ephemeral Wetlands Focus Area.

Partnering organizations include the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and the Minnesota Department of Natural Resources.

POINTS OF CONTACT
Jeff DeZellar, Corps of Engineers, St. Paul District, Project Manager, 651-290-5433
U.S. Fish and Wildlife Service – Sharonne Baylor, EMP Coordinator, 507-494-6207
Scot Johnson, Minnesota Department of Natural Resources, Habitat Project Coordinator, 651-345-5601

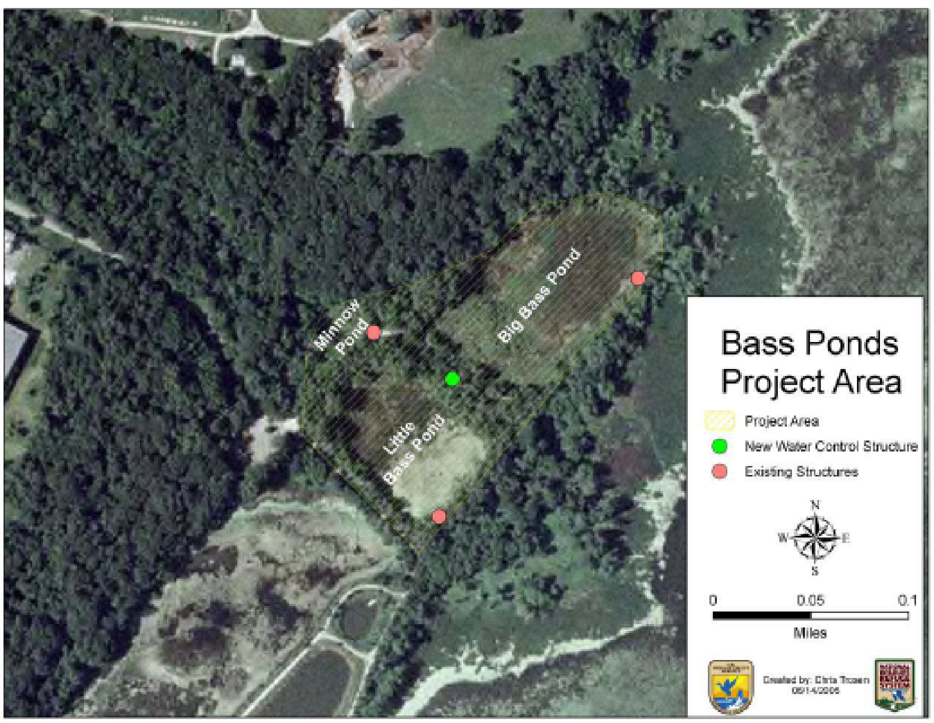

Figure 1 – Bass Ponds Project Area

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USACE-MVP-0000123932

7 September 2010

Figure 2 – Continental Grain Project Area

Figure 3 – Fisher Lake Project Area

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7 September 2010

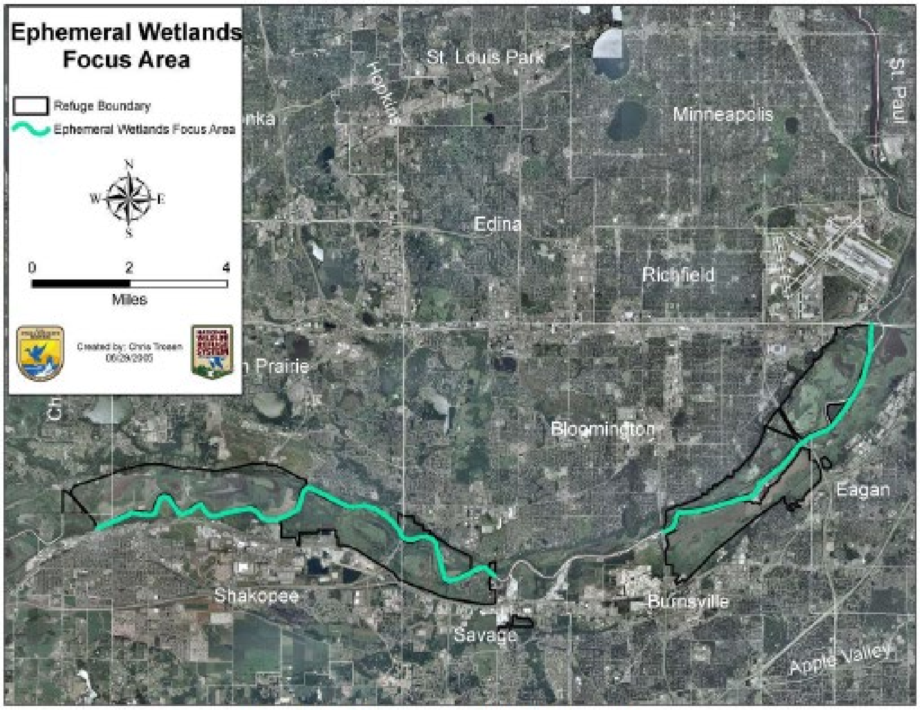

Figure 4 – Ephemeral Wetlands Focus Area

6
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2 USFWS Priorities Submitted to USACE in 2017

Minnesota Valley NWR Habitat Project Priorities

In response to a request to submit priority habitat projects on Minnesota Valley National Wildlife Refuge, our biological staff has met and reconsidered the HREP project previously approved. Portions of the "Bass Ponds, Marsh, and Wetland Habitat Restoration Project" HREP still apply, however, some conditions have changed since the initial submission and consequently the priorities.

Number 1 priority: In the "Marsh" project, Fisher Lake, at river miles 17 to 18 consists of 363 acres of valuable wetland habitat that has supported an abundance of waterfowl and other wetland dependent species. Management, including drawdown capability, was achieved with a water control structure and an intra-lake channel. Five years ago the structure and outlet culvert finally succumbed to the elements and has now deteriorated to the point that it is no longer viable. The lake has sat unmanaged in a full pool state, and habitat conditions have deteriorated. It had been one of the most valuable and manageable wetland resources on the Refuge. In order to manage the lake again a water control structure and newly dredged intra-lake channel is needed. In addition, the current degraded structure is under-sized and does not allow for a timely drawdown or the sediment-flushing benefits that would have kept the channel open. Note that this site is situated adjacent to a previous EMP project-Rice Lake HREP.

Number 2 priority: The other project area within the "Marsh" is Continental Grain Marsh, also at river miles 17 to 18. This 206 acre wetland was the site of a previous EMP project where the natural levee was restored, with a spillway, in order to protect the wetland from a breach. The same conditions apply as in the original HREP fact sheet. The levee has deteriorated and needs widening and/or riprapped; though it has stabilized, portions of the levee are down to just a few feet on top. The water control structure also needs rehabilitation or relocation. Drainage into Eagle Creek is less of a concern at this point and also seems to have stabilized.

Number 3 priority: In the "Bass Ponds" area, at river mile 7, priorities have changed. The main concern is a dike adjacent to this site that provides a holding pond area for runoff from the City of Bloomington. It helps to protect the water quality of the adjacent 1,500 acre Long Meadow Lake wetland complex; also the site of a completed EMP project. The dike is failing at the new control structure and approximately 150 feet will need to be replaced. The water control structures on the Little and Big Bass Pond wetlands, including culverts for a water supply, are still viable projects in order to provide environmental education. Running through the Bass Ponds area is a historic trout stream, Ike's Creek, that has been restored with thriving native trout. It is a priority to continue restoration in the lower creek area with a regrading of the streambed and establishment of plunge pools. Maintaining and managing the Bass Ponds on either side of the trout stream has become a higher priority since the restoration of the stream; as sediment from the urban watershed continues to threaten this resource.

While all three of these projects are top priority habitat projects for Minnesota Valley, Fisher Lake stands above the rest as one which will have significant wildlife benefits if management capabilities are once again restored. Years of biological monitoring has shown the benefits of active management with a water control structure and full-drawdown capability.

3 Public Outreach

3.1 Communication Flyer

A Communication Flyer was sent out in July 2018 to stakeholders, agencies, and neighboring industry. Following endorsement of the Tentatively Selected Plan, an updated flyer will be sent out.

Addressees:

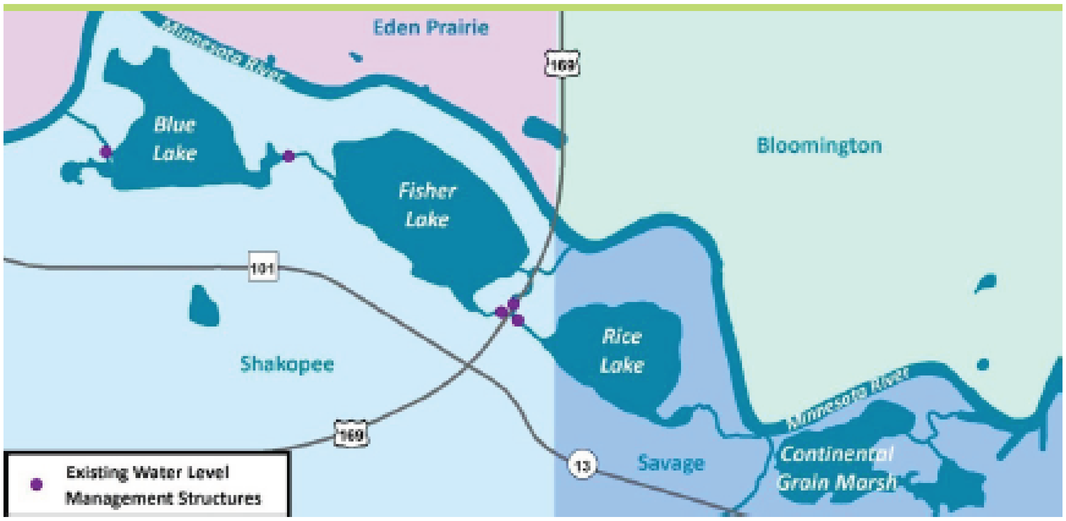
- XCEL Energy
- Scott County
- City of Savage
- Prior/Spring Lake Watershed District
- MN DNR- Parks and Trails, St. Paul
- City of Shakopee
- MN DNR, Shakopee
- Lower Minnesota River Watershed District
- Met Council
- Magellan Pipeline
- USFWS
- FAA
- Shakopee Mdewakanton Sioux Community
- Prairie Island Indian Community
- Lower Sioux Indian Community
- Upper Sioux Community
- Sisseton Wahpeton Oyate

US Army Corps of Engineers
St. Paul District

BASS PONDS, MARSH & WETLAND
HABITAT REHABILITATION & ENHANCEMENT PROJECT

Project Summary

The Army Corps of Engineers is studying the feasibility of constructing habitat enhancement features in the Bass Ponds, Marsh & Wetland area as part of the Corps of Engineers' Upper Mississippi River Restoration Program. The project would be located within the Minnesota Valley National Wildlife Refuge and is sponsored by the U.S. Fish and Wildlife Service (FWS). The study area is between Minnesota River miles 15 and 21.



775 ACRES | **3** LAKES | **1** MARSH

THE PROBLEM ► Changes in climate and land use have altered the hydrology of the study area. Currently the lakes, wetlands and marshes experience prolonged full pool conditions with depths of 3-to-4 feet throughout the year. The lack of seasonal variability in water levels has resulted in a degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity and the availability of quality habitat for migratory waterbirds and waterfowl.

CURRENT OBJECTIVES FOR HABITAT RESTORATION

1. Create quality feeding and resting habitat for waterfowl
2. Increase diversity and quantity of emergent plants
3. Increase diversity and quantity of submergent plants

Project Status

Potential project features under consideration include water level management measures such as water control structures, rock-lined channels, earthen plugs, and dredged channels. These features would improve the FWS's capacity to manage water levels within the lakes. With this project, the FWS would be able to conduct full or partial drawdowns periodically, exposing some or all of the lakebeds to stimulate the germination and growth of aquatic plants. Improving the density and diversity of aquatic plants within the waterbodies will benefit resident and migratory waterbirds and waterfowl throughout the warmer months by providing high quality habitat for nesting and brooding, and fall feeding and resting during the annual migration. The costs of the project would be 100 percent federal.

QUESTIONS OR FEEDBACK CONTACT: **Tom Novak**, Program Manager, Tom.Novak@usace.army.mil | **Kelli Phillips**, Project Manager, Kelli.A.Phillips@usace.army.mil

3.2 Public Meeting

A Public Meeting will be held at the USFWS Visitor Center, Bloomington, MN on February 12, 2019. Three members of the public attended and asked questions about the project. Members of the PDT gave a presentation on the selection of the Tentatively Selected Plan. Handouts included a Placemat (two-page summary with images of the project) and a Comment Card. No critical comments regarding the selected alternative were received.

3.3 Public Review and Comment Period

The report was released for 30 day public review from February 11 – March 15. During the review period, 1 comment was received from the public, copied below, which is in opposition to a water level management project.

Table 1: Summary of Comments Received During Public Review

Commenter	Comment summary	Response
EPA	Document clarification. EA did not include info on Factsheet locations or discussion. Revise EA to include zoomed-in maps for the Bass Ponds / Marsh / Wetland areas. Describe why narrowed to only Marsh projects.	The EA includes the entire Factsheet in Appendix A, as well as the locations of these areas and discussion. Zoomed-in maps of these locations are found in the Factsheet Figures. The Main Report summarizes the screening of the study area down to the "Marsh" location (Priority #1 and #2) in Section 3.3. Additional detail, including maps on the priority areas can be found in Appendix C – Plan Formulation. Additional text was added to Appendix C to clarify the connection between the original factsheet and the updated USFWS priorities.
	Revise EA to discuss wetland impacts and mitigation.	Text added to EA documenting impacts. The project will improve approximately 1,000 acres of wetland habitat within the project area. Improvement of this habitat will offset wetland loss, therefore no mitigation is proposed.
	Staging areas and access roads should be designed to avoid wetland impacts.	Planned access roads are improvements on existing roads to avoid undisturbed wetland areas. Because the roads already exist, very few trees will need to be cleared to accommodate construction equipment. Existing parking lots will be used for staging areas to avoid wetlands.
	Revise EA to include construction restrictions for NLEB and fish.	Text has been added.
	Reference updated National Climate Assessment	NCA 2014 reference added to the reference section. Evidence and information from the 2018 NCA added to the report and a referenced in the reference section.
	Update performance indicator 1 in Appendix K	Performance indicators were developed with USFWS in accordance with the Refuge's Habitat Management Plan.
	Beneficial reuse should be discussed in the EA	Text was added to Section 6.2.2 – Channel Dredging. Beneficial reuse was not pursued for a number of reasons:

		• Unknown if the dredged material is contaminated. There is some concern with material being located near the city and railroad that the dredged material may contain contaminates. Soil samples of the dredged material will be obtained and tested for contamination. • The dredged material will not meet requirements for suitable backfill for the structures. The dredged material is considered to be very soft and saturated which is not adequate fill to be used for backfill of the structures. • Other uses of the dredged material were considered (islands, berms, and upland forests) but were not feasible in the project area due to potential flood impacts. Any major elevation raise in the project area would have implication to flood levels which are not tolerable for the project.
	Add EPA Region 5 to coordination list	EPA Region 5 was added to the stakeholder list.
Kevin Schafer	Long-term project benefits, structure integrity	The current lake/marsh structures are not accomplishing the goals of USFWS. The current structures are non-functioning and do not allow the lakes to be drawn down when the river allows. The proposed structures as part of the Bass Ponds HREP will accomplish the USFWS goals. These structures are designed to manage the increased Minnesota River discharge found in the climate change analysis. The structures will be designed to manage the annual overtopping flows during spring snow melt and precipitation. The increased river discharges/events in the project area prove the need for these new robustly designed structures.

3.3.1 Public Comment – Email

-----Original Message-----
From: Kevin Schafer [mailto:kayshay8000@gmail.com]
Sent: Friday, March 8, 2019 10:10 PM
To: Khazrajafari, Shahin CIV USARMY CEMVP (USA) <Shahin.Khazrajafari@usace.army.mil>
Subject: [Non-DoD Source] Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project

Thank you for the opportunity to comment.

I just wanted to voice my general opposition to the proposed plan to manage water levels, in the proposed project area.

The use of millions of tax payer dollars, to attempt to modify a naturally existing floodplain, that is already doing it's intended job, feels wasteful to me. Paired with the millions in tax dollars being used to pave a segment of trail, on this same floodplain, seems shortsited both fiscally, and environmentally, and I am skeptical, that with the increased precipitation, the upper Midwest now sees as normal, that this project will actually have meaningful long term benefits for the area. Letting the river do it's job, as it has forever, in it's history, is the proper approach to maintaining harmony with the nature that surrounds it. I fear these small structures will fall into disrepair, due to the extremes of our local climate, and end up being yet another, tax payer funded project, sitting there, with poor long term vision to sustain them.

Sincerely,
Kevin Schafer
Richfield Minnesota.
612-827-2059

3.3.2 EPA Comment – Letter

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAR 0 8 2019

REPLY TO THE ATTENTION OF:

Shahin Khazrajafari
U.S. Army Corps of Engineers – St. Paul District
Regional Planning & Environmental Division North
180 Fifth Street East
St. Paul, Minnesota 55101

RE: EPA Comments: Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement – Detailed Project Report and Draft Environmental Assessment; Scott County, Minnesota

Dear Mr. Khazrajafari:

The U.S. Environmental Protection Agency has reviewed the U.S. Army Corps of Engineers' (USACE) Detailed Project Report and Environmental Assessment (hereafter: Draft EA) examining the feasibility of constructing habitat enhancement and water control features within the Minnesota Valley National Wildlife Refuge (NWR). The U.S. Fish and Wildlife Service (USFWS) is a cooperating agency and the federal project partner. Section 509 of Water Resources Development Act of 1999 provides USACE with the authority to plan, design, and construct Habitat Restoration and Enhancement Projects (HREP), such as the proposed project. This letter provides our comments on the Draft EA, pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA Implementing Regulations (40 CFR 1500-1508), and Section 309 of the Clean Air Act.

The study area is located in Scott County, Minnesota, southwest of St. Paul, adjacent to the Minnesota River (River) between River Miles (RM) 15 to 21. Located within the Minnesota Valley National Wildlife Refuge (NWR), the study area is approximately 2,085 acres in size. The USFWS manages the study area as part of the NWR, which extends from RM4 to RM35 and covers over 14,000 acres of river valley. Established in 1976, the Minnesota Valley NWR is one of the few NWRs located within a major metropolitan area. The proposed study area is mostly on Refuge land, with privately-owned (Cargill) and state-owned (Minnesota Department of Transportation (MnDOT)) parcels on the east end of the study area.

The study area includes three interconnected backwater lakes (Blue, Fisher, and Rice Lakes) and a wetland known as the Continental Grain Marsh. The waterbodies in the study area are all relatively shallow. When the Minnesota River is high, flows overtop the banks and completely inundate the study area. During low River flow, the backwater lakes are largely isolated from

Currently, the three lakes and the Continental Grain Marsh experience prolonged full pool conditions with depths of 3-to-4 feet throughout the year. Compounding the impacts from prolonged high water levels is the inability of water in the backwater lakes to recede even after the River recedes. The lack of seasonal variability in water levels has resulted in degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity, and the availability of quality habitat for migratory birds.

The primary impedance of flow between the connected systems within the study area is the worsening condition of the existing channels, culverts and water control structures between the backwater lakes and the Continental Grain Marsh. There are eight existing structures within the study area, seven of which are not expected to last for the 50-year period of analysis of the Draft EA. These structures are deteriorating, have high operation and maintenance costs, are undersized, and in some cases, are no longer functional. The desired new endpoint is providing water level management capabilities that increase the ability of land managers to draw floodwaters off the backwater lakes and increase the number of days of low water conditions (drawdown) during the growing season.

The objectives of the project are to increase the diversity and percent cover of desirable emergent and submergent aquatic plant species and to provide quality feeding and resting habitat for a wide variety of waterfowl and water birds. To successfully achieve the management objectives of the Refuge, the Refuge manager's goals are to be able to adjust water levels throughout the season (full, partial, optimal pool elevations), and when scheduled, to be able to drawdown water quickly (i.e., in less than 10 days). Another goal is to manage each backwater lake independently by storing and supplementing water from upstream to downstream sources, depending on conditions.

To meet these goals, an array of measures (both structural and non-structural) were initially considered. The measures retained in the Draft EA for further consideration (no action, stoplog structures, rock-lined channels, access dredging, plugs, and pump stations) were derived from the planning objectives to be the most complete, effective, efficient, and acceptable within the range of measures considered. In addition to studying the implications of implementing the No Action Alternative, USACE developed a final array of action alternatives from the measures carried forward. The hydrologic analysis of the study area was the most influential in the development of alternatives. Of the final four action alternatives considered to be cost effective ("Best Buys"), two were dismissed due to Operation and Maintenance costs, and one was deemed ineffective. Therefore, only the No Action Alternative and Alternative 11 (BFR5-M2) were carried forward.

Alternative 11 was tentatively selected as the preferred alternative and is referred to as the "tentatively selected plan (TSP)." USFWS supports this alternative over other Best Buy plans. The TSP proposes the removal and replacement of five existing water control structures and construction of one new water control structure and one earthen plug. All new structures are proposed to be cast-in-place concrete stoplog control structures. The stoplog control structures are designed to give USFWS the capability to control water levels in Blue, Fisher, and Rice lakes along with Continental Grain Marsh when the Minnesota River discharges are below bank full conditions. The structures include pre-formed scour holes on the upstream and downstream ends for energy dissipation and rock lined slopes upstream and downstream for erosion protection. To access the water control structures, access road improvements are proposed, and a new access road would need to be constructed to access the earthen plug.

Based on our review of the Draft EA, EPA offers the following comments, which are enclosed. Generally, our comments focus on document clarification, impacts to wetlands/waters, mitigation commitments, and the proposed monitoring and adaptive management plan.

Thank you for the opportunity to review and comment upon this Draft EA. We are available to discuss the contents of this letter at your convenience, should you desire. **Please send us a copy of future NEPA documents for this project, including the decision document**. If you have any questions about this letter, please contact the lead NEPA reviewer, Liz Pelloso, at 312-886-7425 or via email at pelloso.elizabeth@epa.gov.

Sincerely,

Kenneth A. Westlake, Chief
NEPA Implementation Section
Office of Enforcement and Compliance Assurance

Enclosure: *EPA's Detailed Comments: Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement - Detailed Project Report and Draft Environmental Assessment Scott County, MN*

cc with enclosure (via email):
Eric Hanson, USACE-St. Paul District
Tom Novak, USACE-St. Paul District
Sarena Selbo, USFWS-Minnesota Valley NWR
Jennie Skancke, MDNR

3

EPA's Detailed Comments
Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement
Detailed Project Report and Draft Environmental Assessment
Scott County, Minnesota

March 8, 2019

DOCUMENT CLARIFICATION

- The title of the Draft EA, "Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement" is misleading as it refers to three separate and discreet locations/projects. The project alternatives analyzed in the Draft EA focus only on what is referred to as the "Marsh" area, which includes Blue, Fisher, and Rice lakes and the Continental Grain Marsh. The Draft EA is silent on what is meant by the "Bass Ponds," "Marsh," and "Wetlands" as noted in the document title.

  The "Bass Ponds" floodplain marsh area[1] is located in the Long Meadow Lake Unit of the Minnesota Valley NWR at Minnesota River Mile (RM) 7. The "Marsh" area[2] includes Blue Lake, Fisher Lake, Rice Lake, and the Continental Grain Marsh (within the study area of the Draft EA). The "Wetlands" area[3] is located in the Long Meadow Lake, Wilkie, and Bloomington Ferry Units at RM 5 to 11 and RM 14 to 21. As stated above, these three separate areas (referred to as "Bass Ponds," "Marsh," and "Wetland" habitat restoration areas) are three separate areas encompassing three separate projects. The focus of the Draft EA is only on the areas called "Marsh" in the project title.

  The Draft EA did not include any information on the locations of each discreet project Bass Ponds / Marsh / Wetland) as locations as noted above. Information on these separate projects gathered by EPA from other USACE documents, including an October 2018 Information Paper on the project and a September 2010 Fact Sheet on the wider project as it was initially proposed. The Draft EA did not include a wider discussion of the three discreet sites (Bass Ponds / Marsh / Wetland) as identified in prior project fact sheets. The Draft EA did not discuss that two of the three areas were not studied in the Draft EA, nor did it explain why only the "Marsh" area was studied for enhancement in the Draft EA, or why the other two project areas were dropped from further study in this EA.

  Early in the Draft EA (p.19), the document stated, "*Based on site visits and interagency discussions, it was agreed to screen out the third priority area (Bass Ponds) from further consideration…[as] restoration and enhancement measures to improve this area would jeopardize the adjacent trout stream (Ike's Creek), which…[agencies]…decided was not worth the risk. In addition, early in the planning process it was determined that no action*

[1] The "Bass Ponds" consist of three small wetlands in the floodplain of the Minnesota River, known as Minnow pond, Little Bass pond, and Big Bass pond. This area was NOT studied in any alternative in the Draft EA.
[2] The "Marsh" area is the focus of this current Draft EA.
[3] The "Wetlands" area is converted agricultural land now managed for wildlife and native plant communities. This area was NOT studied in any alternative in the Draft EA.

Page 1 of 5

would be taken at Hogback Ridge Dike south of Bass Ponds as clear problems or opportunities for habitat restoration were not identified for that location." Again, there was no context provided on these locations or these discreet projects. The change in project priorities (i.e., to only focus on the "Marsh" site) was also noted in Appendix A, but again, the three separate locations and discreet projects are not clearly laid out in the Draft EA.

Recommendation: Revise the Final EA to include additional information on the initial scope of the project. Discuss how the project was revised and narrowed in scope to only the "Marsh" areas. Provide information in plain language allowing for a reviewer not familiar with the project locations, area history, related/previous projects in the vicinity, or a background in science or engineering, to understand the proposal. Zoomed-in inset maps should be added for each specific project area (for all Bass Ponds / Marsh / Wetlands areas). Describe why the project and this Draft EA was narrowed to only the "Marsh" projects.

WETLANDS / WATERS IMPACTS

- Section 4 of the Draft EA is an assessment of the existing environmental resources and the expected environmental consequences of implementing the Tentatively Selected Plan. Section 4 did not include a subsection on wetlands, which should have included information on both existing conditions as well as expected wetland impacts due from implementation of both the No Action Alternative and the Tentatively Selected Plan. Table 6 in the Draft EA is a matrix of expected project outcomes, and it includes wetlands as a subcategory under "Natural Resource Effects." However, there is no corresponding text to discuss current wetland conditions and expected wetland impacts.

  Cumulative effects to wetlands were discussed, but not quantified, in Section 5.2 of the Draft EA. The effects to wetlands associated with implementation the Tentatively Selected Plan noted only the expected enhancement to wetlands. There was no discussion of expected wetland impacts in Section 5.2, in Section 4, or anywhere else in the narrative of the Draft EA. However, as is discussed in appendices, there will be wetland fill and wetland impacts should the Tentatively Selected Plan be implemented.

  The Tentatively Selected Plan proposes installation of new access roads and improvements to existing access pathways currently in place to access existing water control structures. As nearly the entire study area is already wetland, installation of the proposed access roads will involve the placement of dredged material into Waters of the United States. Construction plans provided in Appendix I show the typical plan section of access road as a 15' wide path. Impacts to wetlands associated with access road construction (and with any associated construction staging) was not described or quantified in the Draft EA.

  Additionally, the Clean Water Act Section 404(b)(1) evaluation in Appendix B states, "*It is anticipated that all features [proposed in the Tentatively Selected Plan] will have impacts to wetlands; however, the fill action will help wetland plant communities and associated biota. A general summary of the extent of impacts is listed below in Table 1.*" Table 1 in the 404(b)(1) evaluation lists a total of 10.37 acres of impact to Waters of the U.S.; of this, 5.18

Page 2 of 5

acres of impact are associated with construction of access roads. Again, these quantifications and acknowledgement of wetland impact were not discussed in the EA itself. Furthermore, the Draft EA was also silent about the potential requirement for wetland mitigation for proposed wetland impacts.

Recommendations: Revise the Final EA to discuss and quantify expected wetland impacts to mirror information summarized in the Section 404(b)(1) evaluation. Wetland impacts should be further quantified by acreage of emergent, scrub-shrub, and forested wetland. The Final EA should also include the addition of a discussion on mitigation, and whether wetland mitigation is expected to be required by the state resource agencies. If mitigation is required, details on mitigation should be provided. If mitigation is not required by the resource agencies, the rationale for why not should also be provided.

- Page 2 of the Clean Water Act Section 404(b)(1) evaluation states, "*The proposed water control structures and earthen plug would be placed into emergent wetlands whereas access roads would be constructed through forested wetlands.*"

Recommendations: Staging areas and access roads should be thoughtfully designed and sited and configured to avoid impacts to natural wetlands wherever possible. The removal of forested wetland should be avoided to the extent possible as the temporal loss of trees will take decades to replace.

CONSTRUCTION RESTRICTIONS / MITIGATION COMMITMENTS

- Page 35 states, "*USACE has initially determined that the proposed project may affect NLEB [the Northern Long Eared Bat]. Trees will need to be removed to allow construction equipment access to the project features.*" However, Section 6.4.1 of the Draft EA (Construction Restrictions) does not discuss the need for seasonal tree restriction removal dates (to protect bats) or in-water work restriction dates (to protect aquatic resources).

Section 6.4.1 mentions the general restrictions that would be implemented if bald eagle nests are located nearby, but does not specifically state expected working date restrictions. However, page 53 of the Draft EA states, "*One active bald eagle nest is located in the study area, adjacent to the proposed Fisher Lake structure. The USFWS recommends maintaining a buffer of at least 660 feet between project activities and active eagle nests. However, the location of access dredging through the Fisher Lake outlet is within the 660 feet of a nest. Alternate routes over 660 feet from the nest are not practicable. Construction in this area will be scheduled outside of the nesting timeframe (nesting typically occurs between February 1 – July 15). Assistance from USFWS staff would be used to monitor eagle behavior at this nest during construction activities.*"

Recommendation: Revise the Final EA to note the definitive existence of an eagle nest within the project vicinity. Revise Section 6.4.1 in the Final EA to discuss necessary construction restriction dates to protect endangered species (northern long eared bat), bald eagles, and fisheries (in-water restriction dates). Commit to specific construction date restrictions (for both tree removal, nesting, and/or in-water work) in the Final EA and also in the forthcoming NEPA Decision Document (assumed to be a Finding of No Significant Impact (FONSI)).

CLIMATE ADAPTATION

- The Draft EA, including Appendix F, included a robust discussion of climate change, including USACE's assessments and a literature review of climate change trends at a regional scale. Page 21 of Appendix F also references results from the U.S. Global Research Program's *Third National Climate Assessment for the Upper Midwest*.

  Page 21 of Appendix F states, "*Streamflow/discharge and duration are the most important hydrometeorological variable affecting ecological conditions and engineering resilience for the project. Trends in streamflow and the corresponding water surface elevations will be considered when designing project features.*"

  Page 45 of Appendix F states, "*The high potential for increased river discharge in the future, as is evident within the historic and projected data considered as part of this analysis, was considered during the design of this project. Project features are designed to be able to handle projected changes in climate and hydrology in the basin. The stoplog structures are designed to be larger than the current structures to facilitate more efficient drawdowns. The original goal was to design structures to complete a drawdown in at least 10 days. These structures were overdesigned (size-wise) to enable even faster drawdowns than 10 days and to prevent debris blockage. In addition to design modifications aimed at creating efficient and robust structures tolerant to higher flows, resilience will be built into the proposed project by using lessons learned from successful and stable ecosystem restoration projects all constructed between 1981 and 2015.*"

  EPA acknowledges climate analysis undertaken for this project has allowed USACE to anticipate reasonably foreseeable effects that changes in the climate may have on the proposed project and the project area, including its long-term infrastructure. EPA commends USACE for implementing design modifications to improve the resilience of the proposed project.

  Recommendation: The Fourth National Climate Assessment[4] was released in 2018. The Final EA should be updated to reference the most recent data.

MONITORING AND ADAPTIVE MANAGEMENT

- Performance Indicators are discussed in Section 3 of Appendix K (Monitoring/Adaptive Management Plan). Indicator 1A – emergent vegetation diversity and cover states, "*Vegetation monitoring will be conducted once prior to construction and in Years 1, 3, 6 and 10 following project construction. Exact methodology is still being considered.*" Additionally, performance standards ("monitoring targets") relate to percent cover, species richness, and total cover. Percent cover targets are specified as "*≥75% native, non-invasive plant species and <25% invasive and/or non-native plant species*."

[4] See https://nca2018.globalchange.gov/. Chapter 21 (Midwest) is found at: https://nca2018.globalchange.gov/chapter/21/

Performance standards also call for a combination of 80% cover of native emergent, submergent, and floating leaved aquatic vegetation for both emergent vegetation density and cover (Performance Indicator 1A) and 80% cover for submergent vegetation density and cover (Performance Indicator 2A). It is unclear if achieving 80% cover for both emergent and submergent strata is realistic.

Recommendations:

1. Modify the language of Performance Indicator 1A to ensure the area is dominated by native, hydrophytic vegetation, not just any type of native vegetation. Suggested language modifications for this performance standard are as follows:
   - "*≥75% native, non-invasive plant species and <25% invasive and/or non-native plant species. Greater than 50% of native, non-native plant species must have a wetland indicator of FAC (i.e., facultative) or wetter by the end of the first monitoring year and 85% by year 3, as measured by vegetation sampling transects and photo points*."
2. Revisit and assess the ability to achieve 80% cover in all strata, and revise if necessary.

BENEFICIAL REUSE

- Section 6.2.2 of the Draft EA states that dredged soil from proposed dredging associated with the Tentatively Selected Plan will be "*hauled to the adjacent Burnsville Landfill, which is less than 2 miles east of the study area.* The Draft EA did not mention the possibility of, or potential for, beneficial reuse of dredged materials. If dredged materials are generally clean/inert materials, and are suitable for upland placement or disposal, the possibility for beneficial reuse should exist. Beneficial reuse of dredged sediments is a viable, and publicly-accepted and supported alternative to upland disposal or landfilling.

  Recommendation: Beneficial reuse should be discussed in the Final EA, as it pertains to the Tentatively Selected Plan. Sufficient justification as to why beneficial reuse opportunities do, or do not exist, should be explained in the Final EA.

OTHER

- Section 8.2 of the Draft EA mentions the Communication Flyer sent out to interested stakeholders and agencies regarding development of the proposed project. EPA was not included in this list. Scoping, early coordination, and the development and distribution of the Environmental Assessment (EA) were undertaken by USACE/USFWS under requirements of NEPA.

  Recommendation: Add EPA Region 5 (NEPA program) to your list of coordinating agencies for all future projects requiring NEPA documentation. Earlier coordination with EPA under NEPA will provide for more environmentally-informed decision making.

4 Coordination with Native American Groups

4.1 Informal Notification

An email including the Communication Flyer was sent out in August 2018 to various Native American Groups that historically resided in the study area, which include:

- Shakopee Mdewakanton Sioux
- Lower Sioux Community
- Upper Sioux Community
- Sisseton Wahpeton
- Prairie Island

4.2 Formal Consultation Letter

A formal consultation letter was sent out 28 November 2018 to the same groups listed above.

A copy of the letter and Tribal Engagement form is copied below.

- Figure 1 is the Executive Summary Figure in the Main Report.
- Figure 2 is the Communication Flyer, found in Section 3.1 of this Appendix.

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

November 28, 2018

Regional Planning and Environment Division North

Dianne Desrosiers
Tribal Historic Preservation Officer
Sisseton Wahpeton Oyate
12554 BIA HWY 711
PO Box 907
Agency Village, South Dakota 57262

Dear Ms. Desrosiers:

The U.S. Army Corps of Engineers, St. Paul District (Corps) is proposing to partially restore lake and marsh habitats located in the Minnesota Valley National Wildlife Refuge, Scott County, Minnesota (Figure 1). We are contacting your office to initiate consultation under Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulation 36 CFR 800. This correspondence provides an outline of the project. The accompanying assessment form is intended to facilitate communication.

The habitat concerns around Blue, Fisher, and Rice lakes and Continental Grain Marsh primarily include prolonged high water levels and lack of quality habitat for birds and aquatic plants. The objectives of the project aim to provide quality feeding and resting habitat for a wide variety of water birds with particular emphasis on fall migrating waterfowl and increasing the diversity and cover of desirable emergent and submergent aquatic plant species.

Proposed features of the restoration project include water level management structures (single and double bay stoplog structures), an earthen ditch plug, access dredging, rock-lined overflows, and construction of access roads. Locations of the project features and project summary are presented in Figure 1 and Figure 2.

No historic properties have been documented within the project area. Surface reconnaissance and limited deep site testing indicate that the tentatively selected plan would preliminarily have no impacts to historic properties. Placement of water control structures and a ditch plug would occur in previously disturbed areas. Limited subsurface testing identified a sequence of buried soil horizons underlying varying depths of post settlement alluvial along the natural levee at Continental Grain Marsh. Construction of access roads along natural levees within the Project Area have the potential to affect buried cultural deposits. Additional testing will be completed based on the design of access roads.

The Corps is interested in the comments and opinions of your community. Please find enclosed an assessment form to facilitate your response. If you have another preferred format for response, please feel free to use it. We look forward to hearing from you. Any comments or questions should be directed to Dr. Bradley Perkl, archaeologist, (651) 290-5370 or Bradley.e.perkl@usace.army.mil

Sincerely,

Elliott L. Stefanik
Acting Deputy Chief, Regional Planning and
Environment Division North

Enclosure

THPO Assessment Form

US Army Corps of Engineers
St. Paul District

U.S. Army Corps of Engineers
St. Paul District
Tribal Engagement

180 Fifth Street East | Suite 700 | St. Paul, MN 55101

Date November 26 2018

MVP Study or Project
Bass Ponds

Location
Minnesota River Valley NWR, Scott Co., MN

Contact
Brad Perkl

Phone
651-290-5370

Email
bradley.e.perkl@usace.army.mil

Project
Marsh and Wetland Habitat Rehabilitation and Enhancement Project around Blue, Fisher and Rice lakes within the Minnesota River Valley National Wildlife Refuge.

***********************************Please Respond Below***********************************

Please Identify your Interest
- ☐ We are interested in the proposed study or project area and request additional information.
- ☐ We defer to other Tribes who have expressed interest in the study or project area.
- ☐ There is no interest in the proposed study or project at this time.

Who should we contact for study/project related information?

Date

Name

Title

Phone

Email

Comments

5 Letter of Support from the Sponsor

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Minnesota Valley National Wildlife Refuge
and Wetland Management District
3815 American Blvd. East
Bloomington, Minnesota 55425

IN REPLY REFER TO:
FWS/R3/NWRS/MNV

Colonel Sam Calkins
District Engineer
U.S. Army Corps of Engineers
St. Paul District
180 5th St. East, Ste. 700
St. Paul, Minnesota 55101-1678

Dear Colonel Calkins:

The US. Fish and Wildlife Service (Service) has reviewed the January 2019 draft Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project (HREP) Feasibility Report with Integrated Environmental Assessment, as well as the draft Memorandum of Agreement. Coupled with continued partner agency support, we are pleased to support the Bass Ponds HREP Tentatively Selected Plan.

This Bass Ponds project meets the goals and objectives of the Minnesota Valley National Wildlife Refuge and Wetland Management District (Refuge) which was established by Congress in 1976 to provide a refuge and breeding ground for migratory birds, fish, other wildlife, and plants. There have been many changes in environmental conditions on the Minnesota River Valley since the Refuge was established that have resulted in substantial ecosystem degradation. The Bass Ponds HREP provides an opportunity to improve environmental conditions within these backwater habitats that will benefit migratory birds, fish, other wildlife, and plants.

The Tentatively Selected Plan would result in positive long-term benefits to waterfowl and submergent and emergent aquatic vegetation in and around the Bass Ponds study area. The Tentatively Selected Plan is Alternative 11, which includes one double bay stoplog structure (Blue Lake), five single bay stoplog structures (Interlake, Fisher Lake, Rice Lake, Secondary Outlet, and Continental Grain Marsh), a plug at Continental Grain Marsh, and access dredging and construction road improvements to each structure. We anticipate 2000 acres of lake and wetland habitat will be enhanced.

Because the project is located on national wildlife refuge lands, project costs would be 100-percent federal in accordance with Section 906(e) of the Water Resources Development Act of 1986, Pub. L. 99-662, 33 U.S.C. § 2283(e). The estimated project first cost at current price levels is $5,933,000 (including sunk general design costs). The Tentatively Selected Plan also includes monitoring and adaptive management, which could total up to $128,000, for which USACE would be responsible.

As the project sponsor, the Service would be responsible for 100% of the project operation and maintenance (O&M). The estimated annual O&M costs are $18,200. The Services' financial support would be dependent, of course, on total cost, appropriations authority, O&M responsibility, and benefits to the natural resources. In addition, we find that the draft Memorandum of Agreement appropriately defines agency roles and responsibilities as previously discussed with USACE.

We are pleased to see this project moving forward, and look forward to our continued partnership with the USACE and the Minnesota Department of Natural Resources on this project. Should you have questions regarding this letter, please contact Mr. Eric Mruz, Deputy Refuge Manager at 952-858-0722 or eric_mruz@fws.gov; or Ms. Sharonne Baylor, Environmental Engineer, at sharonne_baylor@fws.gov or 507-494-6207.

Sincerely,

Sarena Selbo
Refuge Manager

cc: Mruz, Shimek, Sherry, Kane; Minnesota Valley NWR
Nick Utrup, Minnesota-Wisconsin Ecological Services Field Office
Rebecca Neeley, La Crosse Fish and Wildlife Conservation Office
James Myster, Region 3 RHPO
Jennie Skancke, Minnesota Department of Natural Resources

US Army Corps of Engineers®
St. Paul District

Appendix B: Clean Water Act Compliance

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix B

Contents

1 Project Description ... 1
1.1 Location and General Description ... 1
1.2 Authority and Purpose ... 2
1.3 General Description of Dredged or Fill Material ... 2
1.3.1 General Characteristics ... 2
1.3.1 Source of Material ... 2
1.3.2 Quantity of Material ... 2
1.4 Description of the Proposed Discharge Site ... 2
1.4.1 Location ... 2
1.4.2 Site and Habitat Description ... 2
1.5 Description of Disposal Method ... 3
2 Factual Determinations ... 3
2.1 Physical Substrate Determinations ... 3
2.1.1 Substrate Elevation and Slope ... 3
2.1.2 Sediment Type ... 3
2.1.3 Fill Material Movement ... 3
2.1.4 Actions Taken to Minimize Impacts ... 3
2.2 Water Circulation, Fluctuation and Salinity Determination ... 4
2.2.1 Water ... 4
2.2.2 Current Patterns and Circulation ... 4
2.3 Suspended Particulate/Turbidity Determination ... 5
2.3.1 Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site ... 5
2.3.2 Effects on Chemical and Physical Properties of the Water Column ... 5
2.3.3 Actions Taken to Minimize Impacts ... 5
2.4 Contaminant Determinations ... 5
2.5 Aquatic Ecosystem and Organism Determination ... 5
2.5.1 Effects on Plankton ... 5
2.5.2 Effects on Benthos ... 5
2.5.3 Effects on Nekton ... 6
2.5.4 Effects on Aquatic Food Web ... 6
2.5.5 Effects on Special Aquatic Sites ... 6

2.5.6 Threatened and Endangered Species 6
2.5.7 Other Wildlife 6
2.5.8 Actions Taken to Minimize Impacts 7
2.6 Proposed Disposal Site Determinations 7
2.6.1 Mixing Zone Determination 7
2.6.2 Determination of Compliance with Applicable Water Quality Standards 7
2.6.3 Potential Effects on Human Use Characteristics 7
2.7 Determination of Cumulative Effects on the Aquatic Ecosystem 7
2.8 Determination of Secondary Effects on the Aquatic Ecosystem 8
3 Finding of Compliance with Restrictions on Discharge 8
4 Section 401 Water Quality Certification Waiver 9

LIST OF TABLES

Table 1: Project Features 1

1 Project Description

1.1 Location and General Description

The US Army Corps of Engineers (Corps), St. Paul District is proposing to restore, protect and create aquatic and wetland habitats in the Minnesota Valley National Wildlife Refuge in Scott County, Minnesota. The study area includes Blue Lake, Fisher Lake, Rice Lake and Continental Grain Marsh which are located south of the Minnesota River between river miles 15 and 21 (see Figure 14 in the Main Report).

The overall purpose of the project is to partially restore the hydrologic regime in the study area by allowing varied water levels to provide optimal quality habitat for migratory birds each season. Objectives include increasing the diversity and percent cover of both emergent and submergent aquatic plant species and providing quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl. To accomplish this, the project would include the replacement of five water control structures, construction of one new water control structure and one earthen plug (see Figure 14 in the Main Report). Each water control structure would have an excavator pad on each side of the structure to allow for routine maintenance. To access the water control structures, road improvements would be needed and a new road would need to be constructed to access the earthen plug (Figure 14 in the Main Report).

A wetland delineation has not been completed at this stage; however, the majority of the project area is identified as wetland on the National Wetland Inventory update for Minnesota (https://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html). It is anticipated that all features will have impacts to wetlands; however, the fill action will help wetland plant communities and associated biota. A general summary of the extent of impacts is listed below in Table 1: Project FeaturesTable 1.

Table 1: Project Features

Project Feature	**Permanent Impact (Acres)**	**Temporary Impact (Acres)**
1 2-bay water control structure with associated excavator pads	0.07	0.09
5 1-bay water control structures with associated excavator pads	0.30	0.25
2 earthen plugs	0.24	
Access roads	4.67	
Channel dredging	3.55	
Rock-lined overflow channels	0.30	
Coffer dams (if needed)		0.20
Total fill	**5.58**	**0.54**
Total dredging	**3.55**	

The project will discharge fill material into 3.43 acres of forested/shrub wetlands and 2.15 acres of emergent wetland.

1.2 Authority and Purpose

Congress authorized the Upper Mississippi River Restoration program (UMRR) in Section 1103 of the 1986 Water Resources Development Act (WRDA) (Public Law 99-662), codified at 33 U.S.C. § 652. Over the course of its first 13 years, the UMRR program proved to be one of this country's premier ecosystem restoration programs, combining close collaboration between Federal and State partners, and an effective planning process. This success led Congress to reauthorize the UMRR program in WRDA 1999 (Public Law 106-53).

1.3 General Description of Dredged or Fill Material

1.3.1 General Characteristics

Dredged or excavated material from the project site will likely not be used as fill or backfill for the project. Impervious fill (clay) would be used for the earthen plug and for backfill associated with the water control structures and excavator pads. Gravel will be used as fill material for the access roads and riprap for the rock-lined overflow structures. Composition of the dredged material will be determined when sediment borings occur in January or February 2019.

1.3.1 Source of Material

Clay material for the earthen plug and backfill would be collected from an approved borrow area. Gravel and riprap would be purchased from a commercial, licensed source.

1.3.2 Quantity of Material

See Table 10 in the Main Report.

1.4 Description of the Proposed Discharge Site

1.4.1 Location

Blue, Fisher, and Rice Lakes and Continental Grain Marsh are located within the Minnesota Valley National Wildlife Refuge in Scott County, Minnesota. All four aquatic resources are located just south of the Minnesota River.

1.4.2 Site and Habitat Description

The study area is approximately 2,085 acres in size and includes 3 backwater lakes (Blue, Fisher and Rice) and Continental Grain Marsh. The Minnesota River banks are overtopped during high-water events, but the lakes are largely isolated from the rest of the complex during normal flows. Blue Lake is a 248-acre backwater lake in the northwest portion of the study area. During normal flows, Blue Lake has two outlets; the northwest outlet flows into the Minnesota River, and the southeast outlet flows into Fisher Lake. During flood conditions, the northwest outlet acts as an inlet and the Minnesota River discharges into Blue Lake. Fisher Lake is located downstream of Blue Lake and is 370 acres. Water from Fisher Lake can either discharge into Rice Lake or through a secondary outlet into the Minnesota River. Rice Lake is downstream from Fisher Lake and is 287 acres. Water from Rice Lake flows through the secondary outlet into the Minnesota River. Under typical summer conditions, all three backwater lakes are less than 4 feet deep.

Continental Grain Marsh is 93 acres and has an average depth of 2.5 feet. The marsh is located downstream from Rice Lake but is not hydrologically connected to the lake. Water currently flows from the marsh into Eagle Creek, a designated trout stream.

The proposed water control structures and earthen plug would be placed into emergent wetlands whereas access roads would be constructed through forested wetlands. With the exception of the Continental Grain Marsh water control structure, earthen plug and access road to the plug, all other project features will be placed within existing footprints.

1.5 Description of Disposal Method

It is anticipated that the contractor will use an excavator to remove soils from areas where water control structures, excavator pads and access roads will be constructed. For the water control structures, concrete excavator pads will be poured on site and structures will either be poured in place or pre-cast and set in place. Following installation of the water control structures and excavator pads, the areas will be backfilled with an impervious clay material. Gravel and riprap will be hauled in via dump trucks to fill in the access roads and rock-lined overflow structures following excavation. Dredging will be conducted manually using a barge with backhoe, swamp excavator or long-reach excavator.

2 Factual Determinations

2.1 Physical Substrate Determinations

2.1.1 Substrate Elevation and Slope

The existing substrate in the project area is relatively flat and the proposed water control structures, excavator pads and earthen plug will increase the substrate elevation. These areas of increased elevation are relatively small in scale compared to the aquatic resources as a whole and will have a long-term minor effect on substrate elevation and slope. The roads will be constructed by excavating and then placing geotextile material within the excavated footprint. This method of road construction will have no effect on the substrate elevation or slope within the project area.

2.1.2 Sediment Type

Sediment borings are scheduled for 2019; however, according to the U.S. Department of Agriculture Web Soil Survey, sediment types within the fill areas are expected to silty clay loam, muck or a stratified silt loam to sand.

2.1.3 Fill Material Movement

Fill material is not expected to move significantly once placed.

2.1.4 Actions Taken to Minimize Impacts

A number of procedures would be used to minimize impacts where needed, including Best Management Practices. All work performed by a contractor will be subject to adherence with a work plan and applicable agency permits and Section 401 State Water Quality certification. The work plan shall detail the contractor’s proposed methods to perform work described by contract drawings. This plan (and other related plans) shall be submitted to Government Representative (Corps COR) for review and acceptance before any site work commences.

2.2 Water Circulation, Fluctuation and Salinity Determination

2.2.1 Water

Some minor, short-term decreases in water clarity are expected from the proposed fill actions. The project will have no effect on salinity, water chemistry, color, odor, taste, dissolved oxygen, nutrients, eutrophication or temperature.

2.2.2 Current Patterns and Circulation

2.2.2.1 Current Velocity and Patterns

Post-construction, current patterns throughout the interconnected lakes will either remain the same or be restored where structures have collapsed. With the construction of an earthen plug in Continental Grain Marsh, water will no longer be allowed to discharge into Eagle Creek.

Current patterns may be temporarily impacted if coffer dams are needed during construction of the water control structures and earthen plug.

2.2.2.2 Stratification

The proposed project would have no effect on stratification.

2.2.2.3 Hydrologic Regime

The proposed project would optimize the hydrology for submergent and emergent aquatic plant growth. The installation of water control structures will allow the refuge to remove excess water from the lakes quickly following flood events. Water levels will gradually be lowered through the spring, maintained through the summer and raised in the fall. Partial drawdowns would be conducted annually in between full drawdown years which would occur every 5 to 7 years.

2.2.2.4 Normal Water Level Fluctuations

The project would not result in water levels outside the normal seasonal range.

2.2.2.5 Salinity

Not applicable.

2.2.2.6 Actions Taken to Minimize Impacts

No special actions would be taken to minimize the effects of the proposed project on water circulation, fluctuation or salinity.

2.3 Suspended Particulate/Turbidity Determination

2.3.1 Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site

Increases in turbidity and suspended particulates would temporarily occur from the discharge of fill material and excavation in the immediate project vicinity; however, levels would return to pre-project conditions upon completion of construction.

2.3.2 Effects on Chemical and Physical Properties of the Water Column

Increased turbidity levels during construction would have a short-term and minor effect to light penetration in the immediate project vicinity. The project would have no appreciable effect on dissolved oxygen, pH or temperature during or after construction.

2.3.3 Actions Taken to Minimize Impacts

The discharge of fill material and excavation will result in disturbance to the existing substrate, causing a temporary and localized increase in turbidity and suspended particulates. As part of the project's plans and specifications, the contractor will be required to develop an environmental protection plan that will include Best Management Practices (BMPs) designed to minimize impacts of the project to the surrounding environment.

2.4 Contaminant Determinations

The existing substrate within appropriate areas of the Bass Ponds project area will be tested in January or February 2019. Contaminated sediments are not anticipated, but if found, concerns will be addressed at that time.

2.5 Aquatic Ecosystem and Organism Determination

2.5.1 Effects on Plankton

During construction of the water control structures, excavator pads and earthen plug, and channel dredging, there may be a temporary increase in turbidity and suspended solids which would locally suppress phytoplankton productivity. However, this effect would be minor and short-term. Plankton populations would quickly recover after construction. Construction of the access roads would likely take place when the ground is frozen and would not have an effect on plankton as the wetlands in these areas are seasonally flooded and would likely be dry.

2.5.2 Effects on Benthos

Prior to installing the new water control structures, the old structures, including a small area around each structure, will be dewatered and excavated. Benthos present in these areas would be destroyed, as well as in the area of the earthen plug and excavator pads. Benthic organisms would likely recolonize the excavated areas following construction. Overall, the large unaffected areas of each wetland would continue to provide habitat for benthos. Construction of the access roads could disturb present biota. However, wetlands in these areas are seasonally flooded and would likely be dry and frozen during the construction timeframe.

2.5.3 Effects on Nekton

During construction of the water control structures, excavator pads and earthen plug, nekton could temporarily be displaced. The wetland areas where access roads are planned for construction do not provide habitat for nekton. Overall, the project is likely to have a long-term positive impact on nekton.

2.5.4 Effects on Aquatic Food Web

The impacts on benthos and plankton productivity as described above could cause a short-term minor temporary impact on the local aquatic food web. Overall, the anticipated increase in aquatic vegetation coverage and diversity would likely have a beneficial effect on the aquatic food web.

2.5.5 Effects on Special Aquatic Sites

The proposed project is located in the Minnesota Valley National Wildlife Refuge. The purpose of the proposed work is to improve wetland habitat within Blue, Fisher and Rice Lakes as well as Continental Grain Marsh. The overall project will have a beneficial effect on the refuge.

Most of the proposed project features (water control structures, excavator pads, channel dredging, earthen plug and access roads) would be constructed in wetlands. All features will be designed to minimize both direct and indirect impacts. Wetlands in the project area are large and features will only impact a very small portion of each. The wetlands will continue to provide the same functions and services after construction as they do currently. These functions include water quality protection, groundwater recharge and discharge, floodwater detention and wildlife habitat.

The proposed project is not located in and will have no effect on any mud flats, coral reefs, vegetated shallows or riffle and pool complexes.

2.5.6 Threatened and Endangered Species

The Corps has determined that there may be a short-term minor effect to the Northern long-eared bat if tree clearing is needed to accommodate construction equipment access. Anticipated effects to the species from tree removal were consulted with USFWS under Section 7 of the Endangered Species Act,16 U.S.C. §1533(d), through a Section 4(d) Rule Streamlined Consultation Form. Consultation began on January 26, 2018. USFWS did not respond within the 30 days; therefore, no further consultation is required. Details on other federally listed species can be found in Section 4.5.1 of the Main Report.

2.5.7 Other Wildlife

The proposed project would have a minor and temporary effect in terms of avoidance of the area by wildlife during construction. However following construction, the project will have a positive long-term effect on wildlife such as waterfowl, shorebirds, turtles, beavers, muskrats and other wildlife species that would utilize the project area.

2.5.8 Actions Taken to Minimize Impacts

Standard BMPs will be used to minimize impacts to biota and other resources (i.e. erosion and sediment control). These actions are anticipated to ensure compliance with associated laws and regulations, including the Endangered Species Act, Bald and Golden Eagle Protection Act, and similar regulations.

2.6 Proposed Disposal Site Determinations

2.6.1 Mixing Zone Determination

The placement of fill material and channel dredging would cause a minor, temporary increase in turbidity in the immediate vicinity; however, no long-term adverse impacts to water quality would occur from any of the proposed project features.

2.6.2 Determination of Compliance with Applicable Water Quality Standards

It is not anticipated that the proposed project would violate Minnesota water quality standards for toxicity. Fill materials would be obtained from a local or licensed source and be free of contaminants. Water quality certification would be obtained from Minnesota prior to project construction.

2.6.3 Potential Effects on Human Use Characteristics

2.6.3.1 Municipal and Private Water Supply

The proposed project will not impact municipal or private water supplies.

2.6.3.2 Recreational and Commercial Fisheries

The proposed project will not impact commercial fisheries. There may be temporary and minor impacts to recreational fisheries during construction. Overall, the recreational fishery potential is limited in the study area due to the shallow depths of the lakes (averaging only 2-3 feet in depth). During construction of the water control structures, excavator pads, and earthen plug, it is possible that fish could be displaced in the areas. Fish would not be affected by the construction of the access roads. Overall, the project is likely to have a long-term positive impact on the local fishery.

2.6.3.3 Water Related Recreation and Aesthetics

The proposed project will have no appreciable impact on water-related recreation and will have a negligible temporary effect on aesthetics.

2.6.3.4 Cultural Resources

Surface reconnaissance and limited deep site testing within the project area indicate that the tentatively selected plan would preliminarily have no impacts to historic properties. There would be no permanent indirect effects to proximal recorded historic properties.

2.7 Determination of Cumulative Effects on the Aquatic Ecosystem

The proposed project would cause no significant adverse cumulative impacts on the aquatic ecosystem. Completion of the project would allow improved management capabilities which would increase the habitat diversity of the area and have an overall positive effect on the aquatic ecosystem.

2.8 Determination of Secondary Effects on the Aquatic Ecosystem

No significant secondary effects on the aquatic ecosystem would be expected from the proposed action.

3 Finding of Compliance with Restrictions on Discharge

1. No significant adaptations of the guidelines were made relative to this evaluation.
2. The proposed fill activity would comply with the Section 404(b)(1) guidelines of the Clean Water Act. The placement of fill is required to provide the desired benefits.
3. There are no practical and feasible alternatives to the placement of fill in the proposed sites that would meet the objectives and goals of this project.
4. The proposed fill activity would comply with State water quality standards. The disposal operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.
5. The proposed project would not result in take of federally listed species.
6. The proposed fill activities would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing. The proposed activities would have minor short-term adverse effects and substantial long-term beneficial effects on aquatic habitat diversity and productivity, wildlife, and water quality. There would also be minor beneficial effects on fish and aesthetic and economic values.
7. On the basis of this evaluation, I conclude that the proposed discharge complies with the Section 404(b)(1) Guidelines for the discharge of dredged or fill material.

11 June 2019
Date

Samuel L. Calkins
Colonel, Corps of Engineers
District Engineer

4 Section 401 Water Quality Certification Waiver

MINNESOTA POLLUTION CONTROL AGENCY

520 Lafayette Road North | St. Paul, Minnesota 55155-4194 | 651-296-6300
800-657-3864 | Use your preferred relay service | info.pca@state.mn.us | Equal Opportunity Employer

March 5, 2019

Elliot L. Stefanik
U.S. Army Corps of Engineers
Regulatory Branch Chief
180 Fifth Street East, Suite 700
St. Paul, MN 55101-1678

Lee Ann Glomski
U.S. Army Corps of Engineers
180 Fifth Street East, Suite 700
St. Paul, MN 55101-1678

RE: Minnesota River National Wildlife Refuge, aka: Bass Ponds, Marsh, and Wetland Rehabilitation and Enhancement Project
Scott County, Minnesota
Section 401 Water Quality Certification Waiver

Dear Elliot L. Stefanik and Lee Ann Glomski:

This 401 Water Quality Certification Waiver decision (401 Waiver or Waiver) is made by the Minnesota Pollution Control Agency (MPCA) under authority of Section 401 of the Clean Water Act, or CWA (33 USC 1251 et seq.), Minn. Stat. chs. 115 and 116 and Minn. R. chs. 7001.1400-1470, 7050, 7052, and 7053. The MPCA has reviewed the public notice and the feasibility study/environmental assessment furnished by the U.S. Army Corps of Engineers (USACE), for the rehabilitation and enhancement project. The project is located in Scott County, Minnesota.

Decision:
The MPCA waives its Section 401 authority to certify the referenced project. The MPCA bases its certification waiver decision upon an evaluation of the rehabilitation and enhancement project and information relevant to water quality considerations. However, this action does not eliminate, waive, or vary the applicant's responsibility of complying with all applicable MPCA statutes and rules, including those regarding water quality standards.

Disclaimer:
A Section 401 Certification Waiver does not release or limit the applicant from obtaining all necessary federal, state, and local permits, nor does it limit more restrictive requirements set through any such program. It does not eliminate, waive, or vary the applicant's obligation to comply with all other laws and state water statutes and rules through the construction, installation, and operation of the project. This letter does not release the applicant from any liability, penalty, or duty imposed by Minnesota or federal statutes, regulations, rules, or local ordinances, and it does not convey a property right or an exclusive privilege.

This MPCA decision is made, in part, on the applicant's representations that environmental review under the Minnesota Environmental Quality Board's Rules, Minn. R. ch. 4410, is not needed for the project or, alternatively, that all necessary environmental reviews and related decisions have been completed. If environmental review for this project is needed and has not been completed, the MPCA does not have legal authority to issue a Certification waiver. In that situation, the MPCA reserves the right to make a Section 401 Certification decision when the environmental review process is completed.

Elliot L. Stefanik and Lee Ann Glomski
Page 2
March 5, 2019

The MPCA reserves the right to revisit or revoke the Certification Waiver due to new or additional information, updated information, changes in technology, or any other changes that could render the Certification Waiver inadequate to provide reasonable assurance that the project will be in compliance with water quality standards. If you have any questions regarding this Certification Waiver, please contact Jim Brist at 651-757-2245.

Sincerely,

Melissa Kuskie
Supervisor
Certification, Environmental Review and Rules Section
Resource Management and Assistance Division

MK/JB:ds

cc: Peter Swenson, EPA
Janice Cheng, EPA
Wendy Melgin, EPA
Andrew Horton, USFWS
Peter Fasbender, USFWS
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US Army Corps of Engineers ®
St. Paul District

Appendix C: Plan Formulation

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix C: Plan Formulation

TABLE OF CONTENTS

1 Purpose 1

2 Defining the Study Area 1

3 Formulation of Alternative Plans 3
  3.1 Screening of Initial Alternatives 6
  3.2 Final Array of Alternatives 6

LIST OF FIGURES

Figure 1: Initial Study Area Based on USFWS Top Priorities 1
Figure 2: Study Area Revised Following Site Visits 2
Figure 3: Final Study Area 3
Figure 4: Formulation Strategy in the Development of Alternative Plans 4

LIST OF TABLES

Table 1: Initial Array of Alternatives 5
Table 2: Final Array of Alternatives 6
Table 3: Comparison of Net AAHU Gains with and without the Impact of Droughts 7
Table 4: Combinations of Final Array of Alternatives for CE/ICA Analysis 8

1 Purpose

The purpose of this appendix is to augment Section 3 of the Main Report by including additional details on the Plan Formulation process for the Bass Ponds HREP. Some of the important factors that led to the development of the final array of alternatives for this project are described below.

2 Defining the Study Area

The study area was refined based on initial site visits, existing information, and feedback from inter-agency discussions. The study area based on the 2010 Factsheet was defined broadly as between Minnesota River miles 5 – 21 and focused on three areas "Bass Ponds," "Marsh," and "Wetland" (the Factsheet can be referenced in Appendix A – Correspondence and Coordination)

After the study area was officially selected as an HREP, the Corps received updated priority areas identified by the USFWS in 2017. Priority Areas #1 and #2 includes Fisher Lake and Continental Grain Marsh, which were part of the "Marsh" area referenced in the 2010 Factsheet. Priority Area #3 is the "Bass Ponds" area referenced in the 2010 Factsheet. The ephemeral "Wetland" component in the factsheet was no longer considered amongst the USFWS top priorities, although overall wetland restoration is a part of the #1 and #2 discussion. Both documents were a starting place to guide the site visits and agency discussions (saved in Appendix A – Correspondence & Coordination).

The initial two site visits took place in March of 2018, and the planning team visited all 3 of the priority areas identified by the USFWS (Figure 1).

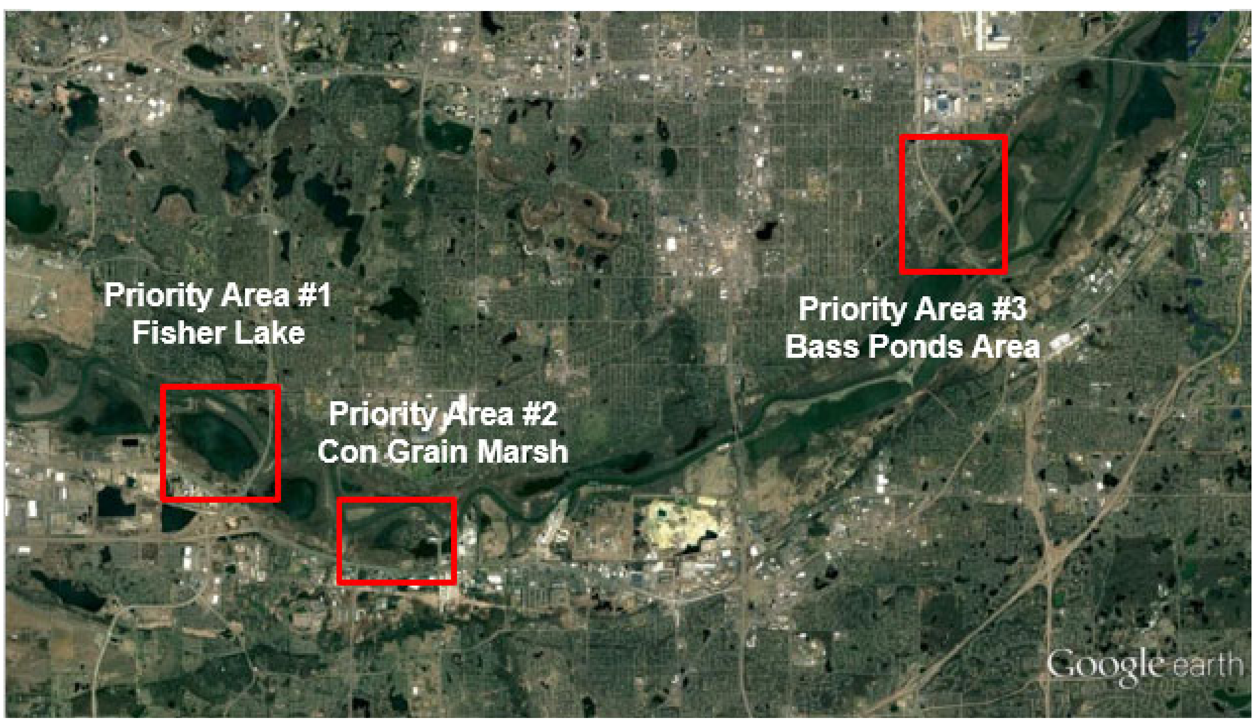

Figure 1: Initial Study Area Based on USFWS Top Priorities

Based on the initial meetings and site visits, the study area was refined from the 3 initial priority areas down to 2 primary locations (Figure 2).

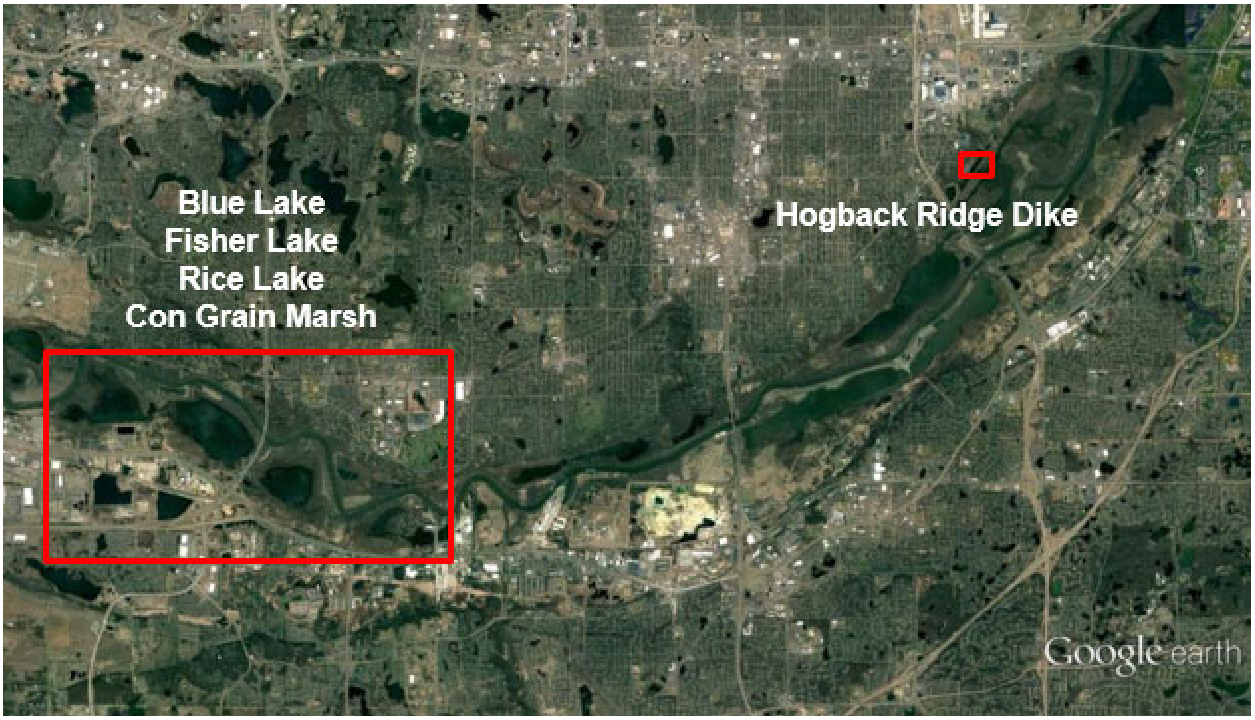

Figure 2: Study Area Revised Following Site Visits

Priority Area #3 was reduced to only include further evaluation of the dike and water level management structure along Hogback Ridge Dike. The Bass Ponds area was screened from further consideration due to improved conditions in the adjacent trout stream (Ike's Creek) and the USFWS desire to avoid any impacts to the stream.

Priority Area #1 (Fisher Lake) was expanded to include Blue Lake and Rice Lake. It was determined that water level management at Fisher Lake was dependent on flows from Blue Lake. Rice Lake was added to the study area as it similarly is impacted by Blue and Fisher Lake flows.

After additional discussion and evaluation of Hogback Ridge Dike, USACE and USFWS determined to screen this area from further consideration as no clear problems were identified. Therefore the final study area was confirmed as between river miles 15-21, to include the 3-lake complex (Blue Lake, Fisher Lake, and Rice Lake) and the adjacent marsh (Continental Grain Marsh) (Figure 3).

Figure 3: Final Study Area

3 Formulation of Alternative Plans

The full discussion of measures can be found in Section 3 of the Main Report. This section provides additional details behind the formulation of alternative plans. After initial measure screening, the primary measures remaining all entailed aspects of water level management.

The primary formulation strategy used was development of the largest plan possible down to the smallest plan possible (Figure 4) that achieved water level management objectives within the study area.

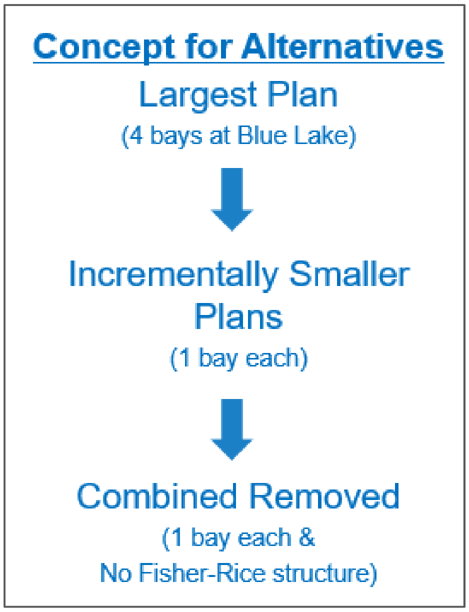

Figure 4: Formulation Strategy in the Development of Alternative Plans

The specific alternatives were formulated by combining the different water level management measures.

One important aspect about the formulation of alternatives for this project is the fact that Blue Lake, Fisher Lake, and Rice Lake are connected by inlet and outlet streams to each other. During major flooding, flow enters the Blue Lake Structure, travels through the Interlake Structure and then out the Fisher and Secondary Structures to the Minnesota River or into Rice Lake. One of the management objectives is to have the ability to store and supplement water from upstream to downstream sources depending on conditions. As a result, it was determined that addressing successful water level management in any single lake was dependent on having the ability to control water levels in the other 2 lakes. Therefore during the formulation of alternatives, the 3 interconnected lakes were not broken down into a smaller alternative plan; water level management would need to be achieved for each lake in order to have a complete plan. On the other hand, standalone alternatives could be applied to the Continental Grain Marsh location as this area does not have connecting stream channels to the 3 lakes.

Based on dependencies discussed above, three standalone alternative groupings were formed, each with different water level management capacities:

- **BFR Alternative** (Blue-Fisher-Rice Alternatives): consisting of a stoplog structure with a rock-lined overflow at each of the lake sites. Different combinations of this alternative included an analysis of a range of max and min numbers of stoplog structures at each lake outlet to determine the most effective design to achieve a fast drawdown rate. (BFR1 was the largest with a maximum of 4 bays at Blue Lake to BFR6 with only 1 bay at each outlet).
- **M1 Alternative** (Marsh Alternative #1); consisting of an earthen plug at Continental Grain Marsh.
- **M2 Alternative** (Marsh Alternative #2): consisting of an earthen plug and a stoplog structure for water level management at Continental Grain Marsh.

The initial array of alternatives is outlined in Table 1.

Table 1: Initial Array of Alternatives

		Blue-Fisher-Rice Alternatives									Marsh Alternatives	
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9	M1	M2
Location	**Meaures**	BFR	BFR	BFR	BFR	BFR	BFR	BFR	BFR	BFR	Plug only	Plug+WLM
Blue Lake	New WLM structure	4 bays	4 bays	2 bays	4 bays	2 bays	1 bays	1 bays	4 bays	1 bays		
	Old Culvert Removal	x	x	x	x	x	x	x	x	x		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	rock overflow	x	x	x	x	x	x	x	x	x		
	Improve Access Rd	x	x	x	x	x	x	x	x	x		
Interlake (Blue to Fisher)	New WLM structure	2 bay	2 bay	2 bay	1 bay	1 bay	1 bay	1 bay	2 bay	as-is		
	Dredge cut	x	x	x	x	x	x	x	x			
	rock overflow	x	x	x	x	x	x	x	x			
Secondary Outlet	New WLM structure	2 bay	1 bay	1 bay	1 bay	1 bay	1 bay	remove	remove	1 bay		
	rock overflow	x	x	x	x	x	x			x		
Fisher	New WLM structure	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay		
	Culvert Removal	x	x	x	x	x	x	x	x	x		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	rock overflow	x	x	x	x	x	x	x	x	x		
	Access to structure	x	x	x	x	x	x	x	x	x		
Rice	New WLM structure	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	Access to structure	x	x	x	x	x	x	x	x	x		
CGMarsh	Plug										x	x
	rock overflow										x	x
	New WLM structure											x
	Dredge cut											x
	Improve Access Rd										x	x

3.1 Screening of Initial Alternatives

Alt 1 was retained as the largest plan, maximizes the flow capacity at all sites.

Based on the initial drawdown analyses, a number of alternatives were screened from further consideration:

Alt 2, 3, & 8 – Screened out all other measures with a double-bay structure at Interlake. Double-bays at this location did not improve the drawdown rate.

Alt 7 & 8 – Removal of the Secondary Outlet was deemed as not acceptable by the agency, and would not meet the project objectives. The Secondary Outlet is needed in order to fill Rice Lake. This can be done by closing the Secondary Outlet and diverting all flows from Fisher Lake to Rice Lake.

Alt 9 – It was determined that leaving the Interlake Structure as-is would not result in a complete project for the 50 year project life. After receiving the results of the field survey, the structure was found to be made out of metal and therefore would not last more than another 20 years. Furthermore, the existing structure was found to have an invert elevation of 3 feet higher than the other structures, preventing flow from passing into Fisher Lake in non-flood events.

3.2 Final Array of Alternatives

Table 2: Final Array of Alternatives

		Blue-Fisher-Rice System				CGM	
Site	**Feature**	**BFR 1**	**BFR 4**	**BFR 5**	**BFR 6**	**M1**	**M2**
Blue Lake	Stoplog	4	4	2	1		
Interlake	Stoplog	2	1	1	1		
Fisher Lake	Stoplog	1	1	1	1		
Secondary Outlet	Stoplog	2	1	1	1		
Rice Lake	Stoplog	1	1	1	1		
Con Grain Marsh	Plug					x	x
Con Grain Marsh	Stoplog						1

A final increment that was added to the BFR Alternatives and the M1 and M2 Alternatives was a pump station increment. Pumps are a type of water level management that can assist in providing water to a system, and can be customized to the acreage of a system. In this study area, pump stations could be used to provide water to the system from the Minnesota River during drought conditions in order to maintain the ability to manage water levels. A pump at Blue Lake (Bp) could be used to provide water to the BFR1-6 alternatives, and a pump at Continental Grain Marsh (Cp) could provide water to the M1 and M2 alternatives.

Based on the period of record, it was determined that droughts occur approximately once every 8 years and once every 10 years for Continental Grain Marsh. More information on the drought analysis can be found in Appendix F – Section 8.3.2.3. To calculate the reduced gains as a result of drought years, the net AAHU gains without drought multiplied by a factor of 0.875 (every 8 years at the lake sites) or 0.9 (every 10 years at the marsh site). More information on how the benefits were calculated using the Dabbling Duck Migration Model can be found in Appendix D - Section 3. Therefore, the benefits from a drawdown or fill (optimal pool conditions) cannot be realized in a drought condition without additional assistance from pump stations.

Table 3 below reflects the net AAHU gains if benefits can be realized (i.e., pump stations can be used to supply water during a drought) compared to slightly lower net AAHU gains when drought is incorporated into the analysis (i.e., no pumps are available during a drought and optimal conditions cannot be achieved).

Table 3: Comparison of Net AAHU Gains with and without the Impact of Droughts

	Net AAHU Gain without Droughts (use of pump station)	Net AAHU Gain with Droughts (no pump station)
Blue	85	74
Fisher	80	70
Rice	92	81
M1 (CGM plug)	13	12
M2 (CGM plug+WLM)	34	31

The alternatives carried forward in the CE/ICA analysis incorporate drought and are reflected in Table 4; All alternatives without pump stations are assumed to be impacted during drought years and have reduced net AAHUs compared to the analogous alternative that has pump station and avoided drought impacts (Cp and/or Bp alternatives). For example:

- BFR1 (no pump stations; droughts reduce project benefits) = 74+70+81 = 225
- BFR1+Bp (use of pump stations during drought years increases benefits) = 85+80+92 = 257

Table 4: Combinations of Final Array of Alternatives for CE/ICA Analysis

	Alternative	HEP (AAHU Gains)	Construction Estimate	PED	Construction Management	IDC	Adaptive Mgmt /Monitor (3%)	Total Project Cost	Annualized O&M	Annualized Cost	Cost per AAHU
	No Action	0	$-	$-	$-	$-	$-	$-	$-	$-	$-
1	BFR1	225	$3,243,000	$438,000	$234,000	$ 113,000	$97,000	$4,125,000	$14,800	$171,300	$762
2	BFR4	225	$3,058,000	$413,000	$220,000	$ 106,500	$92,000	$3,889,500	$14,800	$162,400	$722
3	BFR5	225	$2,857,000	$386,000	$206,000	$ 99,500	$86,000	$3,634,500	$14,800	$152,700	$679
4	BFR6	225	$2,765,000	$373,000	$199,000	$ 96,300	$83,000	$3,516,300	$21,800	$155,200	$690
5	BFR1-M1	237	$3,560,000	$481,000	$256,000	$ 124,000	$107,000	$4,528,000	$16,800	$188,600	$797
6	BFR4-M1	237	$3,374,000	$456,000	$243,000	$ 117,500	$101,000	$4,291,500	$16,800	$179,700	$758
7	BFR5-M1	237	$3,174,000	$429,000	$229,000	$ 110,600	$95,000	$4,037,600	$16,800	$170,000	$717
8	BFR6-M1	237	$3,082,000	$416,000	$222,000	$ 107,300	$92,000	$3,919,300	$23,700	$172,400	$727
9	BFR1-M2	255	$3,938,000	$531,000	$284,000	$ 137,100	$118,000	$5,008,100	$18,200	$208,200	$815
10	BFR4-M2	255	$3,752,000	$506,000	$270,000	$ 130,600	$113,000	$4,771,600	$18,200	$199,300	$782
11	BFR5-M2	255	$3,552,000	$479,000	$256,000	$ 123,700	$107,000	$4,517,700	$18,200	$189,600	$744
12	BFR6-M2	255	$3,459,000	$467,000	$249,000	$ 120,500	$104,000	$4,399,500	$25,200	$192,200	$754
13	M1	12	$317,000	$43,000	$23,000	$ 11,100	$10,000	$ 404,100	$1,900	$ 17,200	$1,433
14	M2	31	$695,000	$94,000	$50,000	$ 24,200	$21,000	$ 884,200	$3,400	$ 37,000	$1,194
15	M1-Cp	13	$990,000	$143,000	$76,000	$ 34,900	$30,000	$1,273,900	$19,006	$ 67,300	$5,177
16	M2-Cp	34	$1,368,000	$194,000	$103,000	$ 48,000	$41,000	$1,754,000	$20,506	$ 87,100	$2,562
17	BFR1-Bp	257	$3,916,000	$538,000	$287,000	$ 136,800	$117,000	$4,994,800	$31,906	$221,400	$861
18	BFR4-Bp	257	$3,731,000	$513,000	$273,000	$ 130,300	$112,000	$4,759,300	$31,906	$212,500	$827
19	BFR5-Bp	257	$3,530,000	$486,000	$259,000	$ 123,300	$106,000	$4,504,300	$31,906	$202,800	$789
20	BFR6-Bp	257	$3,438,000	$473,000	$252,000	$ 120,100	$103,000	$4,386,100	$38,906	$205,300	$799
21	BFR1-M1-Cp	238	$4,233,000	$581,000	$310,000	$ 147,800	$127,000	$5,398,800	$33,806	$238,700	$1,003
22	BFR4-M1-Cp	238	$4,048,000	$556,000	$296,000	$ 141,400	$121,000	$5,162,400	$33,806	$229,700	$965
23	BFR5-M1-Cp	238	$3,847,000	$529,000	$282,000	$ 134,400	$115,000	$4,907,400	$33,806	$220,000	$924
24	BFR6-M1-Cp	238	$3,755,000	$516,000	$275,000	$ 131,200	$113,000	$4,790,200	$40,806	$222,600	$935
25	BFR1-M2-Cp	259	$4,611,000	$632,000	$337,000	$ 161,000	$138,000	$5,879,000	$35,306	$258,400	$998
26	BFR4-M2-Cp	259	$4,426,000	$606,000	$323,000	$ 154,500	$133,000	$5,642,500	$35,306	$249,400	$963
27	BFR5-M2-Cp	259	$4,225,000	$579,000	$309,000	$ 147,500	$127,000	$5,387,500	$35,306	$239,700	$925
28	BFR6-M2-Cp	259	$4,133,000	$567,000	$302,000	$ 144,300	$124,000	$5,270,300	$42,306	$242,300	$936
29	BFR1-M1-Bp	269	$4,233,000	$581,000	$310,000	$ 147,800	$127,000	$5,398,800	$33,806	$238,700	$888
30	BFR4-M1-Bp	269	$4,048,000	$556,000	$296,000	$ 141,400	$121,000	$5,162,400	$33,806	$229,700	$854
31	BFR5-M1-Bp	269	$3,847,000	$529,000	$282,000	$ 134,400	$115,000	$4,907,400	$33,806	$220,000	$818
32	BFR6-M1-Bp	269	$3,755,000	$516,000	$275,000	$ 131,200	$113,000	$4,790,200	$40,806	$222,600	$828
33	BFR1-M2-Bp	288	$4,611,000	$632,000	$337,000	$ 161,000	$138,000	$5,879,000	$35,306	$258,400	$898
34	BFR4-M2-Bp	288	$4,426,000	$607,000	$323,000	$ 154,500	$133,000	$5,643,500	$35,306	$249,500	$866
35	BFR5-M2-Bp	288	$4,225,000	$580,000	$309,000	$ 147,600	$127,000	$5,388,600	$35,306	$239,800	$833
36	BFR6-M2-Bp	288	$4,133,000	$567,000	$302,000	$ 144,300	$124,000	$5,270,300	$42,306	$242,300	$841
37	BFR1-M1-Cp-Bp	270	$4,906,000	$681,000	$363,000	$ 171,700	$147,000	$6,268,700	$50,912	$288,800	$1,070
38	BFR4-M1-Cp-Bp	270	$4,721,000	$656,000	$349,000	$ 165,200	$142,000	$6,033,200	$50,912	$279,800	$1,036
39	BFR5-M1-Cp-Bp	270	$4,520,000	$629,000	$335,000	$ 158,200	$136,000	$5,778,200	$50,912	$270,200	$1,001
40	BFR6-M1-Cp-Bp	270	$4,428,000	$616,000	$328,000	$ 155,000	$133,000	$5,660,000	$57,912	$272,700	$1,010
41	BFR1-M2-Cp-Bp	291	$5,284,000	$732,000	$390,000	$ 184,800	$159,000	$6,749,800	$52,412	$308,500	$1,060
42	BFR4-M2-Cp-Bp	291	$5,099,000	$706,000	$376,000	$ 178,300	$153,000	$6,512,300	$52,412	$299,500	$1,029
43	BFR5-M2-Cp-Bp	291	$4,898,000	$679,000	$362,000	$ 171,400	$147,000	$6,257,400	$52,412	$289,900	$996
44	BFR6-M2-Cp-Bp	291	$4,806,000	$667,000	$355,000	$ 168,200	$144,000	$6,140,200	$59,412	$292,400	$1,005

BRF = Blue Fisher Rice System; M1 = Continental Grain Marsh plug; M2 = M1 + stoplog; Cp = Pump at Continental Grain Marsh; Bp = Pump at Blue Lake; Highlighted = Best Buy

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Appendix D: Habitat Evaluation Procedure

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix D

Contents

1 Introduction 3

2 Methods, Data and General Assumptions 3
2.1 Habitat Evaluation Procedures 3
2.2 Evaluation Species and Model Selection 3
2.3 Data Sources 3
2.3.1 Aerial Imagery and Light Detection and Ranging (LIDAR) 4
2.3.2 Bathymetry 4
2.3.3 Software 4
2.3.4 Evaluation Area Delineation 4

3 Migratory Habitat Model for Dabbling Ducks 7
3.1 Assumptions and Predictions 7
3.1.1 Existing Conditions 7
3.1.2 Future Without Project 7
3.1.3 Future With Project 8
3.2 Dabbling Duck Migration Model HSI Determination 8
3.3 Dabbling Duck Migration Model Results 9

4 References 11

LIST OF FIGURES

Figure 1 Blue Lake bathymetry 5
Figure 2 Fisher Lake bathymetry 5
Figure 3 Rice Lake bathymetry 6
Figure 4 Continental Grain Marsh bathymetry 6

LIST OF TABLES

Table 1 Dabbling Duck HEP Variables 8
Table 2 Habitat assessment for existing conditions (FWOP) and FWP conditions 10

1 Introduction

Habitat Evaluation Procedures (HEP) are used to evaluate and document habitat losses and habitat gains. The Migratory Habitat Model for Dabbling Ducks (Devendorf 2013) was the HEP model chosen to evaluate the potential benefits of alternative habitat improvement features (water control structures, ditch plug and pumps) for the Bass Ponds Habitat Rehabilitation and Enhancement Project. This appendix describes the data collection and evaluation methods, assumptions and results of this model in comparing habitat conditions existing and expected to occur in Blue, Fisher, and Rice Lakes and Continental Grain Marsh across alternatives.

2 Methods, Data and General Assumptions

2.1 Habitat Evaluation Procedures

The U.S. Fish and Wildlife Service's 1980 version of Habitat Evaluation Procedures (HEP) was used to quantify and evaluate potential project effects and benefits. The HEP methodology utilizes a Habitat Suitability Index (HSI) to rate habitat quality on a scale of 0 to 1 (1 being optimum). The HSI is multiplied by the number of acres of available habitat to obtain Habitat Units (HUs). One HU is defined as one acre of optimum habitat. HUs are calculated for the baseline conditions, future without-project (FWOP) conditions, and future with-project (FWP) conditions. HUs are summed across the economically analyzed project lifespan (50 years) and then averaged for each year to estimate average annual habitat units (AAHUs). The AAHUs of different project features and combinations of features (alternatives) can then be compared through an incremental cost analysis.

2.2 Evaluation Species and Model Selection

Selection of evaluation species for a project is an important component of measuring the potential benefits of a project and comparing benefits among different alternatives. The selected evaluation species should reflect the project's objectives and the ecological and economic values of the project area. The objectives developed for the project are to (1) increase the diversity and percent cover of desirable emergent aquatic plant species, (2) increase the diversity and percent cover of desirable submersed aquatic plant species, and (3) provide quality feeding and resting habitat for a wide variety of waterfowl and water birds with particular emphasis on fall migrating waterfowl. A wide variety of HEP models that assess the value of habitat for bird species are available and were reviewed with the project objectives in mind. The Dabbling Duck Migration Model for the Upper Mississippi River (Devendorf 2013) was selected to evaluate potential benefits of the proposed project. The model species represent the project objectives and the model components reflect the majority of the proposed habitat improvements.

2.3 Data Sources

Variables in the dabbling duck model required input from several available sources, as well as the collection, extrapolation and interpretation of additional data. Data inputs and their sources are discussed below.

2.3.1 Aerial Imagery and Light Detection and Ranging (LIDAR)

Aerial images from multiple sources and years, along with LIDAR data were used for many inputs to the habitat model. Multiple years of aerial imagery were examined to infer vegetation types and coverage, current lake conditions and surrounding land use. Images used were from fall time periods.

2.3.2 Bathymetry

Bathymetry from the project area was used to categorize water depths in the area of evaluation. Bathymetry data was collected in Blue, Fisher, and Rice Lakes and Continental Grain Marsh by the Corps of Engineers (Corps) in May of 2018. Bathymetry data was processed by the Corps.

2.3.3 Software

ArcMap version 10.3.1 for Microsoft Windows was used to examine, evaluate and present the various layers of spatial information used to develop suitability indexes for a variety of habitat variables. Spreadsheets developed in Microsoft Excel were used to store and analyze data. These outputs were incorporated in the Corps IWR Planning Suite software to conduct cost effectiveness and incremental cost analysis.

2.3.4 Evaluation Area Delineation

The boundary of the evaluation area used for the Dabbling Duck Migration Model was delineated to reflect the contiguous areas that have the potential for or are currently being used by ducks. The evaluation areas are limited to Blue, Fisher and Rice Lakes as well as Continental Grain Marsh. These evaluation areas comprise approximately 998 acres within the 2085 acre project area. A combination of aerial imagery and LIDAR elevation data was used to delineate areas that were likely to support wetland plants for ducks. Areas observed during site visits that contained vegetation reflective of areas often inundated corresponded with an elevation of approximately 700 feet above mean sea level (amsl). Figures 1 - 4 show the model evaluation area boundaries for Blue, Fisher and Rice Lakes and Continental Grain Marsh along with the bathymetry.

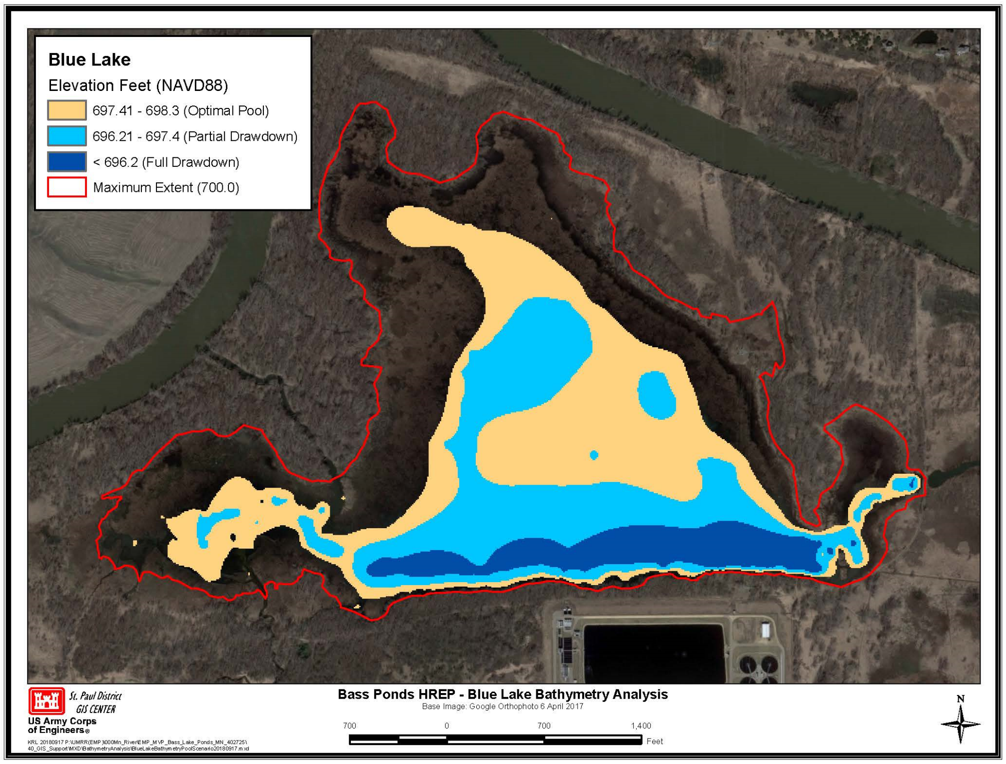


Figure 1. Blue Lake evaluation area and bathymetry

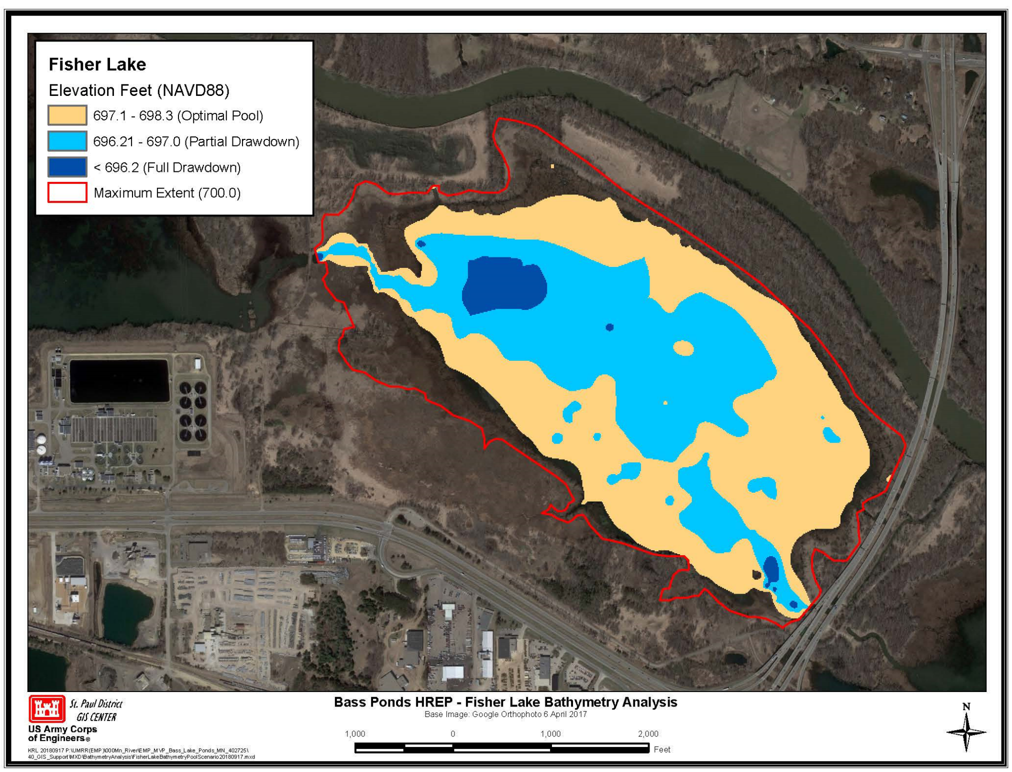


Figure 2. Fisher Lake evaluation area and bathymetry

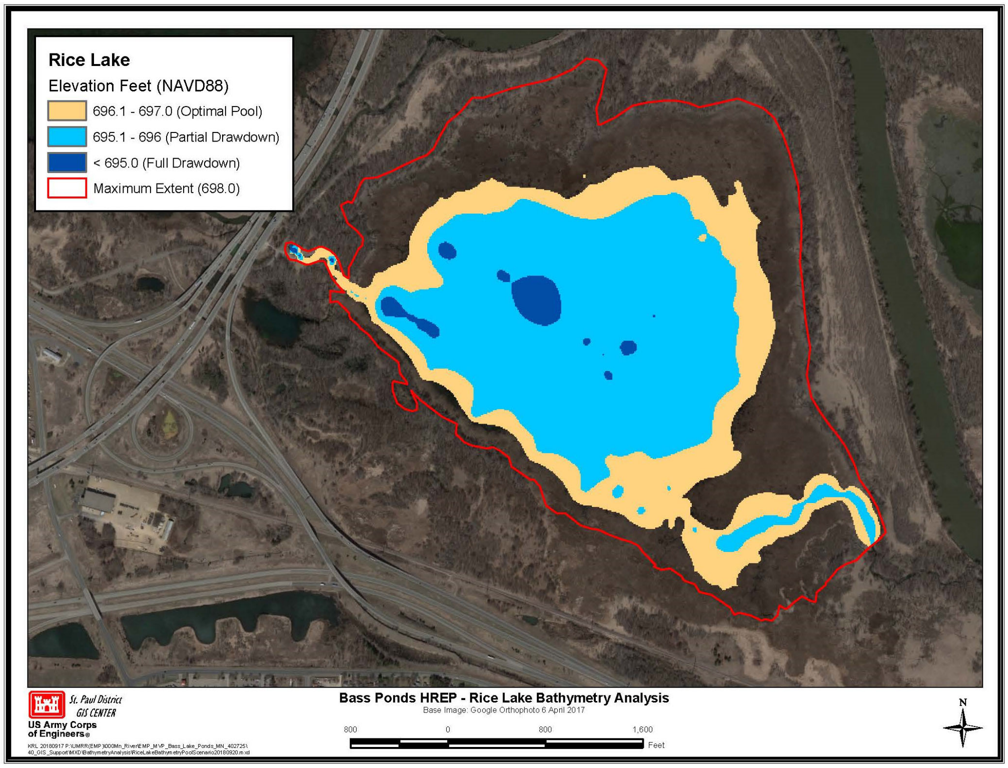


Figure 3. Rice Lake evaluation area and bathymetry

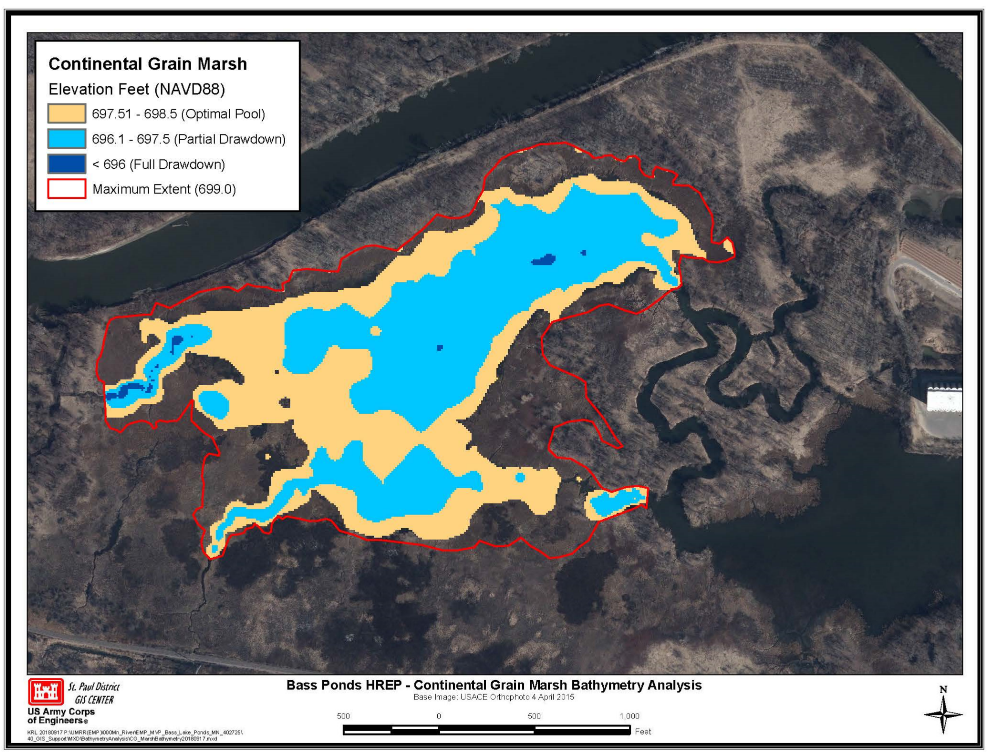


Figure 4. Continental Grain Marsh evaluation area and bathymetry

3 Migratory Habitat Model for Dabbling Ducks

3.1 Assumptions and Predictions

The Dabbling Duck Migration Model requires information regarding the type and extent of vegetation communities currently present and those predicted to be present in the evaluation area. Predictions were based on a number of assumptions explained below and were developed for existing conditions, FWOP conditions, and FWP conditions for each alternative.

Vegetation community grouping was based on criteria provided for Variable #6 of the Dabbling Duck Migration Model, and include the following categories:

- Woody Terrestrial
- Grasses/Forbs
- Emergents
- Rooted Floating Aquatics
- Rooted Floating Aquatics – Emergents
- Rooted Floating Aquatics – Submergents
- Emergents – Rooted Floating Aquatics – Submergents
- Submergents

3.1.1 Existing Conditions

Boundaries were delineated using a combination of on-site observations, interpretation from aerial imagery from multiple years and sources and LiDAR data. Areas of emergent vegetation included species such as bulrush, arrowhead, smartweed, wild rice and water hemlock. Submergent species found in the project area include a variety of pondweed species, wild celery, coontail, elodea and naiad. The project area is dominated by native species; however, small areas of invasive species can be found in the project area and include phragmites, reed canary grass, purple loosestrife and curly-leaf pondweed.

3.1.2 Future Without Project

Due to changes in climate and land-use, the hydrology in and around the project area has changed substantially over the years. Increased flows in the Minnesota River have increased the number of flood events within the project area. The frequency and duration of high water events has reduced aquatic plant diversity resulting in a reduction in habitat quality for migrating waterbirds. The current water control structures within the project area are constructed out of corrugated metal pipe (CMP) which typically does not last more than 20 years. One structure has already failed and the remainder are rusting, are clogged with debris and/or are undersized (see Figure 7 in the main report). The current structures are not expected to last for the 50-year period of analysis; therefore, the wetland plant communities in the project area are anticipated to remain in a degraded state throughout the 50-year planning timeframe (2020-2070). A degraded wetland plant community will affect the number of waterbirds utilizing the area. The timing of current water control structure failure is unknown; therefore, HUs for both existing conditions and FWOP are assumed to be the same. This approach is conservative and likely results in numbers that slightly underestimate the value of action alternatives.

3.1.3 Future With Project

The proposed water control structures and earthen plug will allow for water levels to be managed within the Bass Ponds study area. The refuge will be able to remove excess water from the lakes quickly following flood events. Water levels will gradually be lowered through the spring, maintained through the summer and raised in the fall. It is assumed that with the ability to control water levels and conduct yearly drawdowns, aquatic plant diversity and coverage will increase, resulting in an increase in the number and diversity of waterbird species utilizing the area.

3.2 Dabbling Duck Migration Model HSI Determination

The variables and maximum scores are listed in the table below (Table 1). The formulas for each model variable can be found in the original model documentation, and are therefore omitted from this report for the sake of brevity.

Table 1 Dabbling Duck Migration Model HEP Variables

	Variable	Max Score
1	Distance to bottomland hardwoods, species composition and water availability	5
2	Distance to cropland and cropland practices	5
3	Water depths 4-18 inches in fall	10
4	Water depths < 4 inches in fall	10
5	Percent open water	10
6	Plant community diversity	10
7	Important food plant coverage	10
8	Percent of the area containing loafing structures	5
9	Structures to provide thermal protection	5
10	Disturbance in the fall	10
11	Visual barriers	5
	Total	**85**

The Corps certified spreadsheet was used to calculate and document the HSI for each of the lakes (Blue, Fisher and Rice) both FWOP and FWP. For Continental Grain Marsh, HSI was calculated for FWOP and FWP for both the plug only and plug plus water control structure alternatives. Table 2 summarizes the values of each variable for each waterbody. The HSI for each was determined by the following equation:

$$\frac{V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 + V11}{\text{Max Score (85)}}$$

AAHUs under full project performance for each waterbody were calculated by multiplying the HSI value by the number of acres being evaluated. AAHU was calculated using the average HSI over the 50 year evaluation period, where HSI for year 1 was equal to FWOP, HSI for year 2 was 50% optimal conditions ((HSI FWOP + HSI FWP)/2), and HSI for years 3 – 50 was equal to FWP. The AAHU gain was then calculated by subtracting the AAHU for FWP from the AAHU for FWOP. To account for periodic droughts, the AAHU gain values were then adjusted to reflect a drought once every 8 years for Blue, Fisher and Rice Lakes (multiply AAHU by a factor of 0.875) and once every 10 years for Continental Grain Marsh (multiply AAHU by a factor of 0.9).

Frequency of droughts was determined by reviewing Minnesota River gauge data from 1980 – 2018. More information on the drought analysis can be found in Appendix F Section 8.3.2.3.

3.3 Dabbling Duck Migration Model Results

Habitat assessment for existing conditions (FWOP) and FWP conditions were completed for Blue, Fisher, and Rice Lakes as well as Continental Grain Marsh, and are summarized in Table 2, along with AAHU values (with and without drought). Net gains with and without drought ranged from 12 to 81 and 13 to 92 across evaluation areas, respectively. Using the AAHU net gains for each waterbody, the AAHU net gains for each alternative were calculated and are summarized in Table 3 of Appendix C.

Table 2 Habitat assessment for existing conditions (FWOP) and FWP conditions.

		Blue FWOP	Blue FWP	Fisher FWOP	Fisher FWP	Rice FWOP	Rice FWP	CGM FWOP	CGM FWP Plug	CGM FWP WLC
Dabbling Duck Migration Model Variables										
1 Distance to bottomland hardwoods, species composition & water availability	(max 5)	3	5	3	5	3	5	3	3	5
2 Distance to cropland & cropland practices	(max 5)	3	3	3	3	3	3	3	3	3
3 Water depth 4-18 inches in fall	(max 10)	4	10	8	10	8	10	4	8	10
4 Water depth <4 inches in fall	(max 10)	1	10	5	10	1	10	1	5	10
5 Percent open water	(max 10)	7	10	10	10	5	10	7	7	10
6 Plant community diversity	(max 10)	6	10	6	10	6	10	4	6	10
7 Important food plant coverage	(max 10)	4	10	4	10	4	10	4	6	10
8 Percent of area containing loafing structures	(max 5)	5	5	5	5	5	5	5	5	5
9 Structure to provide thermal protection	(max 5)	5	5	5	5	5	5	5	5	5
10 Disturbance in the fall	(max 10)	1	1	1	1	5	5	8	8	8
11 Visual barriers	(max 5)	5	5	5	5	5	5	5	5	5
TOTAL	(max 85)	44	74	55	74	50	78	49	61	81
HSI		0.52	0.87	0.65	0.87	0.59	0.92	0.58	0.72	0.95
Period of Evaluation Average HSI[1]			0.86		0.86		0.91		0.71	0.94
Dabbling Duck Migration Model HU Calculation										
Acres		248	248	370	370	287	287	93	93	93
Period of Evaluation (years)		50	50	50	50	50	50	50	50	50
Average Annual Habitat Units (AAHU)[2]		128	213	239	319	169	261	54	66	88
Net AAHU Gain without drought			85		80		92		13	34
Net AAHU Gain with drought[3]			74		70		81		12	31

[1]Average HSI for period of evaluation: HSI for year 1 = FWOP, HSI for year 2 = 50% optimal conditions ((HSI FWOP + HSI FWP)/2), HSI for years 3 – 50 = FWP

[2]AAHU was calculated using the average HSI over the 50 year evaluation period. AAHU rounded to the nearest whole number.

[3]Net AAHU Gain with drought was calculated by multiplying Net AAHU Gain without drought by a factor of 0.875 for Blue, Fisher and Rice Lakes and by 0.9 for Continental Grain Marsh.

4 References

Devendorf, R.D. 2013. A Dabbling Duck Migration Model for the Upper Mississippi River. U.S. Army Corps of Engineers, St. Paul District.

US Army Corps of Engineers ®
St. Paul District

Appendix E: Geotechnical and Water Quality

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix E: Geotechnical & Water Quality

TABLE OF CONTENTS

1 General 1

2 Geology 1

3 Geotechnical Design 1

- 3.1 Subsurface Exploration 1
- 3.2 Seepage and Stability 1
- 3.3 Settlement 1
- 3.4 Erosion Protection 1

4 Phase 1 HTRW 2

5 Water Quality 2

6 References 4

7 Attachments 4

LIST OF FIGURES

Figure 1: Lower Minnesota River Watershed Monitoring and Assessment Report • June 2017 Minnesota Pollution Control Agency 3

LIST OF TABLES

No table of figures entries found.

1 General

This appendix provides the geologic and geotechnical data, analysis, and computations for the Recommended Plan for the Bass Ponds, Marsh, and Wetland Habitat Restoration and Enhancement Project (Bass Ponds HREP). The report was based on developing sufficient geotechnical engineering and design to enable refinement of the project features, prepare the baseline cost estimate, and allow detailed design of the Recommended Plan. The geotechnical data includes existing borings for the project to define soil parameters. Discussion on analysis and computation to complete stability and settlement, borrow sites, and rock fill gradations. Some of the work is acknowledged to be completed during Preconstruction Engineering and Design (PED).

2 Geology

Bass Ponds HREP study area is located between Minnesota River miles 15 and 21, in the cities of Savage and Shakopee. The Minnesota River Valley trends northeast and is approximately 2.5 miles wide in the vicinity of the project. The study area includes three shallow lakes (less than 4 ft in depth) and adjacent wetland and marsh areas. See the Executive Summary in the Main Report for a map of the study area and background information.

The region surrounding the Bass Ponds HREP study area was glaciated extensively during the Pleistocene Epoch. Advancing and retreating glaciers laid down thick deposits of unsorted till and outwash sand that today form a hummocky, poorly-drained plain dotted with numerous marshes and small lakes. The glacial drift can reach thicknesses of between 200 and 250 feet, and it overlies dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations.

The wide valley of the present Minnesota River was carved by Glacial River Warren, which carried large volumes of water discharging from the now-extinct Glacial Lake Agassiz located in western Minnesota and eastern North Dakota. Glacial River Warren cut deeply into bedrock, scouring and reworking an earlier valley filled with outwash, stratified drift, and till. Episodic increases in flow caused Glacial River warren to cut lower into the older valley fill, leaving remnants of higher channel bottoms as terraces. When Lake Agassiz eventually ceased to drain to the south, the Minnesota River was formed by local drainage and established its present floodplain in the valley.

Three alluvial and bedrock terraces rise above this floodplain and form regionally prominent benches which parallel the river valley. The lower terrace is 30 to 50 feet above the floodplain, the middle terrace is 75 to 115 feet above the floodplain, and the upper terrace is 120 to 180 feet above the floodplain. The walls of the river valley form a bluff that grades into a hummocky, poorly-drained regional highland.

3 Geotechnical Design

The following section describes the subsurface exploration, and the geotechnical work expected to be completed for future Plans and Specifications.

3.1 Subsurface Exploration

The only borings completed in the project area were for the Rice Lake HREP, which is within the Bass Ponds HREP study area. A total of 4 borings were completed for the Rice Lake HREP, during the late 1990s. Three borings were taken along the Rice Lake ditch alignment and another boring was taken near the Minnesota River bank for determining slope stability. No undisturbed or environmental testing was done on the samples taken from the borings. The strength parameters were estimated from Standard Penetration Test results. The borings are included in Attachment E-1.

It is currently proposed that during PED, additional borings will be completed within dredge cuts to determine the dredge material and environmental condition of the soil. Additionally, borings would be proposed at each of the control structures to determine the foundation condition.

3.2 Seepage and Stability

Seepage and stability are not considered to be significant concerns for the Bass Ponds HREP. The project consists mostly of control structures, earthen plug, and ditch channels. As some exploration and testing are completed, some seepage and stability analysis may be completed to verify the earthen plug and ditch channel slopes. Past analysis from the Rice Lake HREP indicates that stability should not be an issue. Attachment E-2 contains stability results from the Rice Lake project for reference.

3.3 Settlement

The main concern with settlement will be at the control structures and the ditch plug. These structures are considered be relatively small structures. It is anticipated that settlement of these structures will be small and will not require remedial action. During PED and after soil exploration and testing, settlement of the structure will be analyzed to verify this assumption.

3.4 Erosion Protection

Erosion protection will be required for the control structures and earthen plug. The erosion protection will consist of riprap, a layer of bedding, and geotextile fabric. The final gradation and thicknesses will be further developed during PED. Additionally, material sources will also be developed at that time.

4 Phase 1 HTRW

See Appendix L for the HTRW evaluation.

5 Water Quality

The study area is located along the Minnesota River in the City of Mendota Heights-Minnesota River Aggregated 12-HUC subwatershed, which is in the eastern edge of the Lower Minnesota River Watershed.

Water quality in the Minnesota River mainstem has persistent problems with excess phosphorus, nitrate, sediment, bacteria, and other contaminants. The Minnesota River is the biggest contributor of sediment and nutrient pollution to the Mississippi River in Minnesota and is a significant contributor to the oxygen-depleted dead zone in the Gulf of Mexico (MPCA 2017).

The three lakes (Blue, Fisher, and Rice) and the Continental Grain Marsh are influenced by both the main stem Minnesota River as well as increased runoff from impervious surfaces and contamination from residential and industrial point source pollutants, such as, oil, grease, toxic chemicals, lawn fertilizers, chloride, and elevated bacteria concentrations from pet waste. In addition, storm sewer runoff along the adjacent steep slopes of the Minnesota River bluffs threatens slope stability and serves as another source of sediment to the project area (LMRWD, 2018 Draft).

According to the 2017 MPCA assessment report, the most common impairments in the project's subwatershed as shown in Figure 1 below are: nutrients, mercury, E-coli, turbidity and fish and invertebrate Index of Biotic Integrity (IBI).

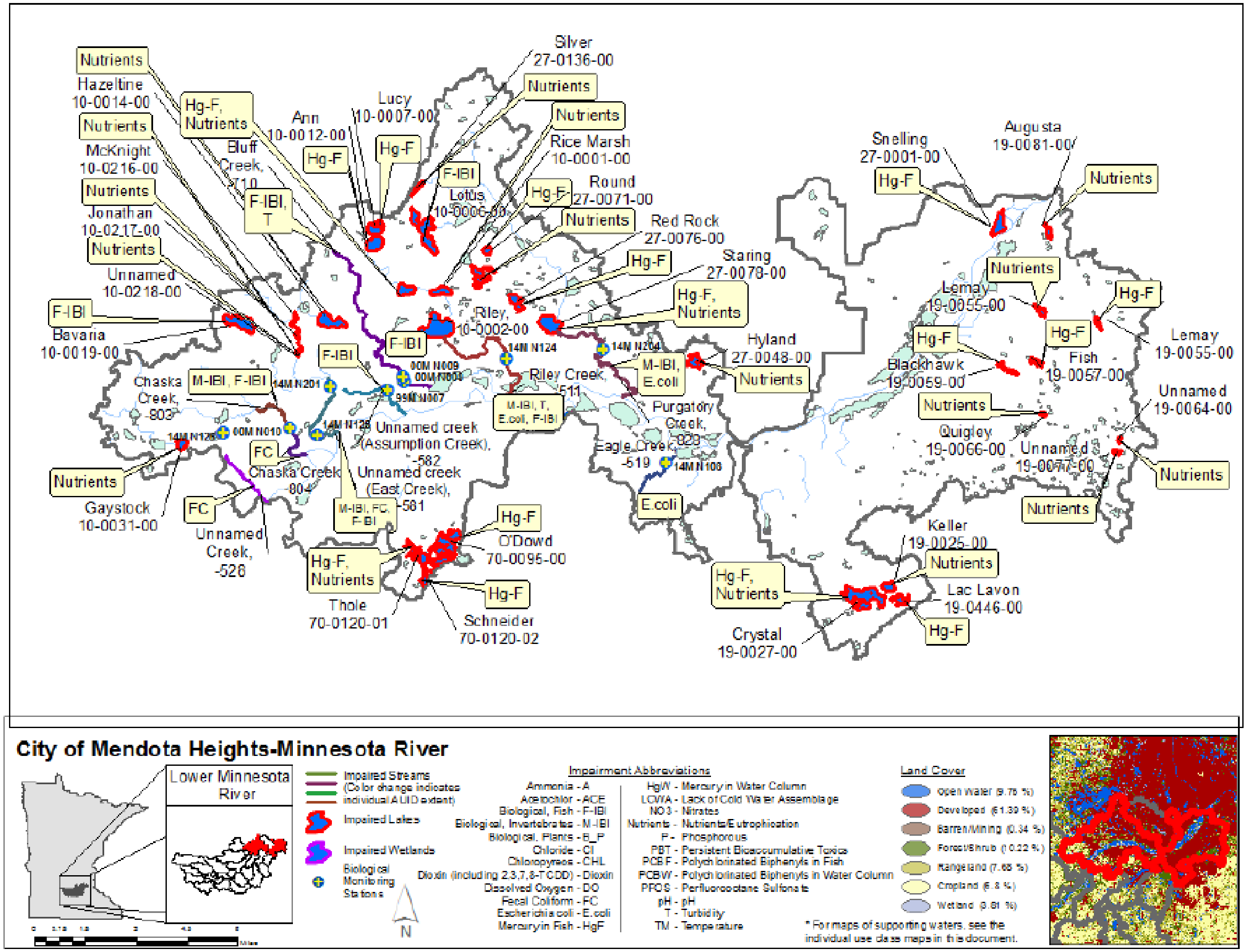


Figure 1: Lower Minnesota River Watershed Monitoring and Assessment Report • June 2017 Minnesota Pollution Control Agency

Although the lakes in the project area were not specifically addressed by the MPCA's 2017 Lower Minnesota watershed assessment report, 64 lakes in the City of Mendota Heights Subwatershed were reviewed for aquatic recreation use and only two basins were added to the impaired list of 18 basins that were previously listed impaired for aquatic recreation use based on nutrient data.

Adjacent to the project area, Eagle Creek was assessed favorably with good stream habitat scores but impacts from surrounding residential development and storm water runoff may be elevating Total Suspended Solids (TSS) levels during storm events and some high bacteria concentrations have triggered aquatic recreation use impairment on Eagle Creek. In 2018, a Lower Minnesota River Watershed District Capital Improvement Project was initiated for the East Branch of Eagle Creek to restore approximately 2,400 feet of stream and repair erosion under the 128 Street Bridge. Since 1999, the Watershed District, in cooperation with Metropolitan Council Environmental Services (MCES) and Scott Soil Water Conservation District (SWCD), has operated a stream monitoring station on Eagle Creek.

6 References

USACE. Definite Project Report/Environmental Assessment Rice Lake, 1994.

Lower Minnesota River Watershed Monitoring and Assessment Report - June 2017 Minnesota Pollution Control Agency https://www.pca.state.mn.us/sites/default/files/wq-ws3-07020012b.pdf

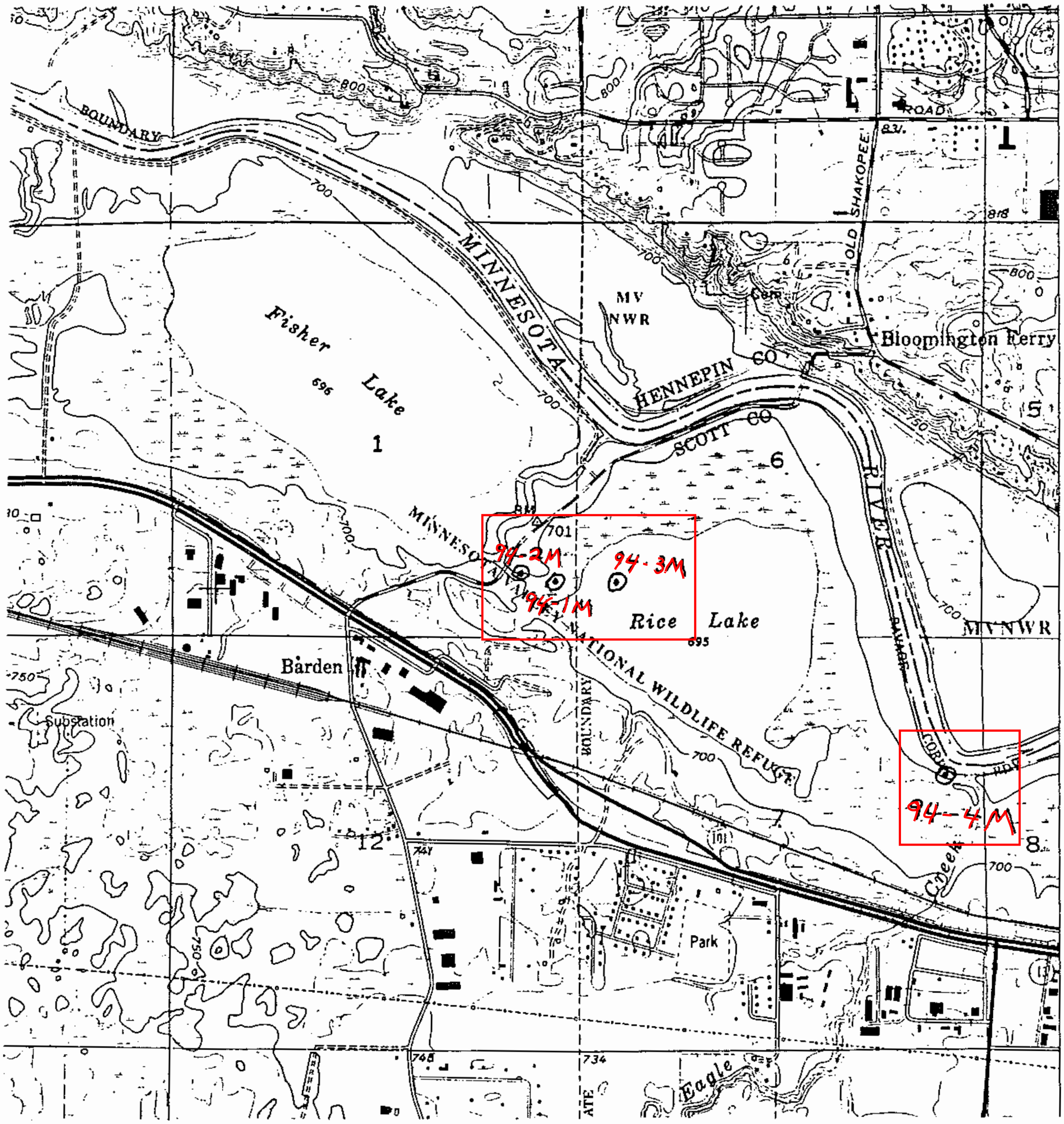
Lower Minnesota River Watershed DRAFT WATERSHED MANAGEMENT PLAN - June, 2018.

7 Attachments

Attachment E-1: Rice Lake Borings
Attachment E-2: Rice Lake Stability Analysis

Attachment E-1: Rice Lake Borings

Bass Ponds - Existing Soil Exploration for Rice Lake Project



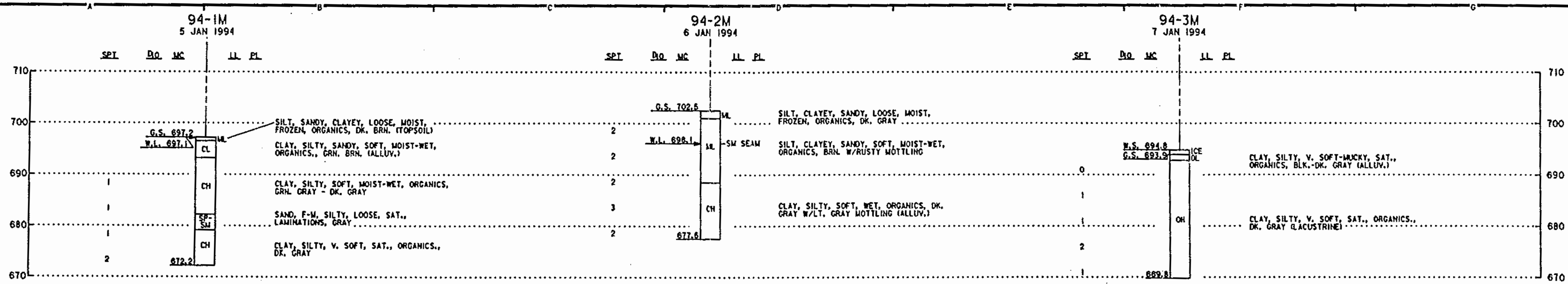
0 2000 ft.
Scale

Rice Lake MVNWR

Boring Locations

HREP/EMP

Bass Ponds - Existing Soil Exploration for Rice Lake Project



NOTES (94-1M)

1. WATER LEVEL DETERMINED AFTER 40 MINUTES:
   BOTTOM OF AUGER AT EL. 683.2
   BOTTOM OF HOLE AT EL. 682.2.
2. HOLLOW STEM AUGER SET TO EL. 683.2. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 683.2.
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. HOLE BACKFILLED WITH TREMMIED CEMENT-BENTONITE GROUT.

NOTES (94-2M)

1. WATER LEVEL DETERMINED AFTER 60 MINUTES:
   BOTTOM OF AUGER AT EL. 687.5
   BOTTOM OF HOLE AT EL. 687.5
2. HOLLOW STEM AUGER SET TO EL. 682.5
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. HOLE BACKFILLED WITH BENTONITE CHIPS-PORTLAND CEMENT

NOTES (94-3M)

1. WATER LEVEL DETERMINED FROM LAKE LEVEL
2. 4" STEEL CASING SET TO 690.8. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 690.8.
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. PULLED CASING AND ALLOWED HOLE TO HEAVE.

GENERAL BORING LEGEND

Symbol	Description
84-1M	YEAR OF BORING-BORING NUMBER, BORING TYPE (EG: M=MACHINE, A=AUGER, TP=TEST PIT, P=PIEZOMETER).
1 MAY 1984	DATE OF BORING
G.S. 1020.2	GROUND SURFACE ELEVATION AT BORING
GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES
GP	POORLY GRADED GRAVELS, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
MH	INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50
CL	INORGANIC CLAYS, LOW TO MED. PLASTICITY, LIQUID LIMIT LESS THAN 50
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50
OH	ORGANIC SILTS OR CLAYS, MED. TO HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
PT	PEAT
SP-SM	BORDERLINE MATERIAL
SP& SM	STRATIFIED MATERIAL
1	LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE
	NO RECOVERY
W.L. 726.7	WATER LEVEL ON DATE OF BORING
700.0	ELEVATION AT BOTTOM OF BORING

GENERAL BORING NOTES

1. GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.
2. MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE LEFT OF THE BORING STAFF.
3. BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12". STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1⅜" X 2" SAMPLER, 140 LB. HAMMER AND A 30" DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT OF DROP ARE AS SHOWN.
4. ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING STAFF.
5. D_{10} SIZE: THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.
6. RQD: ROCK QUALITY DESIGNATION (RQD) IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. RQD IS THE PERCENT RECOVERY CONSISTING OF UNBROKEN PIECES LONGER THAN 4".
7. % RECOVERY: PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF. PERCENT RECOVERY IS LENGTH OF CORE RECOVERED/LENGTH OF CORE CUT X 100. UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4" DIAMETER.
8. ELEVATIONS REFERENCED TO N.G.V.D., 1929 ADJUSTED.
9. THE BORINGS SHOW SUMMARIES OF INFORMATION RECORDED ON THE ORIGINAL FIELD LOGS. THESE LOGS ARE AVAILABLE FOR INSPECTION AT THE ST. PAUL DISTRICT OFFICE. ARRANGEMENTS TO INSPECT LOGS CAN BE MADE BY CALLING (612) 290-5599.

GEN ENG
HYD
HYDR
GEOTECH
STR ENG
MEA

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DEFINITE PROJECT REPORT/ENVIRONMENTAL ASSESSMENT
MINNESOTA VALLEY NATIONAL WILDLIFE REFUGE
ENVIRONMENTAL MGMT. PROGRAM - MINNESOTA RIVER
RICE LAKE HREP — SCOTT CO., MINNESOTA
GEOLOGICAL DATA
BORING LEGEND, GENERAL NOTES AND BORING LOGS
94-1M THRU 94-3M

PE-D	DESIGNED:	JJF
PE-D	CHECKED:	GAR
PE-D	DRAWN:	PAW
PE-M	DESIGNED:	
PE-M	CHECKED:	

DATE: DECEMBER 1994 | CAD FILE NAME: RICESHO1.DGN | SOL. NO.: DACW37-94-B-0000 | DRAWING NUMBER: PLATE 2 | SHT 1 OF 2

Bass Ponds - Existing Soil Exploration for Rice Lake Project

NOTES

1. WATER LEVEL DETERMINED AFTER 2 HOURS:
   BOTTOM OF AUGER AT EL. 691.5
   BOTTOM OF HOLE AT EL. 689.3
2. HOLLOW STEM AUGER SET TO EL. 687.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 687.5.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

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SYMBOL	DESCRIPTION	DATE	APPROVAL

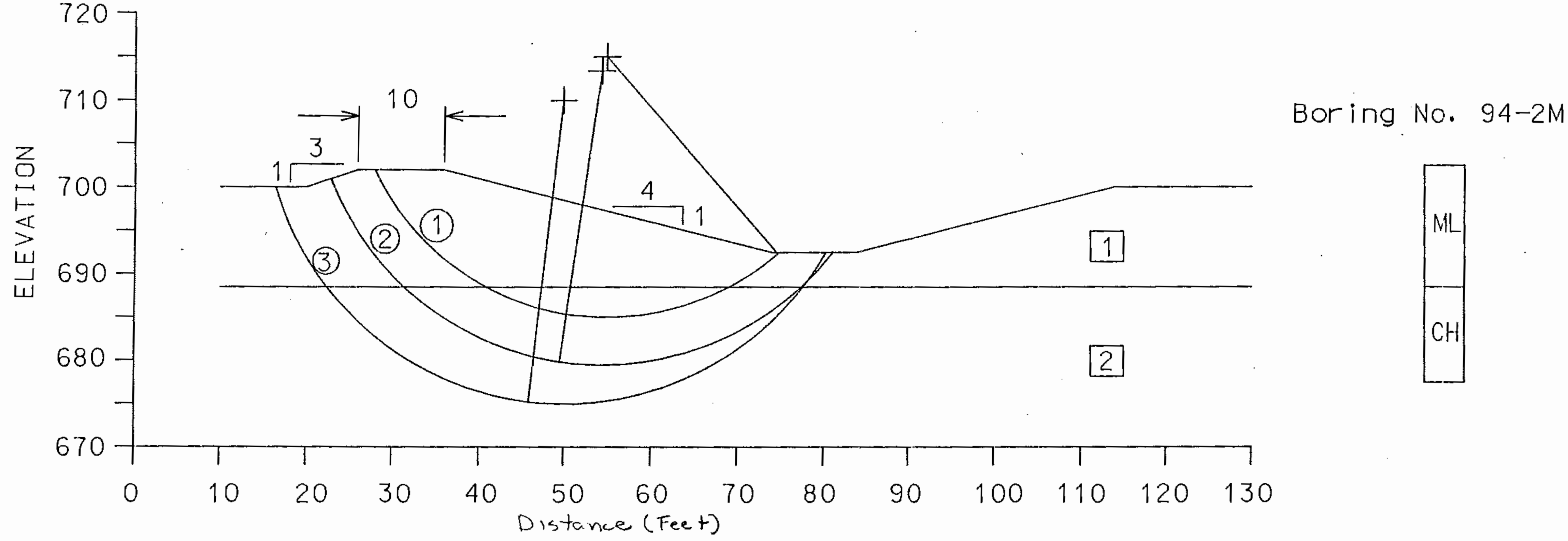
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DEFINITE PROJECT REPORT/ENVIRONMENTAL ASSESSMENT
MINNESOTA VALLEY NATIONAL WILDLIFE REFUGE
ENVIRONMENTAL MGMT. PROGRAM - MINNESOTA RIVER
RICE LAKE HREP SCOTT CO., MINNESOTA
GEOLOGICAL DATA
BORING LEGEND, GENERAL NOTES AND BORING LOGS
94-4M

PE-O: DESIGNED: JJF; CHECKED: GAR; DRAWN: PAW
PE-H: DESIGNED:; CHECKED:
DATE: DECEMBER 1994
CAD FILE NAME: RICESH02.DGN
SOL. NO.: DACW37-93-B-0000
DRAWING NUMBER: PLATE 3
SHT 2 OF 2

Attachment E-2: Rice Lake Stability Analysis



END OF CONSTRUCTION TABULATION OF ARC DATA

ARC NO.	CENTER COORDINATES X	Y	RADIUS	FACTOR OF* SAFETY
①	55.0	715.0	30.0	1.4
②	54.4	713.4	33.9	1.3
③	50.0	710.0	35.0	1.4

* - REQUIRED FACTOR OF SAFETY IS 1.3

SOIL PARAMETERS

SOIL NO.	DESCRIPTION	UNIT WEIGHT MOIST	SATURATED	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
1	SILT	110.0	115.0	180	0
2	CLAY	110.0	110.0	185	0

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CHANNEL STABILITY

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DATE: 15 DEC. 1994
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SPEC NO:
PLATE NUMBER: 6-4
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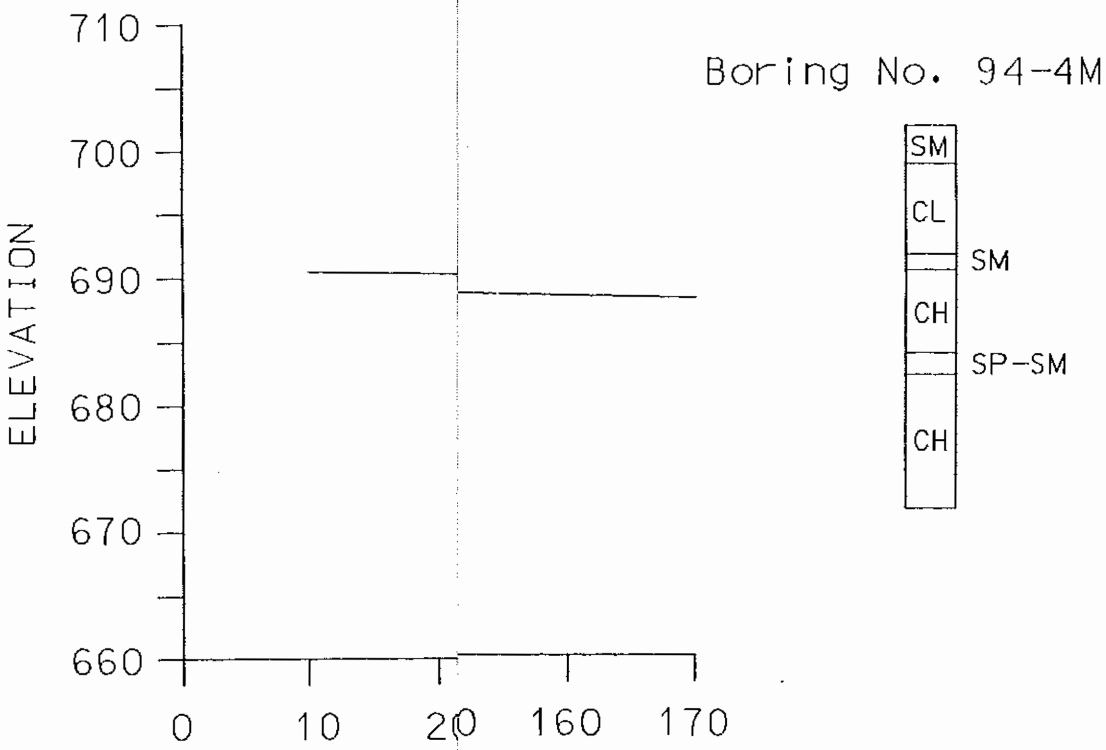

T PARAMETERS

ARC NO.	CENTER COORDINA X	Y	TED	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
①	109.0	713.	5.0	0	28
②	108.0	708.	0.0	320	0
③	107.0	704.			

✳ – REQUIRED FA

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PLUG OF NATURAL OUTLET STABILITY

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DESIGNED:
CHECKED:
DATE: 15 DEC. 1994

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PLATE NUMBER: 6-5
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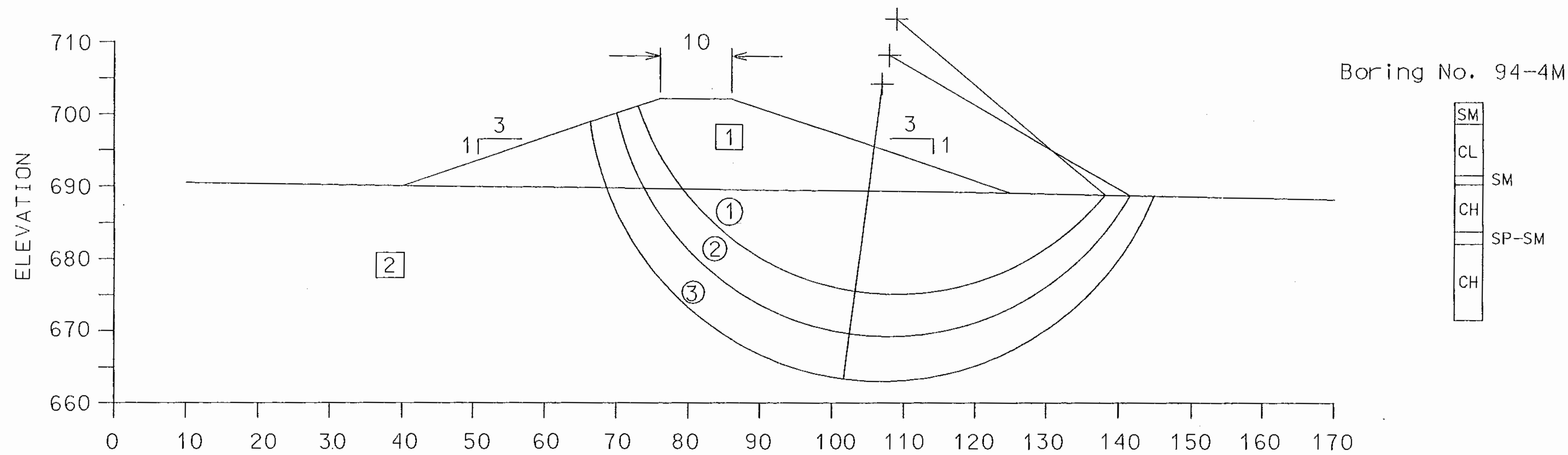
OF



END OF CONSTRUCTION TABULATION OF ARC DATA

ARC NO.	CENTER COORDINATES X	Y	RADIUS	FACTOR OF* SAFETY
①	109.0	713.0	38.0	1.32
②	108.0	708.0	38.8	1.30
③	107.0	704.0	41.0	1.35

* - REQUIRED FACTOR OF SAFETY IS 1.3

SOIL PARAMETERS

SOIL NO.	DESCRIPTION	UNIT WEIGHT MOIST	SATURATED	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
1	SANDFILL	120.0	125.0	0	28
2	CLAY	100.0	100.0	320	0

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RICE LAKE HREP SCOTT CO., MINNESOTA

PLUG OF NATURAL OUTLET STABILITY

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DESIGNED:
CHECKED:
DATE: 15 DEC. 1994

CAD FILE NAME:
SPEC NO:
PLATE NUMBER: 6-5
SHT OF

US Army Corps of Engineers ®
St. Paul District

Appendix F: Hydrology & Hydraulics

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix F

TABLE OF CONTENTS

1 Introduction 5

2 Existing Conditions 5

3 Study Alternatives Considered 9

4 Recommended Plan 15
4.1 Recommended Plan - Lakes 15
4.2 Recommended Plan – Continental Grain Marsh 15
4.3 Identified Risks 18

5 Hydrology 24
5.1 Discharge – Frequency, Discharge - Duration 24
5.2 Climate Change Assessment 27

6 Sedimentation 55

7 Hydraulics 57
7.1 Future without Project 57
7.2 Flood Stage Impacts 58
7.3 Ground Water 58

8 Hydraulic Modeling/Design 59
8.1 HEC-RAS Inputs 60
8.2 HEC-RAS Results 64
8.3 Project Feature Potential – Drawdown, Drought and Major Flooding Analysis at Project Area 71

9 Refuge Summary 80
9.1 Major Flooding 80
9.2 Recommended Plan Structure Drawdown 81

10 References 83

LIST OF FIGURES

Figure 1: Blue/Fisher/Rice Lake Existing Conditions Flow Path Diagram- Flood & Drawdown Operation 7
Figure 2: Continental Grain Marsh Existing Conditions Flow Path Diagram 8

Figure 3: Blue/Fisher/Rice Lake Post-Project Major Flooding Flow Path Diagram..................... 10
Figure 4: Blue/Fisher/Rice Lake Post-Project Drawdown Flow Path Diagram............................ 11
Figure 5: Continental Grain Marsh Post-Project Major Flooding Flow Path Diagram................. 13
Figure 6: Continental Grain Marsh Post-Project Drawdown Flow Path Diagram........................ 14
Figure 7: Bass Ponds HREP – Recommended Plan 17
Figure 8: Magellan Pipeline Location and Right of Way with Respect to Survey Data Points.... 19
Figure 9: Fiber Optic Cable Location 20
Figure 10: Silted Stoplog Structure and Overflow Located on Cargill Private Property 21
Figure 11: Valleyfair Wetland Mitigation Grading Plan from Barr Engineering 23
Figure 12: Minnesota River near Jordan, MN Analytical Frequency Curve (Minnesota River Integrated Watershed Study – Discharge and Elevation Frequency Update, 2017).................. 25
Figure 13: Rating Curve for USGS Gage at Jordan, MN (05330000) Based on the Full Period of Record (1935-2018).. 26
Figure 14: Projected Changes for the Middle of the Current Century (2041-2070) Relative to the End of the Last Century (1971-2000). (Figure source: NOAA NCDC / CICS-NC)...................... 30
Figure 15: Summary of climate trends and literary consensus (USACE, 2015) 31
Figure 16: Location of Project Area within HUC2 and HUC4.. 32
Figure 17: Range of Projected Annual Maximum Monthly Streamflow among Ensemble of 93 Climate-Changed Hydrology Models, HUC 0702 Minnesota... 32
Figure 18: Mean Projected Annual Maximum Monthly Streamflow, HUC 0702 Minnesota. Trendline Equation: Q = 9.69702*[Water Year] – 8918.99, p <0.0001 33
Figure 19: Projected Vulnerability for the Minnesota (0702) with respect to Ecosystem Restoration... 35
Figure 20: Projected Vulnerability for the Minnesota (0702) with respect to Flood Risk Reduction 36
Figure 21: Nonstationary Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014.. 40
Figure 22: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014.. 41
Figure 23: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1990 to 2014.. 42
Figure 24: Peak Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017.. 43
Figure 25: Nonstationary Analysis of Average Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2017 using the Time Series Toolbox 44
Figure 26: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1981 Breakpoint 45
Figure 27: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1990 Breakpoint 45
Figure 28: NOAA National Climatic Data Center MSP Station Location.................................... 46
Figure 29: Nonstationary Analysis of Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox 48
Figure 30: Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 & Subsets of Data Selected Based on the 1976 Nonstationarity.. 49
Figure 31: Nonstationary Analysis of Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox... 50
Figure 32: Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 with Trend Lines for the 1997 Breakpoint 51
Figure 33: MNDNR Minnesota Spring Inventory for the Bass Ponds Project Area..................... 59
Figure 34: Minnesota River Cross Sections with Channel Bathymetry Surveyed in 2013 and 2015 61

Figure 35: HEC-RAS 2D Model Layout 63
Figure 36: Bathymetry Map with Respect to Operating Conditions 65
Figure 37: Rice Fill Operating Scenario using 2012 USGS Gage Data 67
Figure 38: Fisher Fill Operating Scenario using 2012 USGS Gage Data 69
Figure 39: Inundation Area at the Project Area at River Stage 704.5 feet (RM 20) – Major Flooding Condition 74
Figure 40: Period of Record Analysis (Mean Daily Data) with Major Flooding and Successful Full Drawdown Reference 76
Figure 41: Number of days and events each year that the discharge at the Jordan, MN USGS gage (Gage Number 05330000) exceeded 26,600 cfs from 1935 to 2018 77
Figure 42: Operation Water Surface Elevation Inundation Areas 82

LIST OF TABLES

Table 1: Summary of Existing Water Level Management Structures in the Study Area – Flood & Drawdown Operation 6
Table 2: Minnesota River near Jordan, MN Analytical Flow Frequency Summary Table (Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update, 2017) 24
Table 3: Annual Peak Discharge Frequency Analysis with Corresponding Stage 27
Table 4: Projected Vulnerability with respect to Ecosystem Restoration 35
Table 5: Comparison of Different Indicators for the Minnesota Watershed with respect to Ecosystem Restoration 35
Table 6: Projected Vulnerability with respect to Flood Risk Reduction 36
Table 7: Comparison of Different Indicators for the Minnesota Watershed with respect to Flood Risk Reduction 37
Table 8: Select large dams within the Minnesota River Basin 38
Table 9: Nonstationarities Detected Using Maximum Annual Flow 39
Table 10: Nonstationarities Detected Using Average Annual Flow 44
Table 11: Nonstationarities Detected Using Total Annual Precipitation 47
Table 12: Nonstationarities Detected Using Average Annual Air Temperature 50
Table 13: Bass Ponds Climate Risks 54
Table 14: Floodplain Sediment Deposition Estimates on the Lower Minnesota River Based on Four Different Methods or Studies 56
Table 15: Flood Stage Impacts: Existing and Proposed Structure 58
Table 16: Wastewater Treatment Plant Input Values into Blue Lake 60
Table 17: HEC-RAS Input - NLCD Land Type Manning's n Values 61
Table 18: Lake Condition vs Lake Elevation 64
Table 19: Volume of Water Discharged during Full Drawdown Scenario (Optimal Pool to Full Drawdown Elevation) 64
Table 20: River Receded - HEC-RAS and Nomograph Results Comparison 70
Table 21: Marsh Conditions vs Marsh Elevation 70
Table 22: Continental Grain Marsh Drawdown results using Culvert Nomographs 71
Table 23. Period of Record Analysis Conditions 73
Table 24: Successful Drawdown Summary (30-day Duration, prior to Mid-July) based on the period of record at the Jordan Gage 79
Table 25: Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs or less at Jordan) 80
Table 26: NWS Flood Categories at USGS Gage at Jordan, MN 81
Table 27: Lake/Marsh Water Surface Elevations (Feet - NAVD 88) 81
Table 28: Maximized Drawdown Time (River Receded to 10,000 cfs) 81

1 Introduction

The study area includes three lakes and a marsh, situated southwest of St. Paul, Minnesota adjacent to the Minnesota River. Currently the lakes, wetlands, and marshes experience prolonged full pool conditions with depths of 3-to-4 feet throughout the year. The lack of seasonal variability in water levels has resulted in a degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity, and the availability of quality habitat for migratory waterbirds and waterfowl. The objectives of the project are to increase the diversity and percent cover of desirable emergent and submergent aquatic plant species and to provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds.

2 Existing Conditions

The study area includes three interconnected backwater lakes (Blue, Fisher, and Rice) and Continental Grain Marsh. There are currently eight existing structures in this system. Seven of the existing structures no longer function as intended and/or do not operate effectively for the current desired management of the system. Almost all of the existing structures are deteriorating, no longer functional, or are frequently clogged with debris. Table 1 presents the structure location and condition of the current structures.

During major flood events, the Minnesota River natural levees, which enclose the project are overtopped resulting in complete inundation of the study area. During low flows, the lakes are largely isolated from Minnesota River inputs and water recedes by passing through water level management structures. Under current conditions, most often the flow path throughout the system starts with water entering Blue Lake from the Minnesota River through the Blue Lake control structure (when the river is at or above the invert of the culvert, 692.5). The water then can be inputted into Fisher Lake through the Interlake structure between Blue Lake and Fisher Lake. The Fisher Lake structure is completely collapsed which has resulted in the erosion of an adjacent Department of Transportation (DOT) holding pond natural levee separating the pond and the lake, as well as the displacement of a DOT culvert. Water currently flows out of Fisher Lake through eroded ditches and then out to the Minnesota River. At present, Rice Lake is frequently managed separately due to the existing conditions of the surrounding structures. Rice Lake flows into the secondary pond and then out the secondary structure to the Minnesota River. The Blue Lake Structure and the Interlake Structure operate as both an inlet and outlet depending on the river flow conditions. An existing conditions flow path diagram can be viewed in Figure 1.

Continental Grain Marsh currently drains into Eagle Creek (designated trout stream) briefly before flowing out into the Minnesota River. This is due to a blown out beaver dam that had been previously plugging this outlet and holding water in the marsh. An existing conditions flow path diagram can be viewed in Figure 2.

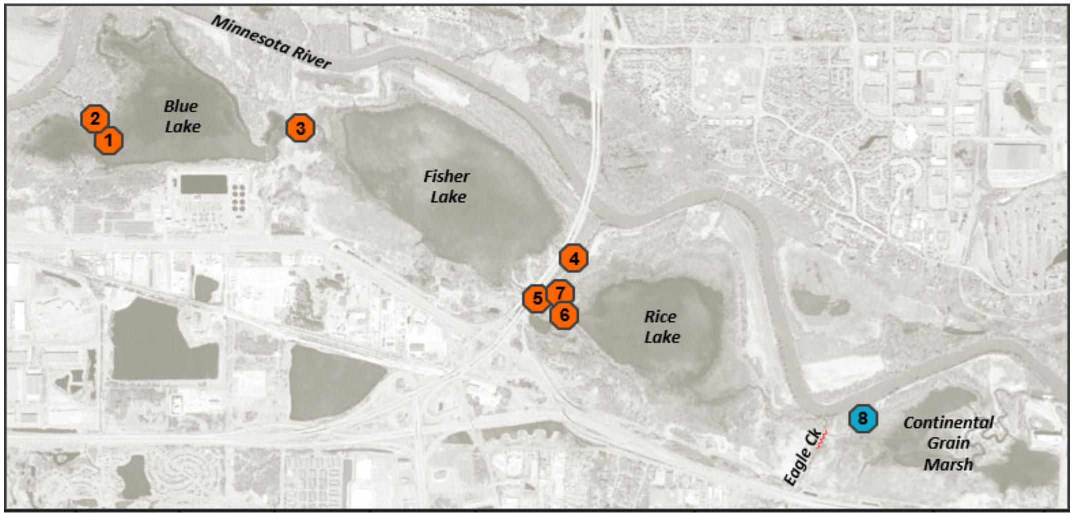


Table 1: Summary of Existing Water Level Management Structures in the Study Area – Flood & Drawdown Operation

	Structure Location	Structure Name	Type	Size	Material	Year Built	Structure Objective	Condition	Currently meets Objective	Projected to meet objective over 50 year Project Life
1	Blue Lake	Blue Lake	Gated Stoplog	10x8 ft	Metal	1985[1]	Drawdown Blue Lake	High O&M, design difficulties	**Partial**	**No**
2	Blue Lake	Blue Lake	Culvert	84 in	Metal	1985[1]	Road crossing for O&M	Rusting, high debris	**Yes**	**No**
3	Blue Lake-Fisher Lake	Interlake	Stoplog	30 in	Metal	1985[1]	Move water from Blue to Fisher Lake	Unable to fill Fisher or Rice (invert 3ft higher), undersized	**No**	**No**
4	Fisher Lake	North Fisher Lake	Stoplog	36 in	Metal	1985[1]	Move water from Fisher to Minnesota River	Silted in, does not pass flows	**No**	**No**
5	Fisher Lake	South Fisher Lake	Stoplog	36 in	Metal	Unknown	Drawdown Fisher, Fill Rice Lake	Collapsed, undersized	**No**	**No**
6	Rice Lake	Rice Lake	Stoplog	42 in	Metal	1998	Drawdown/Fill Rice Lake	Rusting, undersized	**Yes**	**No**
7	Secondary Pond	Secondary Outlet	Stoplog	48 in	Metal	Unknown	Move water from Fisher to Rice Lake[3]	Rusting, clogged with debris, undersized	**Yes**	**No**
8	Continental Grain Marsh	Con Grain Marsh[2]	Overflow	30x100 ft	Rock	1998	Maximum level of marsh	Silted, does not impact functionality	**Yes**	**Yes**

[1]MNDNR Permit #85-6039; [2]Rice Lake HREP feature, [3] The Secondary Outlet Structure is designed to move water from Fisher to Rice Lake is not used during drawdown or flood operation.

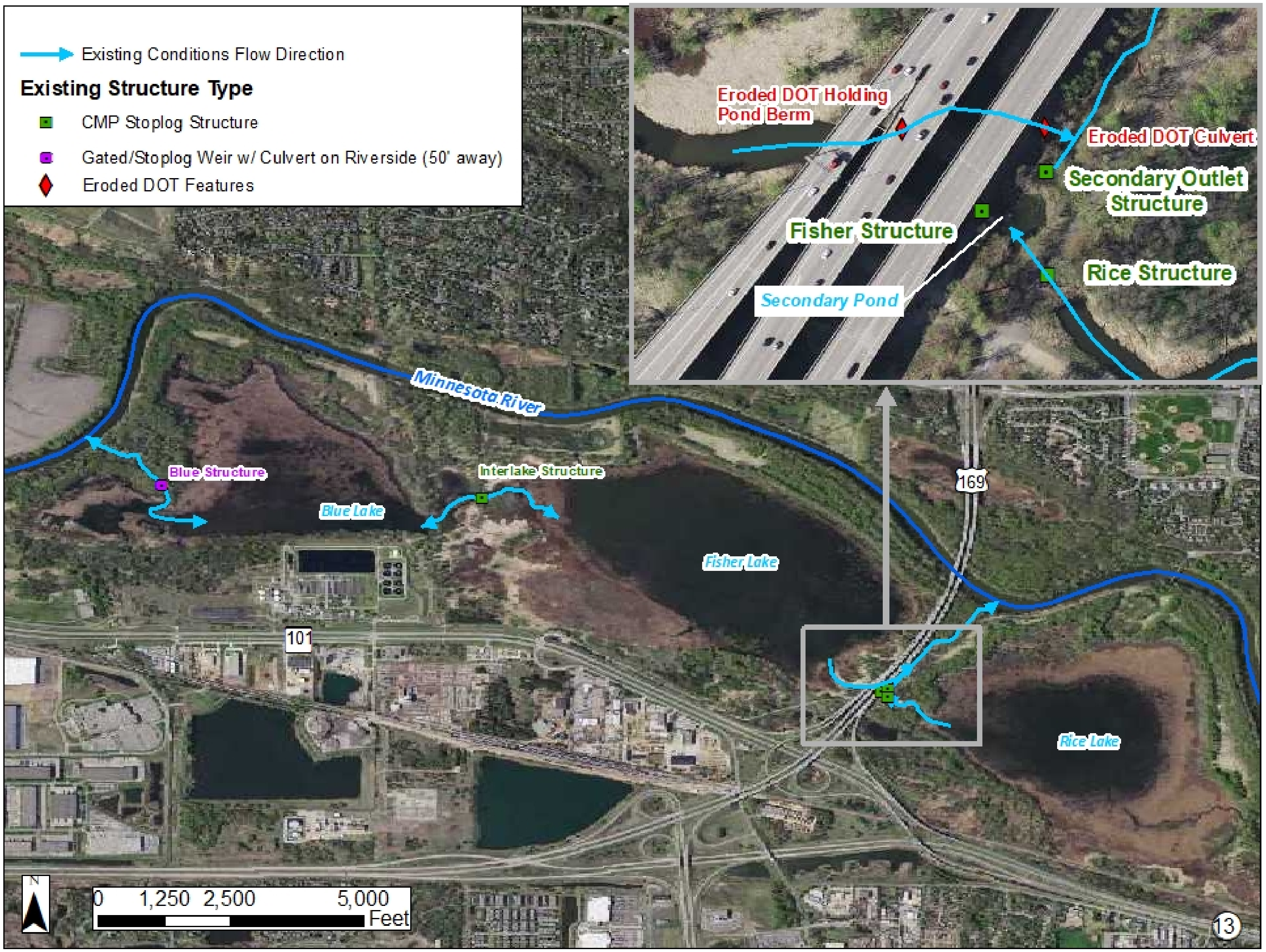


Figure 1: Blue/Fisher/Rice Lake Existing Conditions Flow Path Diagram- Flood & Drawdown Operation

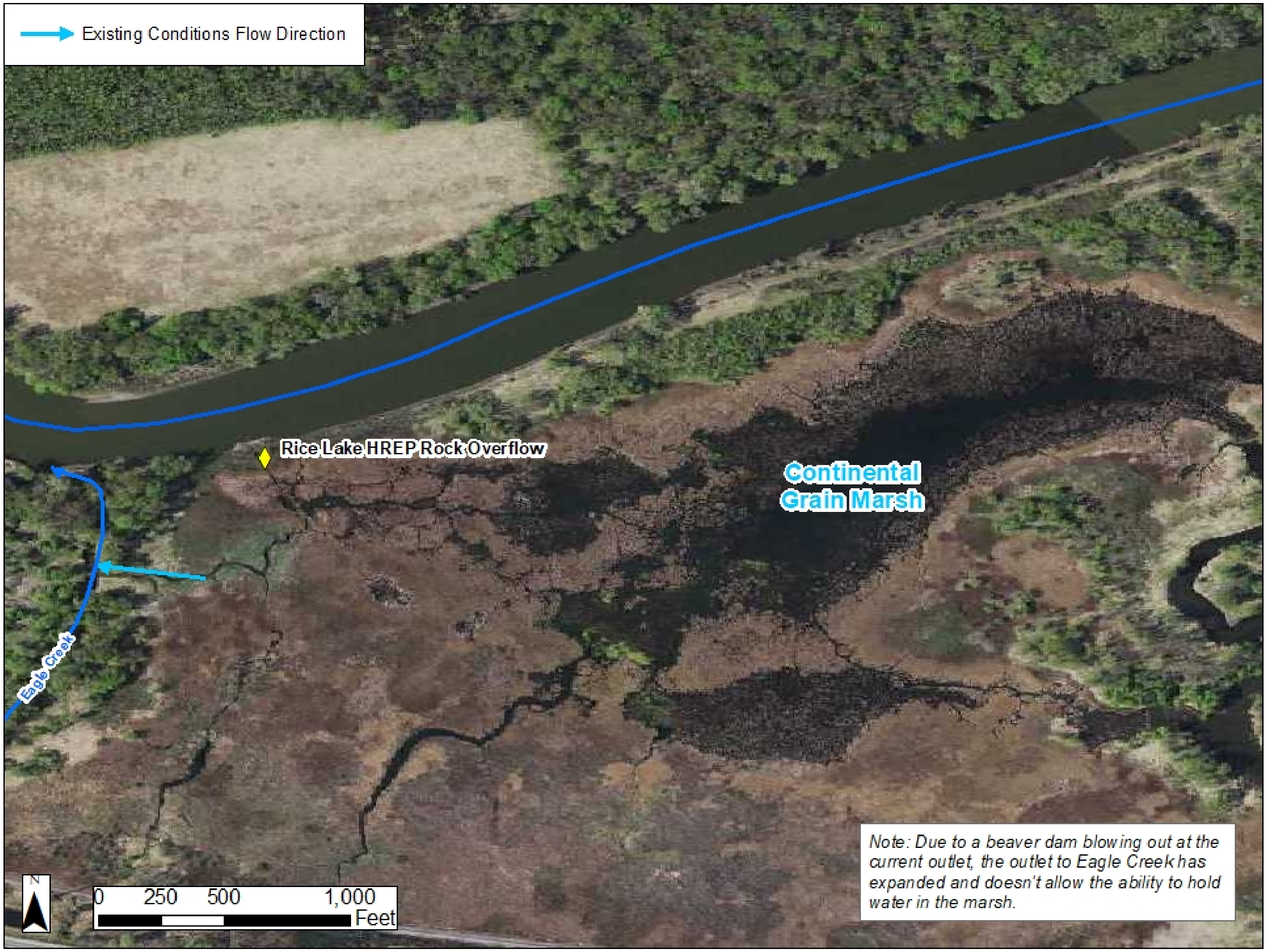


Figure 2: Continental Grain Marsh Existing Conditions Flow Path Diagram

3 Study Alternatives Considered

A variety of measures were identified to achieve project objectives, including water level management structures (single and double bay stoplog structures), earthen ditch plugs, access dredging, and rock-lined overflow channels. The measures were combined in various logical combinations to form alternative project plans. Initial alternatives included standard round culvert sizes of 42”, 60”, and 72”. The Recommended Plan consists of 5’x6’ rectangular culverts (as used in the Long Meadow Lake HREP). As compared to the adopted rectangular conveyance structures included as part of the Recommended Plan, circular culverts resulted in almost twice as many days to drawdown the system. Additionally, anecdotal information from the U.S Fish and Wildlife Service (USFWS) suggested that the round culverts experienced more debris build-up than the rectangular culverts. More detail on the Recommended Plan can be found in the main report.

With the construction of the proposed rectangular culvert system, the water will be able to be efficiently transferred during both drawdown and major flooding conditions. The flow paths during these scenarios differ. During major flooding, flow enters the Blue Lake Structure, travels through the Interlake Structure and then out the Fisher and Secondary Structures to the Minnesota River or into Rice Lake. During the lakes’ drawdowns, the Interlake Structure should be closed forcing Blue Lake to flow out through the Blue Lake Structure to the Minnesota River and forcing Fisher Lake to release flows through the Fisher Lake Structure and Secondary Structure to the Minnesota River. During drawdown, Rice Lake will release water through the Rice Lake Structure and the Secondary Structure to the Minnesota River Figure 3 and Figure 4 help to visualize the post-project flow directions for Blue, Fisher and Rice Lake for major flooding and drawdown scenarios.

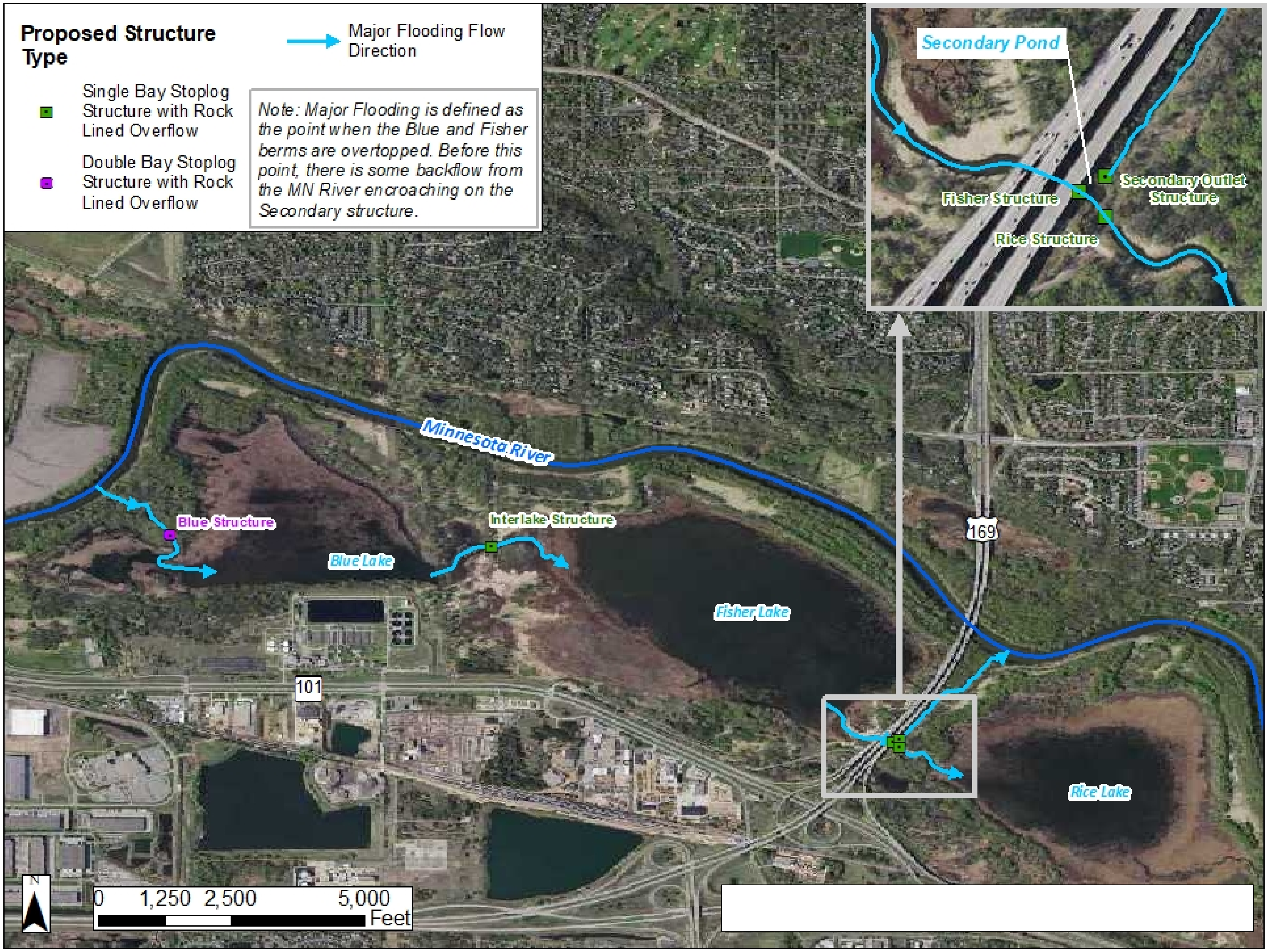


Figure 3: Blue/Fisher/Rice Lake Post-Project Major Flooding Flow Path Diagram

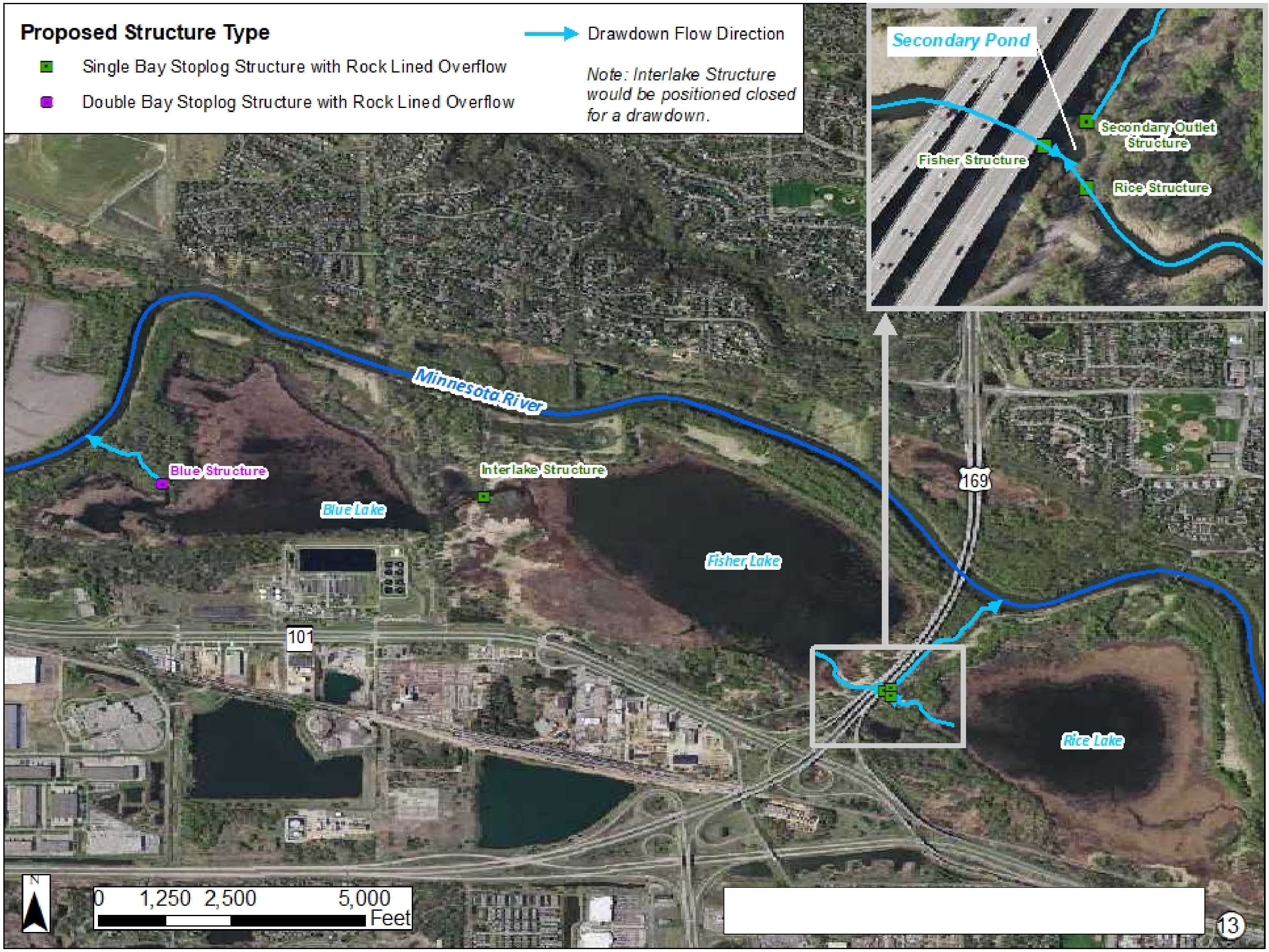


Figure 4: Blue/Fisher/Rice Lake Post-Project Drawdown Flow Path Diagram

As compared to existing conditions, the Continental Grain Marsh will have significantly different flow directions post-project. During major flooding, the stoplog structure will most likely be closed. During flood conditions flow will enter the Continental Grain Marsh if the natural levee surrounding the Continental Grain Marsh is overtopped. This first occurs when the natural levee is overtopped at the Rice Lake HREP rocklined overflow channel (constructed in 1998). The rocklined channel invert is 698.4 feet, so the structure will convey flow when the Minnesota River reaches elevations higher than this value. The next point of overtopping during major flooding will be the Continental Grain Marsh water control structure. During drawdown, the stoplog structure will be the primary outlet. Figure 5 and Figure 6 help to visualize the post-project flow directions for Rice Lake and the Continental Grain Marsh for major flooding and drawdown scenarios.

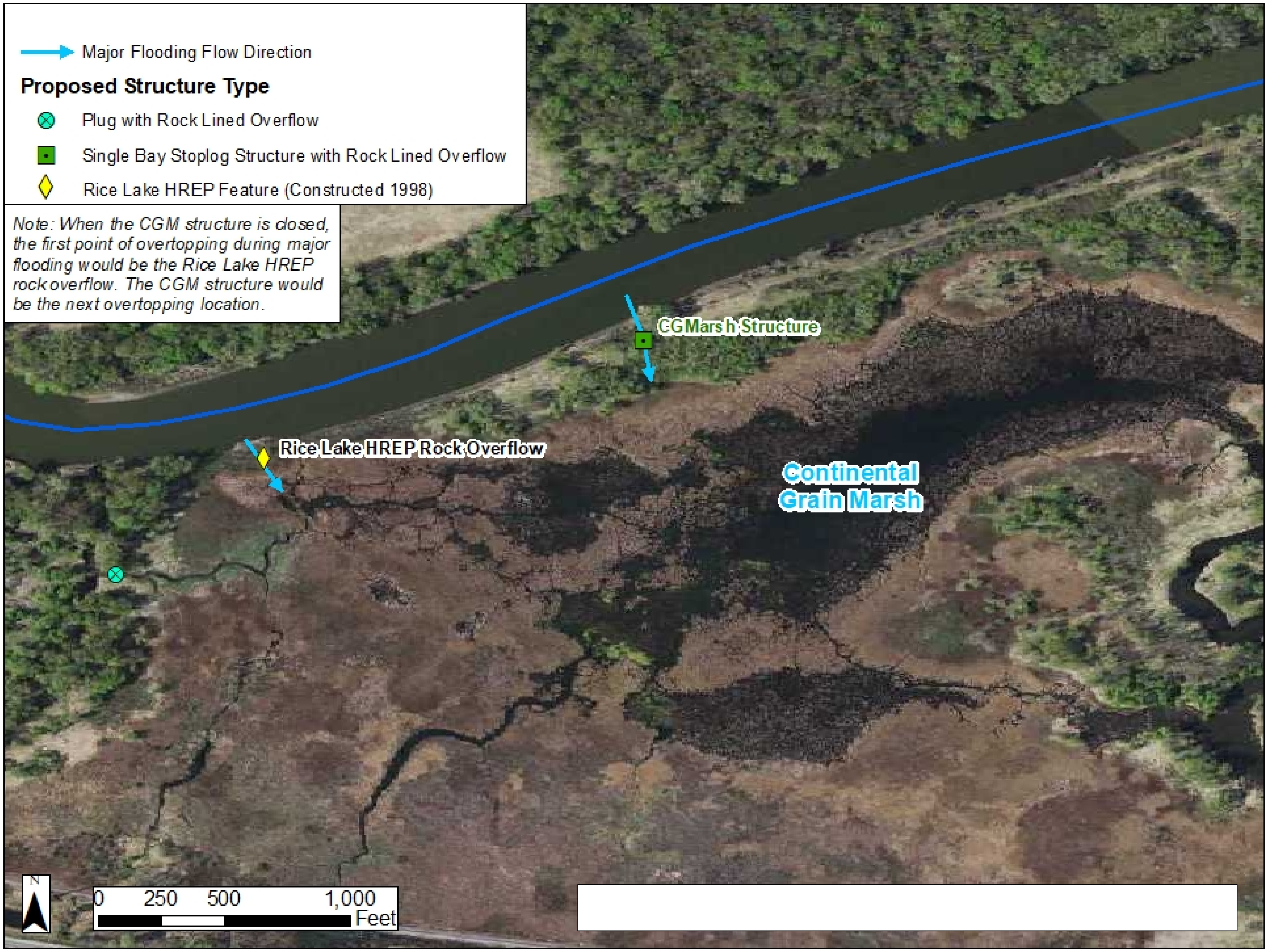


Figure 5: Continental Grain Marsh Post-Project Major Flooding Flow Path Diagram

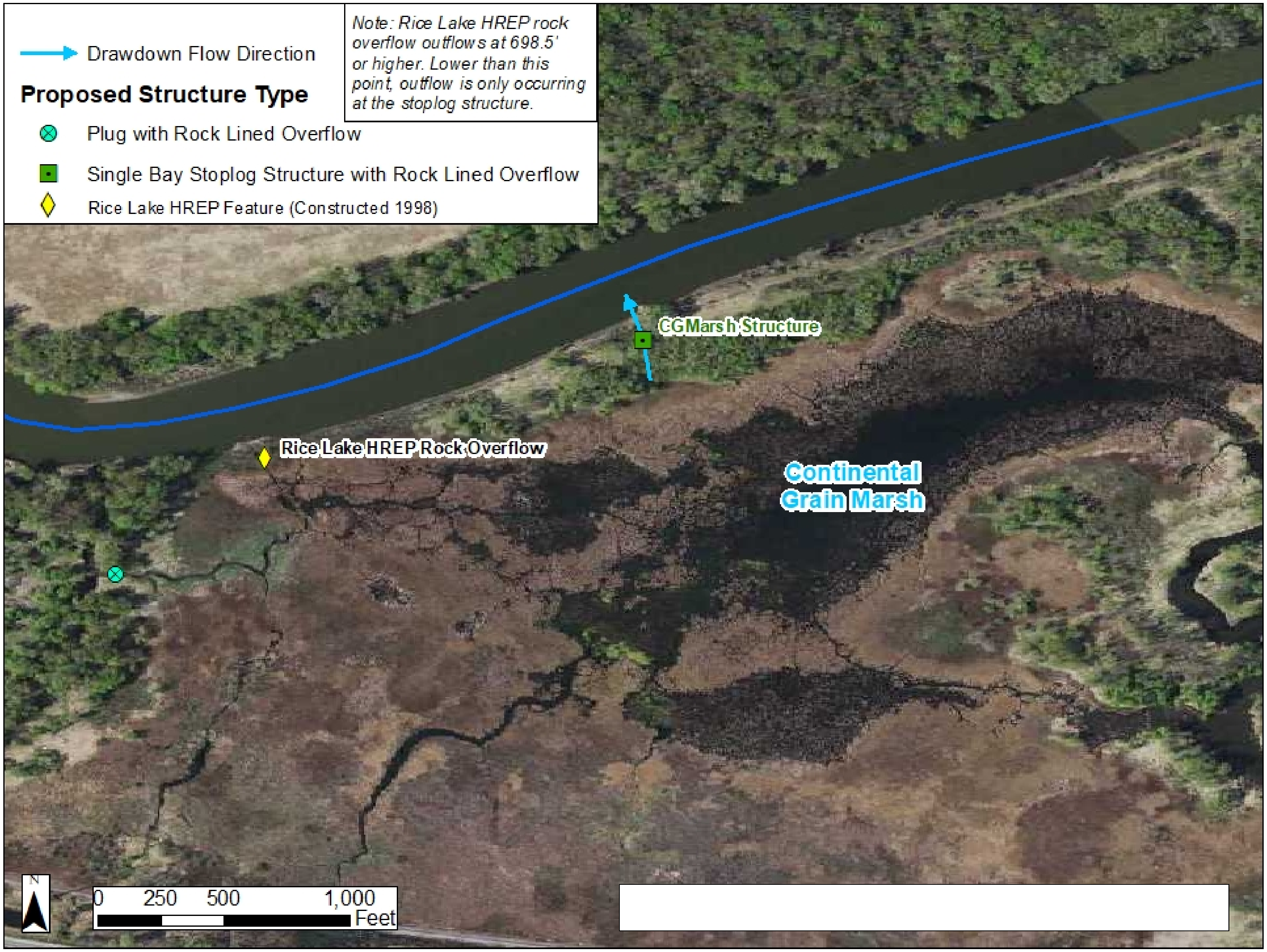


Figure 6: Continental Grain Marsh Post-Project Drawdown Flow Path Diagram

4 Recommended Plan

4.1 Recommended Plan - Lakes

The Recommended Plan (TSP) consists of water level management structure removal and replacement at all three lakes. The structures to be replaced are listed below.

- Blue Lake Outlet Structure
- Interlake Structure (Blue-Fisher)
- Fisher Lake Outlet Structure
- Rice Lake Outlet Structure
- Secondary Outlet Structure (Fisher-Rice)

The structures are all concrete box culverts set at inverts of 693 feet (NAVD 88). The structures are designed to be 5' wide by 6' tall with aluminum stoplogs. Blue Lake will have two concrete box culverts (5'x6' each) while the other structures will only have one box culvert. The size and inverts of the TSP structures were evaluated using drawdown event modelling in HEC-RAS. These structure sizes provide flexibility in drawdown times and the ability to adapt to the more frequent major flood conditions of the lakes. Due to O&M costs, the local sponsor expressed the need for two boxes rather than one at Blue Lake.

The TSP also consists of inlet and outlet channel dredging at the structures at an elevation of 692.5 feet (NAVD 88) and the addition of permanent O&M access roads. All structures will include a rock lined overflow channel adjacent to the structure to reduce the head differential during flood events. All structures will also include inlet and outlet pre-formed scour holes due to the potential head differential of the different management methods. See Figure 7**Error! Reference source not found.** for TSP feature locations.

4.2 Recommended Plan – Continental Grain Marsh

The Continental Grain Marsh TSP consists of plugging the current existing western outlet to Eagle Creek (designated trout stream) and redirecting the flow to the Minnesota River through a water control structure on the north end of the marsh. The earthen, rock armored ditch plug will be flush with adjacent topography at approximately 700.5 feet (NAVD 88). An adjacent rocklined overflow channel will be included in the plug design to lower the head differential at the plug during high water events. The rocklined overflow is designed a foot and a half lower than the adjacent land at approximately 699 feet (NAVD 88).

A water level management structure is included in the TSP at the northeastern side of the marsh. This structure will be the main outlet of the marsh into the Minnesota River. The structure is designed as a 5' wide by 6' tall concrete box culvert set at an invert of 693 feet (NAVD 88) with aluminum stoplogs. The TSP also consists of dredging an inlet channel to the structure at an elevation of 692.5 feet (NAVD 88) and the addition of permanent O&M access roads. The water level management structure will include a rock lined overflow channel adjacent to the structure to reduce the head differential during flood events. Preformed scour holes will be included to reduce the erosion at both the inlet and outlet channels. See Figure 7**Error! Reference source not found.** for TSP feature locations.

There is an existing Rice Lake HREP (completed in 1998) rocklined overflow channel on the northwest side of the marsh that is currently set at an invert of 698.4 feet. This structure will remain in the Continental Grain Marsh design with no work completed to this feature.

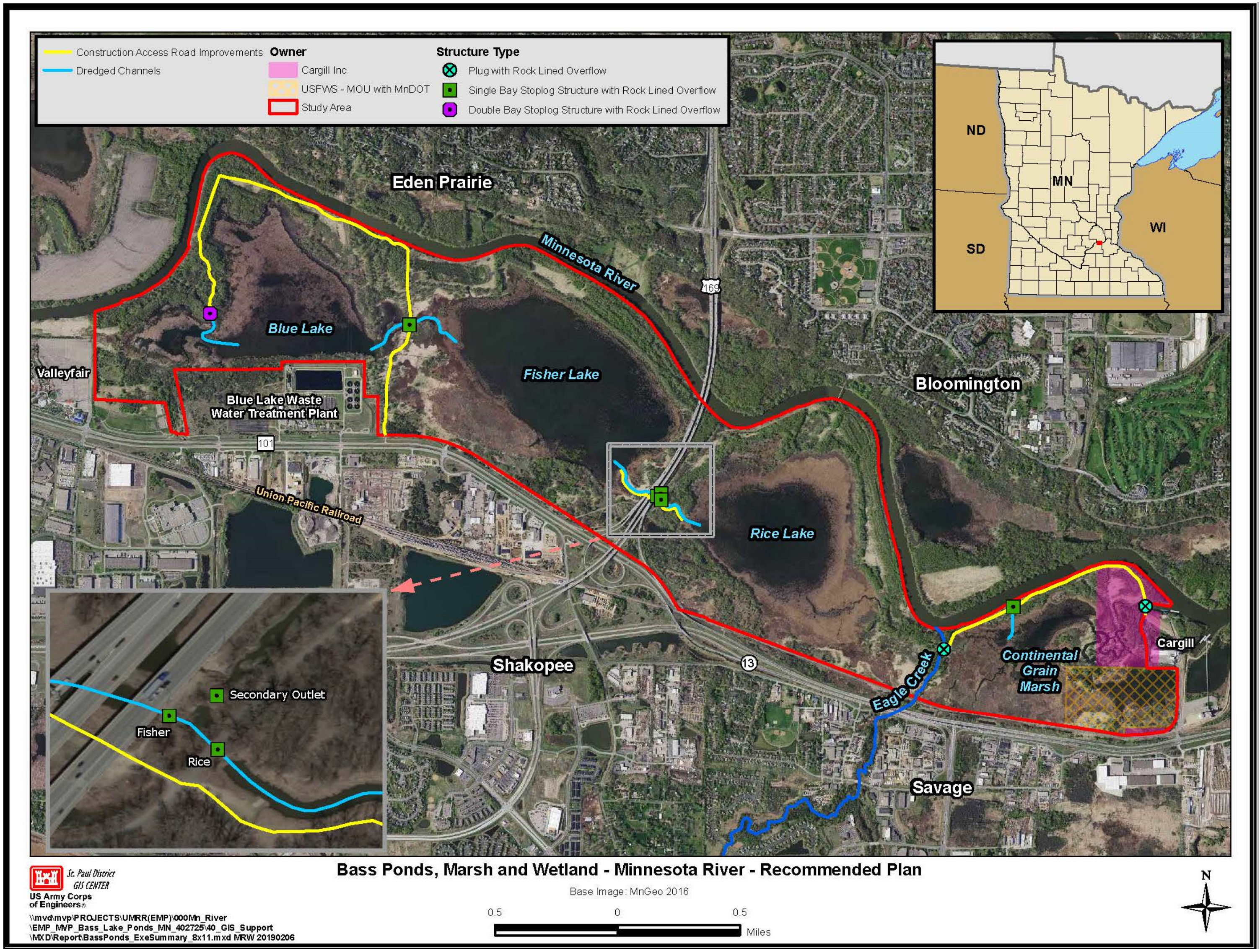


Figure 7: Bass Ponds HREP – Recommended Plan

4.3 Identified Risks

Areas of risk and uncertainty have been analyzed and were defined so that decisions could be made with some knowledge of the degree of reliability of the estimated benefits and costs of alternative plans. Risk depends on the probability or likelihood for an outcome and the consequences of that outcome. Uncertainty refers to a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes.

The team worked to manage risk during plan formulation. One way this was done was by using experience from past projects to identify potential risks and reduce uncertainty during the development of potential measures. The team referenced successful similar water level management work in the UMR (especially Long Meadow Lake, MN and Long Lake, WI), the *UMRR Design Handbook* (USACE, 2012), and used best professional judgment. The team also had several meetings to conduct an Abbreviated Risk Analysis during which project risks were factored into project costs (Appendix G – Cost Engineering).

The primary risks identified for the Bass Ponds, Wetland, and Marsh study area included constructability risks and risks associated with climate change impacts to flow discharges.

Magellan Pipeline
This 12” natural gas pipeline runs just east of the Interlake Structure. The team revised the dredging plan to avoid the pipeline at the Interlake structure by only dredging on the eastern side and staying outside the 80 ft right of way. Figure 8 below shows the location of pipeline, right of way and survey data points.

The existing structure channel is at an elevation of less than 692.5 feet in elevation in most parts of this 80 foot right of way. On the eastern edge of the right of way, the elevation ranges from 692.2 feet and 694.5 feet. A full drawdown for Fisher Lake is described as 696.2 feet or lower, so a full drawdown can still be achieved without dredging this area. Section 8.2 explains the drawdown elevation and operation in more detail.

Transferring water from Blue to Fisher Lake would still be possible. The elevation in Blue Lake would need to be higher than this potential ridge of material that is not able to be dredged. The Blue to Fisher Lake scenario was modelled assuming optimal pool in Blue Lake (698.3) and near empty pool in Fisher. If this is how this scenario is operated in reality, the scenario will still be efficient. Section 8.2 explains this scenario in more detail.

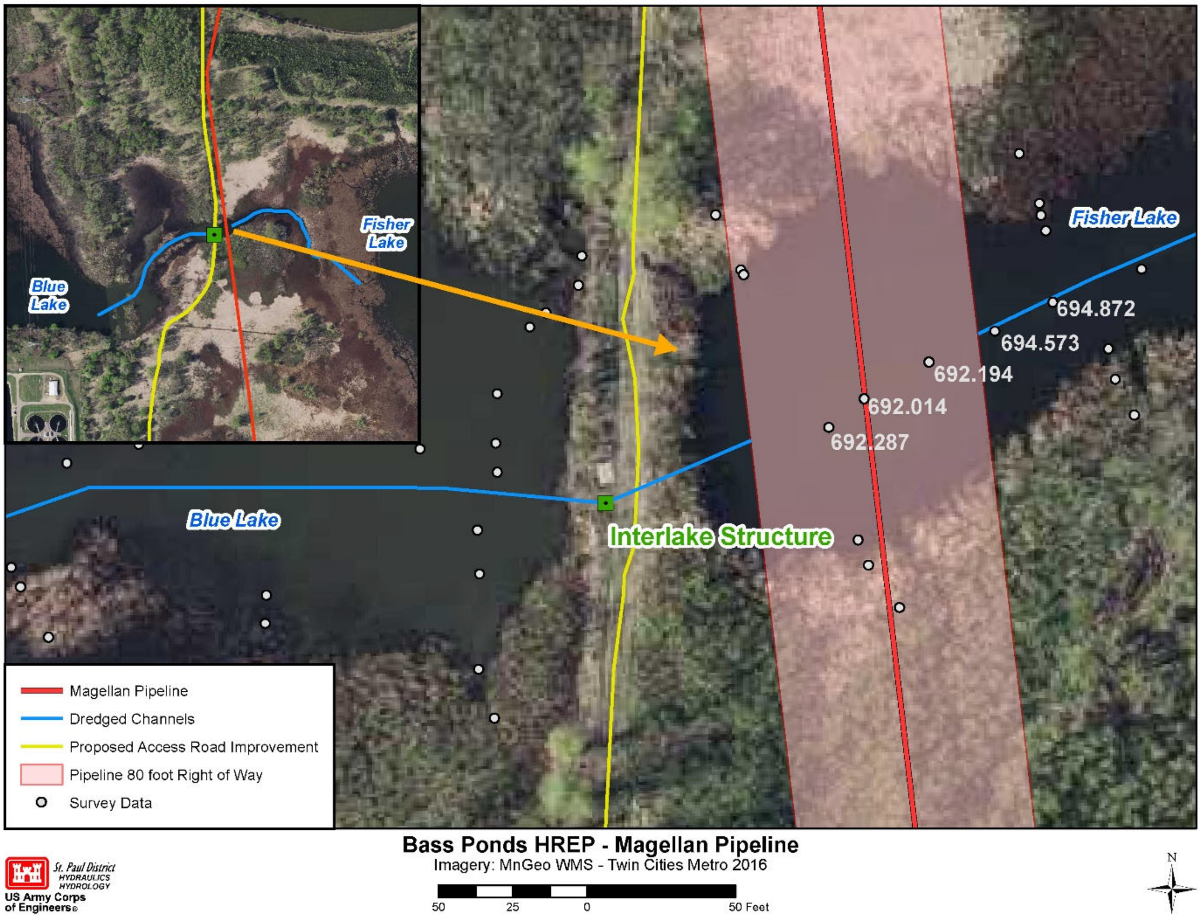


Figure 8: Magellan Pipeline Location and Right of Way with Respect to Survey Data Points

Fiber Optic Cable

The fiber optic cable is located on the most eastern side of Fisher Lake. Figure 9 below shows the location of the fiber optic cable relative the Recommended Plan features. The fiber optic cable is currently located within the footprint of the Fisher Lake proposed water level management structure and proposed access road. To manage risk with the fiber optic cable, the team had several meetings with USFWS and MnDOT to discuss a path forward. In order to manage construction of the Fisher Lake outlet structure, the team included costs associated with relocating the conduit within the Lands, Easements, Right-of-Way, Relocation, and Disposal (LERRDs) component of the cost estimate. The fiber optic cable will be relocated during construction.

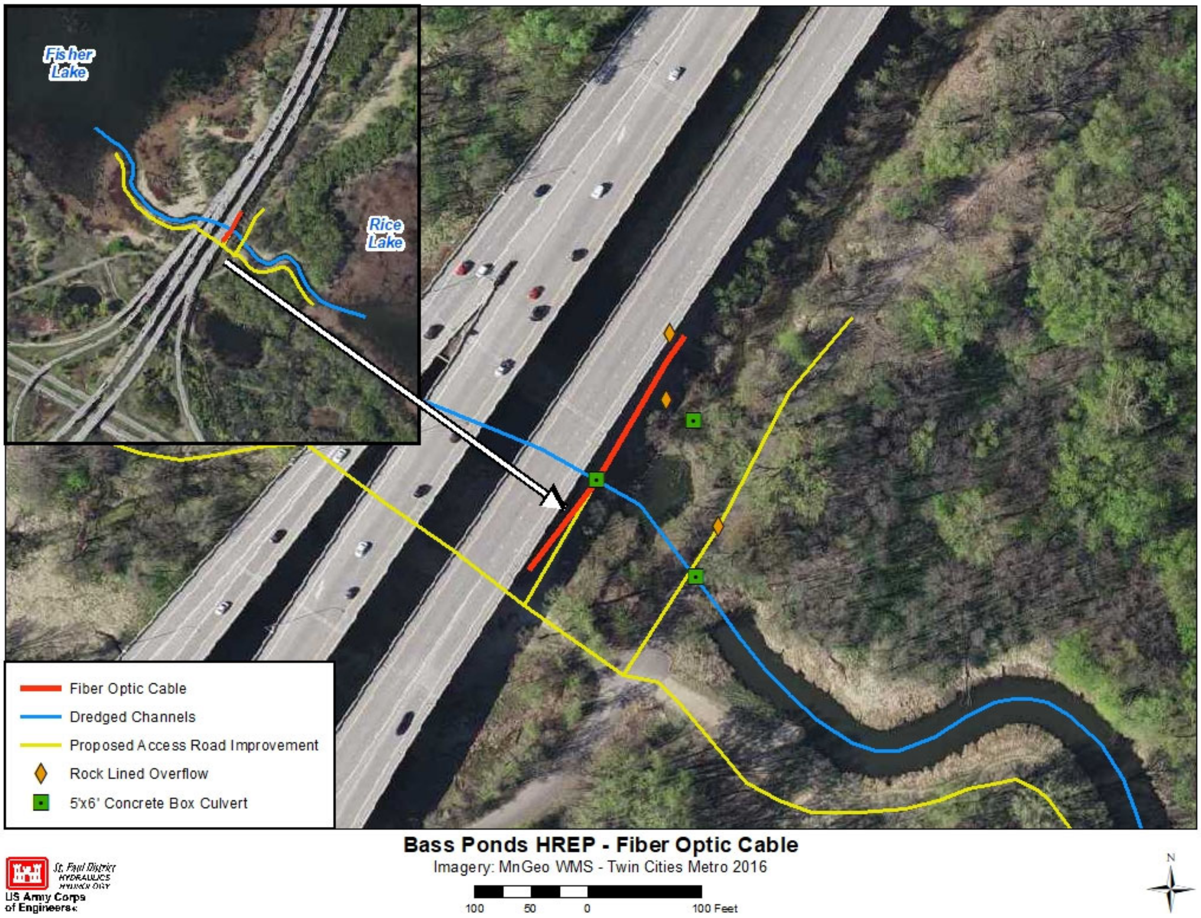


Figure 9: Fiber Optic Cable Location

Cargill Structure
During the flow analysis, the team identified a WLM structure on the east end of Continental Grain Marsh, located on Cargill property. Figure 10 below shows the location of the structure in relation to refuge land. Inspection of the structure indicated that it was silted in and functioning as a plug. There was also significant erosion observed around the failed structure. However, if this structure were to pass flow or fail completely, a new outlet would exist. This new outlet would decrease the effectiveness of the proposed project plug and water level management structure significantly. The Cargill structure was constructed in 1985 by the USFWS which was before the loss of the beaver dam on the western end of the marsh and throughout the lifespan of the Continental Grain Marsh overflow structure that was installed as a part of the Rice Lake HREP. Throughout this time, this structure did not affect the marsh water levels and has been acting as a plug. USACE is currently coordinating a plan with USFWS and Cargill to formulate a solution.

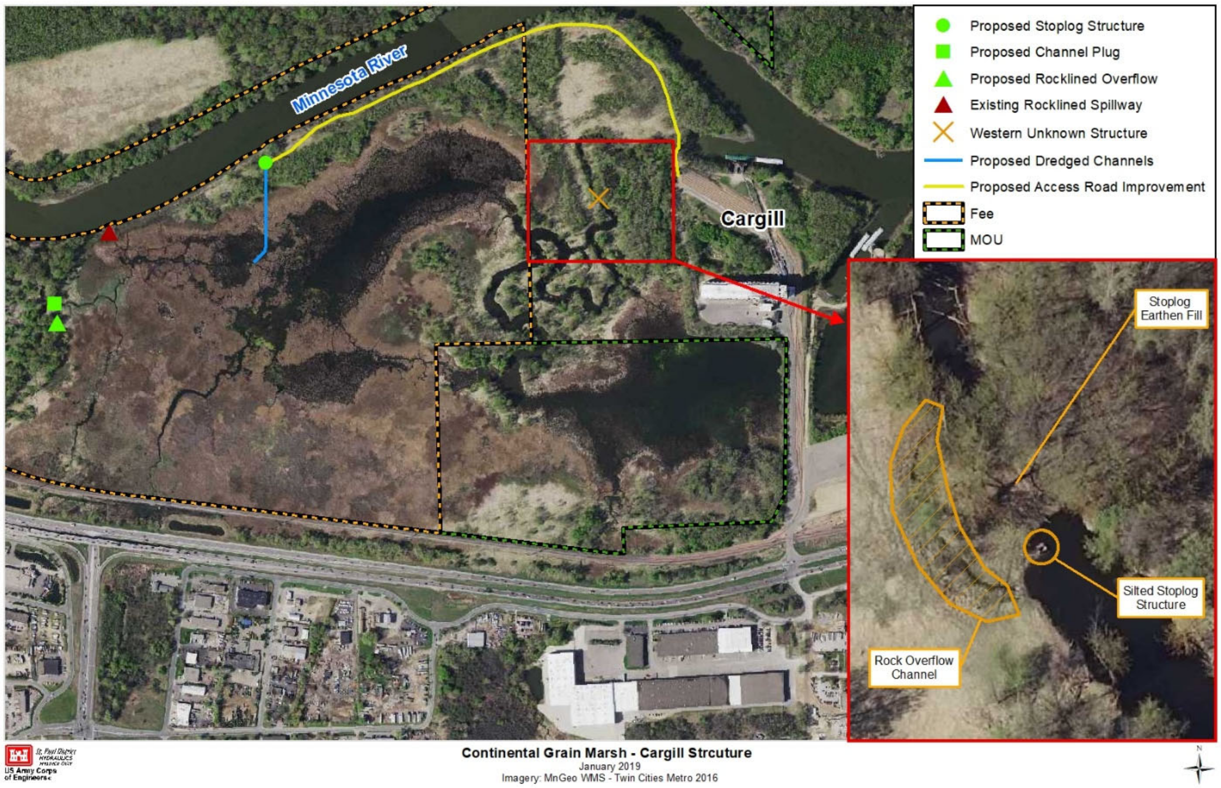


Figure 10: Silted Stoplog Structure and Overflow Located on Cargill Private Property

Valleyfair Mitigation

Valleyfair is an amusement park located to the west of the Bass Ponds HREP project. Recently, the park proposed to expand its facilities, which would result in the loss of 4.52 acres of wetland. To offset wetland impacts associated with its expansion project, Valleyfair has proposed a mitigation plan that includes the creation of 6.38 acres of floodplain forest wetland adjacent to the Minnesota River. An additional 4.64 acres of upland will be preserved and act as buffer to the wetland. The goal of the mitigation plan is to create a backwater wetland system connected to the Minnesota River during flood events that integrates into the Blue, Fisher, and Rice Lake complex. In order to create the mitigation area, Valleyfair would remove topsoil and subsoil, lowering the top of natural levee in the mitigation area. The risk associated with this mitigation plan is if/how this would affect the Bass Ponds HREP. Construction is expected to commence in 2019 for the Valleyfair expansion and mitigation.

The St. Paul District Regulatory office issued a permit and approved the mitigation plan in 2018. The permit includes hydraulics and hydrology input from the Corps concluding whether or not sedimentation and flood waters would affect Blue Lake (just east of Valleyfair). This proposed mitigation site near Blue Lake can be viewed in Figure 11 below. According to the permit, the proposed change in contours will change water circulation patterns in the immediate area. The permit also explains that the mitigation site is intended to offset the loss of flood water storage and potential changes in water fluctuations due to the parking lot construction. A short hydraulic discussion concluded that a lower bank at the mitigation site is not a concern in regards to frequency of flooding and deposition into Blue Lake because the existing high ground control “saddle” is not breached by the project. The “saddle” location can be viewed in Figure 11. Because this high ground will remain intact, the potential for an increase in flood frequency and sediment into Blue Lake is small.

The Valleyfair mitigation plan was not factored into the modelling efforts for this project. However, the hydraulics comments from the issued regulatory permit explained above suggest this should not affect the Bass Ponds HREP features.

Figure 11: Valleyfair Wetland Mitigation Grading Plan from Barr Engineering

5 Hydrology

5.1 Discharge – Frequency, Discharge - Duration

The frequency curve for the Minnesota River at Jordan Gage (USGS 05330000) was obtained from the Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update conducted in 2017. The frequency curve from this study can be viewed in Figure 12 below. The period of record for this analysis is listed as 1903-2015. The numerical values corresponding to this curve are listed in Table 2 below.

Table 2: Minnesota River near Jordan, MN Analytical Flow Frequency Summary Table (Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update, 2017)

Annual Peak Discharge Frequency Analysis			
USGS Gage 05330000 Minnesota River near Jordan, MN Methodology: Bulletin 17C Expected Moments Algorithm			
Exceedance Probability		**90% Confidence Limits (cfs)**	
(%)	**Peak Estimate (cfs)**	**5%**	**95%**
0.20%	150,800	321,300	85,900
0.50%	124,800	227,700	78,200
1%	106,200	173,600	71,700
2%	88,600	130,700	64,400
5%	66,800	87,500	53,500
10%	51,400	62,700	43,800
20%	36,900	42,900	32,200
50%	18,800	21,800	16,000
80%	9,000	10,800	7,200
90%	6,000	7,300	4,400
95%	4,300	5,400	2,800
99%	2,100	3,200	1,100
Statistics			
Mean	4.257	**Systematic Record (MOVE.3)**	113 Years
Standard Deviation	0.364	**Historic Record Length**	135 Years
Adopted Skew	-0.290	**Years in Record (MOVE.3)**	1881 (Historic), 1903-2015

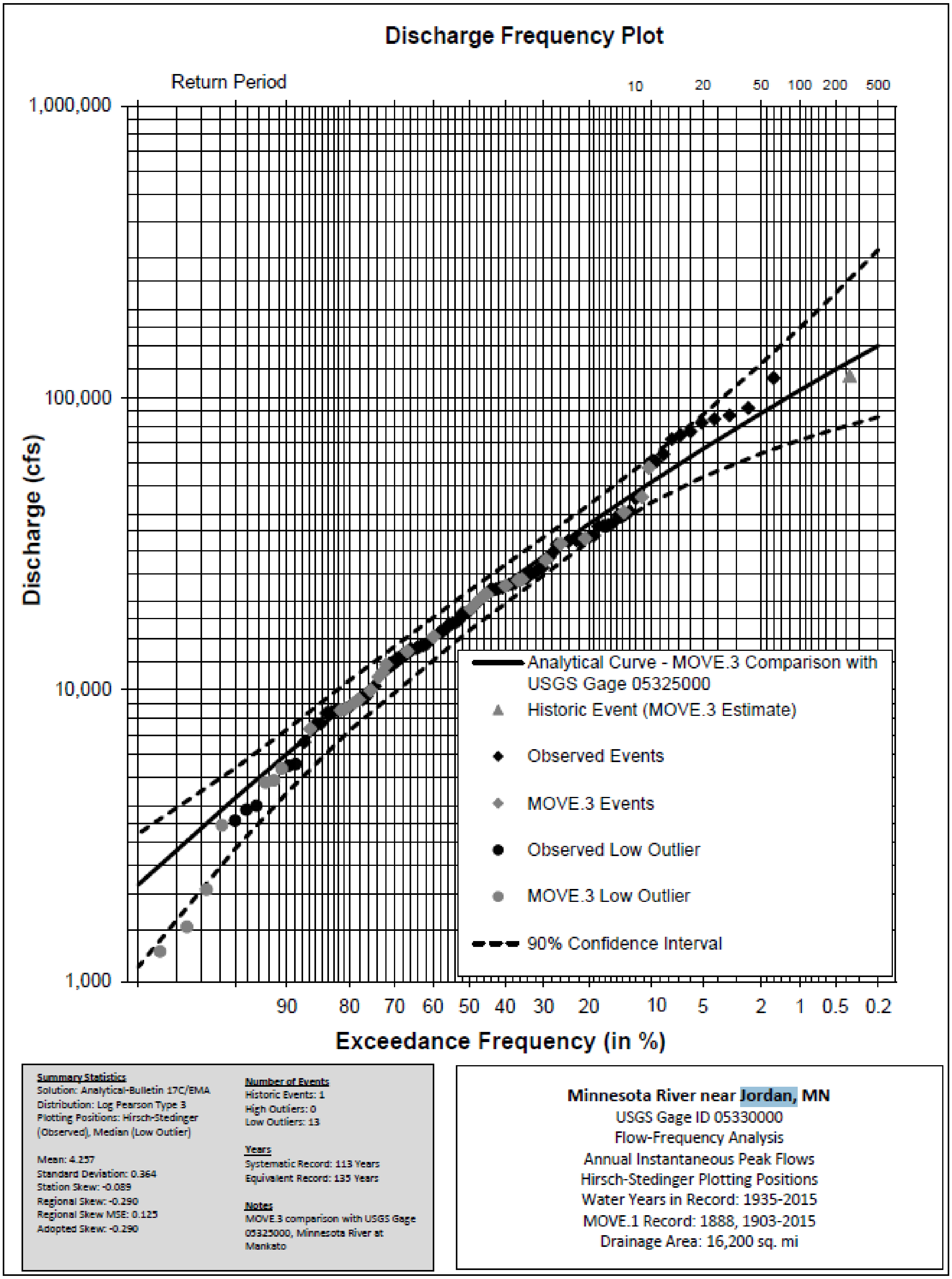


Figure 12: Minnesota River near Jordan, MN Analytical Frequency Curve (Minnesota River Integrated Watershed Study – Discharge and Elevation Frequency Update, 2017)

The USGS rating curve was obtained from the National Ratings Depot for shift-adjusted rating curves for stream gages. Figure 13 below shows the USGS rating curve. This rating curve was last updated in June of 2018. Stage-discharge relations (ratings) are developed from a graphical analysis of numerous discharge measurements. Measurements are made on various schedules and sometimes for different purposes. All discharge measurements are compiled and maintained in a database. Each measurement is carefully made, and undergoes quality assurance review. Some measurements indicate a temporary change in the rating, often due to a change in the streambed (for example, erosion or deposition) or growth of riparian vegetation. Such changes are called shifts; they may indicate a short- or long-term change in the rating for the gage. In normal usage, the measured shifts (or corrections) are applied mathematically to a defined rating. The tables being provided are shift corrected, incorporating the mathematical adjustments for ease of use by the user. The shift adjustments are applied to the individual ratings as measured data becomes available, resulting in an adjusted rating.

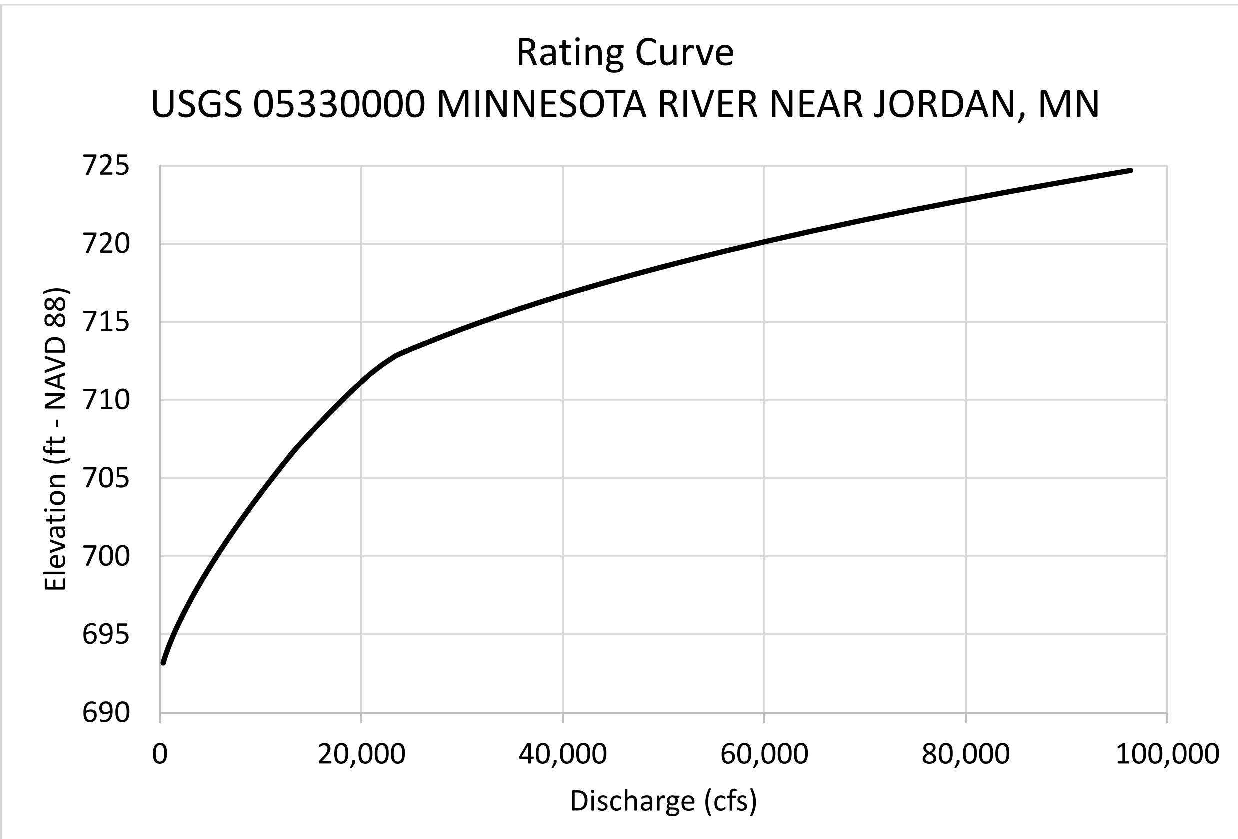


Figure 13: Rating Curve for USGS Gage at Jordan, MN (05330000) Based on the Full Period of Record (1935-2018)

The exact frequency corresponding to various river discharges is not critical to project design. However, it is important to note the frequency the project area experiences major flooding. It's estimated that the discharge at the Jordan Gage that produces major flooding at the project area is about 26,600 cfs. Major flooding for this project is considered the point when the natural levee at Blue Lake is overtopped which produces sheet flow over the three lakes. The annual exceedance probability corresponding to the major flooding discharge is approximately 39%. Section 8.3 discusses the major flooding and potential project drawdown periods in depth. Other flood frequency discharges are related to river stage and project stages in Table 3 below. It is important to note that these values are estimated and could be refined after project construction by using observed project stage data.

Table 3: Annual Peak Discharge Frequency Analysis with Corresponding Stage

Annual Peak Discharge Frequency Analysis with Corresponding Stage			
Exceedance Probability (%)	Jordan Peak Estimate (cfs)	Jordan Stage (NAVD 88)	Project Stage (NAVD 88)
0%	150,800	NA	NA
1%	124,800	NA	NA
1%	106,200	NA	NA
2%	88,600	723.8	715.3
5%	66,800	721.1	712.7
10%	51,400	718.8	710.5
20%	36,900	716.1	707.9
50%	18,800	710.4	702.6
80%	9,000	703.2	695.7
90%	6,000	700.4	693.1
95%	4,300	698.6	691.4
99%	2,100	696.0	689.0

5.2 Climate Change Assessment

Engineering Construction Bulletin (ECB) No. 2018-14 (USACE 2018) provides guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaption policy. This guidance requires the inclusion of a qualitative analysis of potential climate threats and impacts to USACE hydrology-related projects. The goal of this analysis is to describe the observed present and possible future climate threats, vulnerabilities, and impacts of climate change specific to the study goals or engineering designs. This includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant climatic and hydrologic variables.

The important hydrologic variables affecting the proposed Bass Ponds HREP study include water surface elevation (stage) and river discharge. Besides fluctuations in climate, stage can be influenced by long-term geomorphic change, changes to the operation of hydraulic structures, and gage relocation. Discharge can be influenced by changes in upstream water storage due to dam construction, changes in land-use, and measurement techniques. These factors can make it difficult to determine the role of climate change in affecting the hydrologic signal at the project scale The most relevant questions to answer are: (1) Have past climate change events affected the ecological conditions and flood risk within the study area? (2) Is there an observable trend towards a climate change in the future? (3) How will this potential future event impact the resilience, operation and maintenance of the proposed project? Lake stage was chosen as the primary hydrologic variable to analyze for this project with discharge as its proxy. The other hydrologic variable that was analyzed for this project was the flood duration. These variables were chosen for this project to accurately analyze the effects of prolonged high water surface elevations in the lakes on the ecological benefits captured.

5.2.1 Literature Review: Climate Change Trends at a Regional Scale

Both historic, observed hydrometerological datasets, as well as projected, climate changed hydrometerological data was looked at to support some broader statements about how the climate may change over the 50 year project life and 100 year, project performance horizon. Driving hydrometerological variables include streamflow, precipitation, and temperature. The magnitude, seasonal and interannual variation, duration, and rate of change of these variables can affect physical, chemical, and biological characteristics of ecosystems.

A series of regional summary reports on trends in both observed and projected hydrometerological variables were published by the USACE in 2015. In Water Resources Region HUC 07, the Upper Mississippi Region, the report concludes that "increased air temperatures and increased frequencies of drought, particularly in the summer months, will result in increased water temperatures. This may lead to water quality concerns, particularly for the dissolved oxygen levels, which are an important water quality parameter for aquatic life. Increased air temperatures are associated with the growth of nuisance algal blooms and influence wildlife and supporting food supplies. Increased mean annual precipitation in the region may pose complication to planning for ecosystem needs and lead to [increased] variation in flows (Civil Works Technical Report CWTS-2015-13, USACE (2015))." These conclusions were based on a large body of research cited in the report, some of which is summarized below.

In the Upper Mississippi Region, a statistically significant trend of increasing air temperature was found based on observed temperature data for the winter, spring, and summer months; however, a slight decreasing trend was observed in fall temperatures based on the 1950 to 2000 time period (Wang et al. 2009, Westby et al. 2013). Westby et al. (2013) quantified statistically significant warming for the most northern portion of the Upper Mississippi Region and a general cooling trend for the southern region and Johnson and Stefan (2006) identified numerous trends in 20^{th} century hydro-climate data for sites across Minnesota suggestive of a warming climate. These include earlier ice-out dates and later ice-in dates for lakes and earlier spring runoff.

Multiple authors have identified significant, increasing trends in total precipitation in historical records for the study region. Palecki et al. (2005) quantified statistically significant increases in winter storm precipitation totals for the 1972 to 2002 time period. Grundstein (2009) identified significant, positive linear trends (period 1895 – 2006) in both annual precipitation and the soil moisture index for multiple sites within the Upper Mississippi Region. Wang et al. (2009) identified a significant increasing trend in precipitation for the Upper Mississippi Region, particularly in the summer and fall (1950 to 2000). For the northern half of the region, a mild decreasing trend was identified during the winter and spring. McRoberts and Nielsen-Gammon (2011) found that the positive trend in annual precipitation indicates an increase on the order of 5 – 20% per century (1895 to 2009 time period).

Streamflow and duration are the most important hydrometeorological variable affecting ecological conditions and engineering resilience for the project. Elevated water surface elevations, which are directly related to streamflow, can affect all of the project's objectives - increase the diversity and percent cover of desirable emergent and submergent aquatic plant species and provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds. Trends in streamflow and the corresponding water surface elevations will be considered when designing project features. The 2015 USACE literature synopsis cites a number of studies that identified trends of increasing flow metrics in the Upper Mississippi River

Basin (Mauget 2004, Small 2006, Novotny and Stefan 2007, Kalra 2008, Xu 2013). Mauget (2004) analyzed 42 daily streamflow gages throughout the U.S., nine of which are located within the Upper Mississippi Region. He identified an increasing trend (1939 – 1998) in observed, mean annual river flow in the Mississippi watershed as a whole, including the Upper Mississippi and a significant increase in "surplus" flow days and a decrease in drought incidences for the latter part of the record compared to earlier years. Xu et al. (2013) identified statistically significant positive trends in both observed annual streamflow and baseflow for multiple stream gages in the Upper Mississippi Region. Novotny and Stefan (2007) analyzed 20th century historic streamflow data from 36 gages scattered across Minnesota, most of which were located in the Upper Mississippi Region and applied trend analysis to a number of different flow metrics, including mean flow, 7-day low flow, and peak flows. The analysis results suggested statistically significant (p-value <0.1) increasing trends for the period of 1913 to 2002.

In addition to consulting the USACE literature synthesis for Water Resources Region 07, the Upper Mississippi Region, results from the US Global Research Program's Third National Climate Assessment for the Upper Midwest were evaluated. Figure 14, from the US Global Research Program's Third National Climate Assessment (NCA) completed in 2014, shows estimates of increased precipitation throughout the Upper Midwest for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000). Across the entire Midwest, the total amount of water from rainfall and snowfall is projected to increase. The Third National Climate Assessment states that "in the Upper Midwest extreme heat, heavy downpours, and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress, flooding, drought, and late spring freezes." The US Global Research Program's Fourth National Climate Assessment was released in 2018. This report explains that in the Midwest the annual average precipitation has increased and the precipitation increases are projected to occur in winter and spring. The Fourth National Climate Assessment also states that "Over the contiguous United States, annual average temperature has increased by 1.2°F (0.7°C) for the period 1986–2016 relative to 1901–1960, and by 1.8°F (1.0°C) when calculated using a linear trend for the entire period of record."

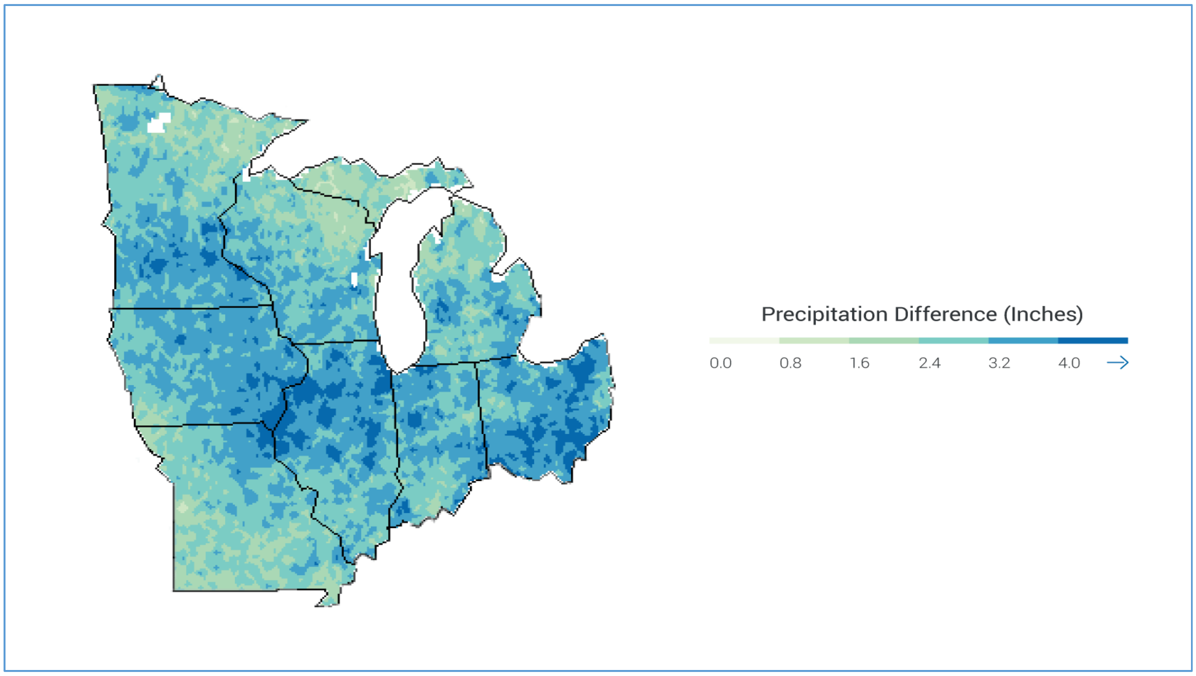


Figure 14: Projected Changes for the Middle of the Current Century (2041-2070) Relative to the End of the Last Century (1971-2000). (Figure source: NOAA NCDC / CICS-NC)

According to the NCA, projected future air temperatures are expected to trend upward, as will annual precipitation. Future increases in the frequency and magnitude of large storm events is expected. Projected changes in temperature, soil moisture and precipitation indicate an increase in the severity of droughts and extreme precipitation events. As a result of projected temperature increases, the number of frost-free days is anticipated to rise. Streamflow has increased over the past century; however, a clear consensus is lacking with regards to projections in future hydrology. Some studies predict increases in projected streamflow and others predict decreases. Figure 15 shows a summary of observed and projected trends in climate variables as well as an indication of the level of consensus within the literature according to the USACE literature synthesis.

These observed and projected increasing trends in air temperature and precipitation as well as observed streamflow could affect ecosystem conditions in the project area and the engineering resilience of project features and was considered during this design.

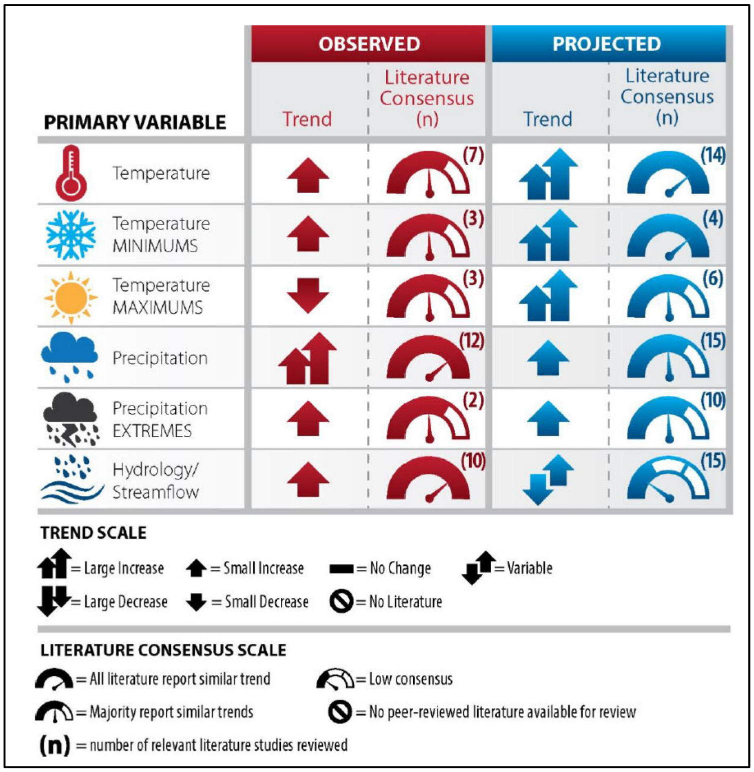


Figure 15: Summary of climate trends and literary consensus (USACE, 2015)

5.2.2 First Order Statistical Analysis: Trends in Streamflow & Climate Change at a Regional Scale

The USACE Climate Hydrology Assessment Tool was used to investigate potential future trends in streamflow for HUC 0706 (Minnesota Watershed). Figure 16 below shows the location of the project area relative to the HUC02 and HUC04 watershed delineations, while Figure 17**Error! Reference source not found.** displays the range of projected, mean annual maximum monthly streamflows computed from 93 different climate changed hydrologic model runs for the period of 1951-2099. This mean annual maximum monthly discharge variable is relevant to this project because the ecological conditions in the study area and the study objectives are most significantly impacted by high flow conditions and because one of the primary constraints to this project is the need to maintain the current level of flood risk in the study area.

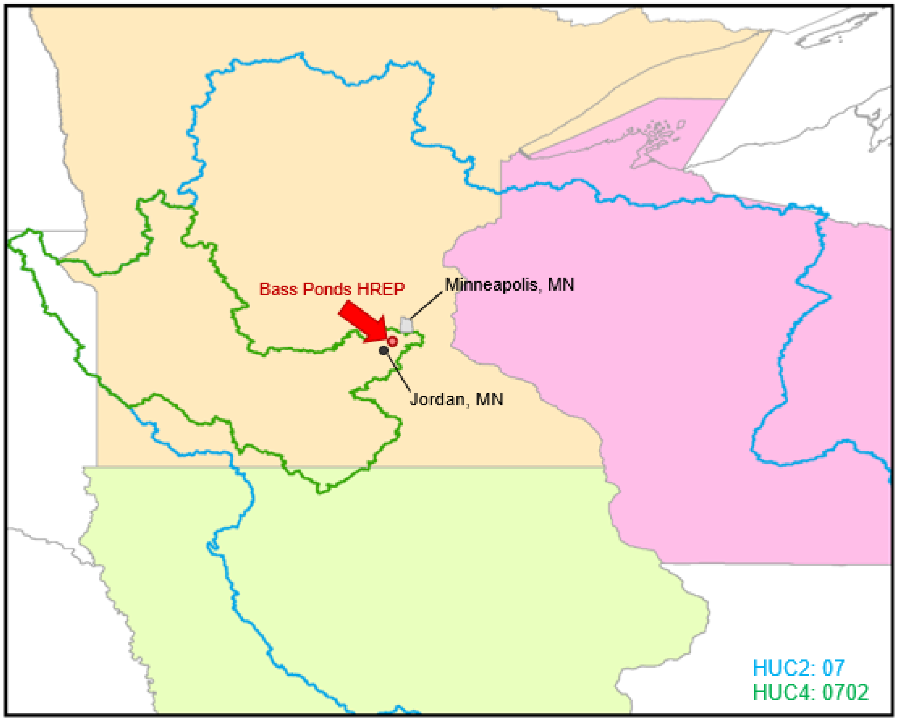


Figure 16: Location of Project Area within HUC2 and HUC4

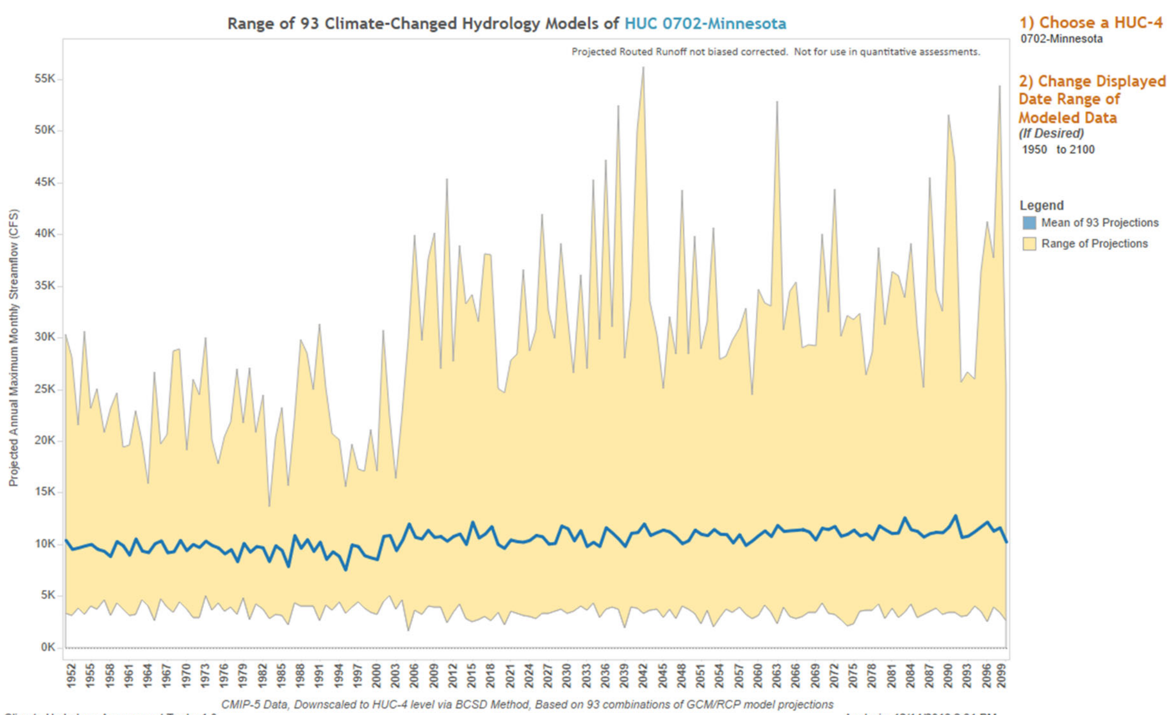


Figure 17: Range of Projected Annual Maximum Monthly Streamflow among Ensemble of 93 Climate-Changed Hydrology Models, HUC 0702 Minnesota

Climate Changed hydrology output is generated using various greenhouse gas emission scenarios (Representative Concentration Pathways, RCPs) and global circulation models (GCM) to project precipitation and temperature data into the future. These meteorological outputs are spatially downscaled using the Bias Corrected Spatial Disaggregation statistical method and then inputted in the U.S. Bureau of Reclamation's (USBR) Variable Infiltration Capacity (VIC) precipitation-runoff model to generate a streamflow response. The effects of regulation are not included within the USBR VIC model.

As expected for this type of qualitative analysis, there is considerable, but consistent spread in the projected annual maximum monthly flows. The spread in the projected annual maximum monthly flows is indicative of the high degree of uncertainty associated with projected, climate changed hydrology.

As shown in Figure 18 below, there is a statistically significant increasing trend in the mean projected annual maximum monthly streamflow. The p-value associated with this trend is less than 0.0001. This is significantly less than the generally accepted threshold for significance of 0.05. This finding suggests that there is potential for annual maximum monthly streamflows to increase in the future in the study area, relative to the current conditions.

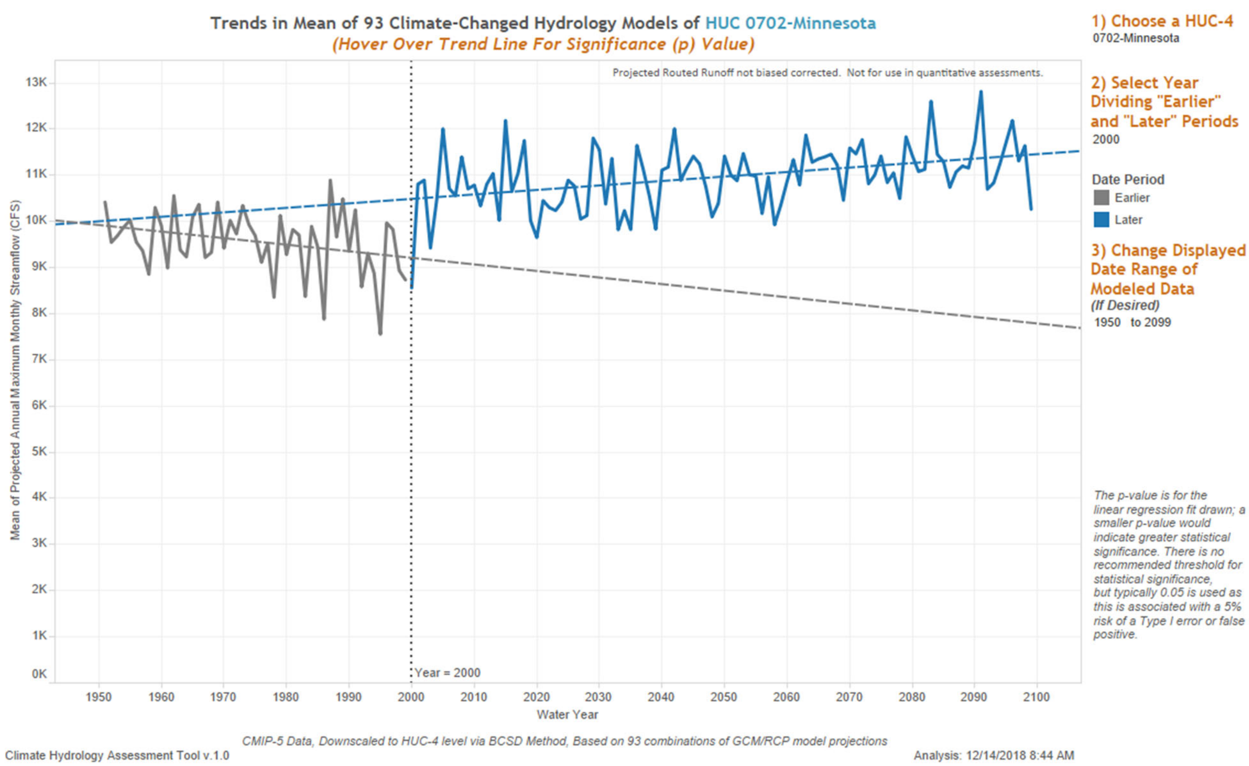


Figure 18: Mean Projected Annual Maximum Monthly Streamflow, HUC 0702 Minnesota. Trendline Equation: Q = 9.69702*[Water Year] – 8918.99, $p < 0.0001$

5.2.3 Screening Level Vulnerability Assessment to Climate Change Impacts

The USACE Watershed Climate Vulnerability Assessment Tool was also used to compare the relative vulnerability of the HUC 0702, the Minnesota Watershed, to climate change to the other 201 HUC-04 watersheds across the continental United States (CONUS). The tool facilitates a screening level, comparative assessment of how vulnerable a given HUC-04 watershed is to the impacts of climate change. The tool can be used to assess the vulnerability of a specific USACE business line to projected climate change impacts. For this study, both the Ecosystem Restoration and Flood Risk Reduction business lines are analyzed. This project is primarily related to ecosystem restoration, but because of the flood stage impacts constraints, flood risk reduction is also relevant. Assessments using this tool help to identify and characterize specific climate threats and particular sensitivities or vulnerabilities, at least in a relative sense, across regions and business lines. The tool uses the Weighted Order Weighted Average (WOWA) method to estimate a vulnerability score which represents a composite index of how vulnerable a given HUC-4 watershed is to climate change specific to a given business line. The HUC-4 watersheds with the top 20% of vulnerability scores are flagged as being vulnerable.

Indicators considered within the vulnerability score for Ecosystem Restoration include: change in sediment load, short-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), macroinvertebrate index (sum score of six metrics indicating biotic condition), two indicators of flood magnification (indicator of how much high flows are projected to change overtime), mean annual runoff, change in low runoff, and percent of at risk freshwater plant communities.

Indicators considered within the vulnerability score for Flood Risk Reduction include: long-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), two indicators of flood magnification (indicator of how much high flows are projected to change overtime) and urban area (acres) within the 500 year floodplain.

When assessing future risk projected by climate change, the USACE Climate Vulnerability Assessment Tool makes an assessment for two 30-year epochs of analysis centered at 2050 and 2085. These two periods were selected to be consistent with many of the other national and international analyses. The tool assesses how vulnerable a given HUC-04 watershed is to the impacts of climate change for a given business line using climate changed hydrology based on a combination of projected climate outputs from the general climate models (GCMs) and representative concentration pathway (RCPs) resulting in 100 traces per watershed per time period. The top 50% of the traces by flow volume are called the “wet” subset of traces and the bottom 50% of the traces are called the “dry” subset of traces. Meteorological data projected by the GCMs is translated into runoff using the USBR Variable Infiltration Capacity (VIC) Macroscale hydrologic model. For this assessment, the default, National Standards Settings are used to carry out the vulnerability assessment.

5.2.3.1 Ecosystem Restoration Vulnerability Assessment

Based on the results of the USACE Watershed Climate Vulnerability Assessment Tool presented in Figure 19 below, relative to the other 201 HUC04 watersheds in the CONUS, the Minnesota watershed (HUC 0702) is relatively less vulnerable to the impacts of climate change on ecosystem restoration. For the Minnesota watershed, the major drivers of the computed vulnerability score are, “At Risk Freshwater Plants”, “Runoff Elasticity”, and “the Measure of Short-term Variability in Hydrology”. Table 4 shows the vulnerability scores for the two 30 year epochs and the scores are relatively constant between both epochs and their wet and dry subsets of traces. Additionally, Table 5 shows the vulnerability score contributions of the different indicators for the 2050 epoch.

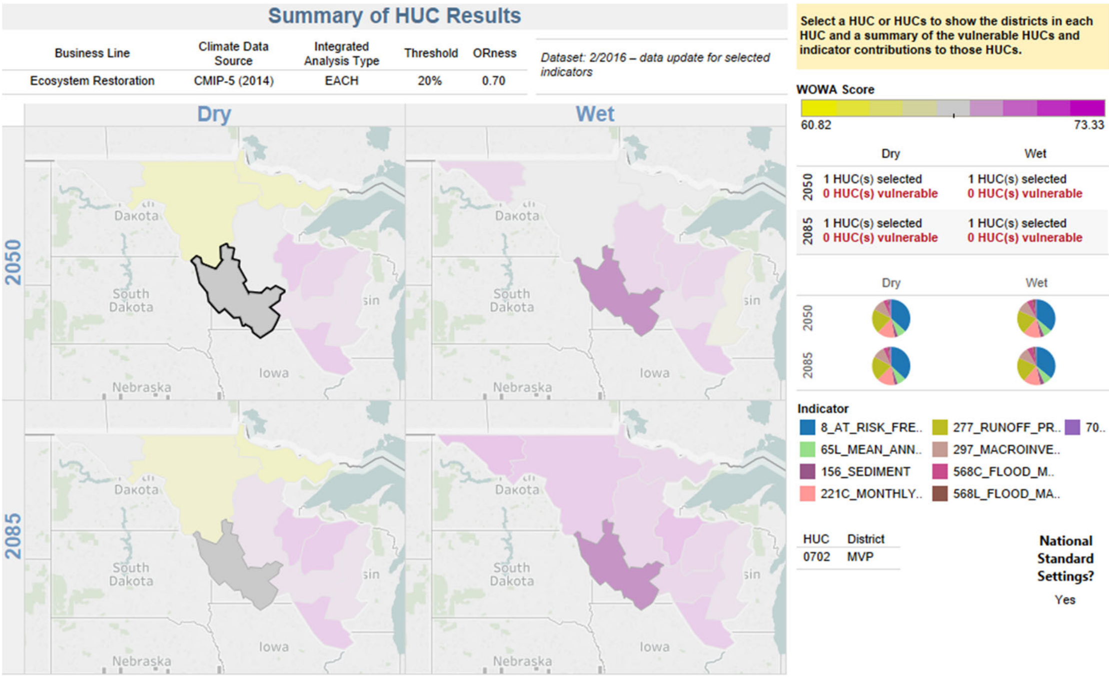


Figure 19: Projected Vulnerability for the Minnesota (0702) with respect to Ecosystem Restoration

Table 4: Projected Vulnerability with respect to Ecosystem Restoration

HUC 4 Watershed	Projected Vulnerability with Respect to Ecosystem Restoration			
	Ecosystem Reduction Vulnerability Score			
	2050 Dry	2050 Wet	2085 Dry	2085 Wet
Minnesota River (0702)	66.92	68.11	66.46	68.30

Table 5: Comparison of Different Indicators for the Minnesota Watershed with respect to Ecosystem Restoration

2050 Epoch	Minnesota River (0702)			
Indicator	Contribution to WOWA Ecosystem Restoration Vulnerability Score			
	Dry		Wet	
Change in Sediment Load Due to Change in Future Precipitation	1.49	3.6%	2.23	5.1%
Short-term Variability in Hydrology (75th Percentile of Annual Ratios of Standard Deviation of Monthly Runoff) - Cumulative	10.02	23.9%	10.08	23.1%
Runoff Elasticity (% Change in Runoff / % Change in Precipitation)	13.88	33.2%	13.87	31.8%
Macroinvertebrate Index of Biotic Condition (Sum of scores for 6 metrics that	6.83	16.3%	6.83	15.7%

characterize macroinvertebrate assemblages)				
Flood Magnification Factor - Cumulative	2.52	6.0%	3.43	7.9%
Flood Magnification Factor- Local	0.77	1.8%	1.36	3.1%
Mean Annual Runoff - Local	5.02	12.0%	4.9	11.2%
Low Flow Reduction Factor	1.34	3.2%	0.88	2.0%
Percentage of Plant Communities at Risk	24.61	58.8%	24.61	56.5%

5.2.3.2 Flood Risk Reduction Vulnerability Assessment

Based on the results of the USACE Watershed Climate Vulnerability Assessment Tool presented in Figure 20 below, relative to the other 201 HUC04 watersheds in the CONUS, the Minnesota watershed (HUC 0702) is relatively less vulnerable to the impacts of climate change on flood risk reduction. For the Minnesota watershed, the major drivers of the computed vulnerability score are, “Flood Magnification Factor - Cumulative”, “Runoff Elasticity”, and “Flood Magnification Factor - Local”. Table 6 shows the vulnerability scores for the two 30 year epochs. Additionally, Table 7 shows the vulnerability score contributions of the different indicators for the 2050 epoch.

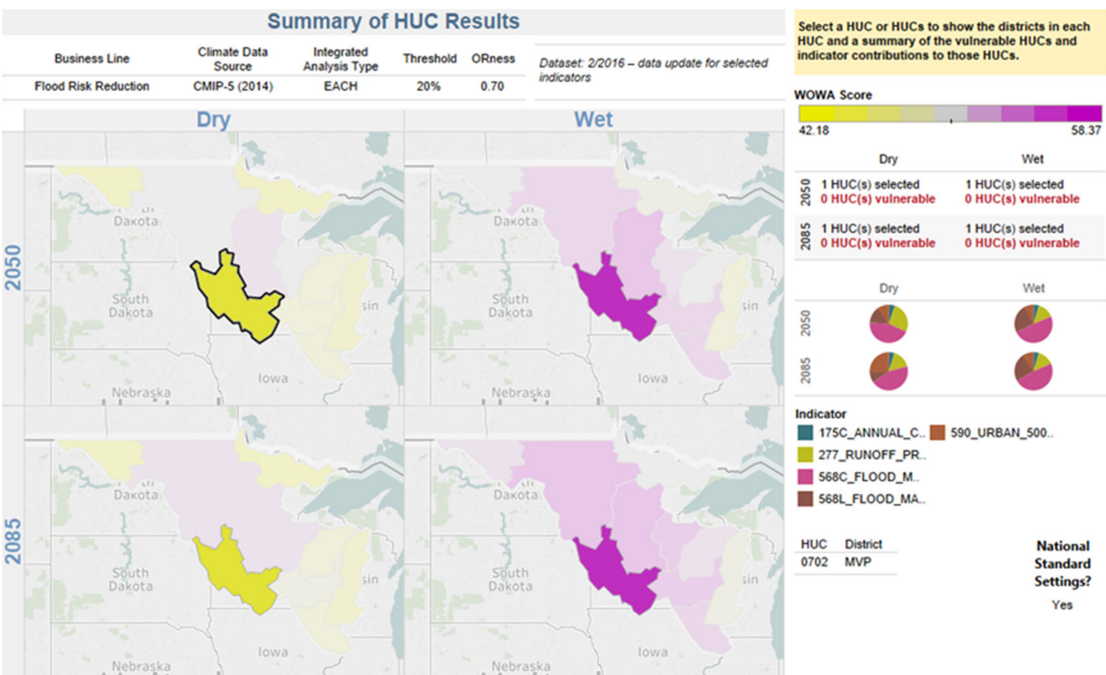


Figure 20: Projected Vulnerability for the Minnesota (0702) with respect to Flood Risk Reduction

Table 6: Projected Vulnerability with respect to Flood Risk Reduction

HUC 4 Watershed	**Projected Vulnerability with Respect to Flood Risk Reduction**			
	Flood Risk Reduction Vulnerability Score			
	2050 Dry	2050 Wet	2085 Dry	2085 Wet
Minnesota River (0702)	45.62	54.85	45.28	56.55

Table 7: Comparison of Different Indicators for the Minnesota Watershed with respect to Flood Risk Reduction

2050 Epoch	**Minnesota River (0702)**			
Indicator	Contribution to WOWA Ecosystem Restoration Vulnerability Score			
	Dry		Wet	
Runoff Elasticity (% Change in Runoff / % Change in Precipitation)	12.08	26.5%	7.65	13.9%
Long-term Variability in Hydrology (Ratio of Standard Deviation of Annual Runoff to the Annual Runoff Mean) - Cumulative	2.38	5.2%	2.60	4.7%
Flood Magnification Factor - Cumulative	20.22	44.3%	26.84	48.9%
Flood Magnification Factor - Local	6.64	14.6%	13.56	24.7%
Acres of Urban Area within 500-Year Floodplain	4.3	9.4%	4.19	7.6%

5.2.4 First Order Statistical Analysis: Site Specific Trends in Observed River Discharge

The primary objective of this study is to improve ecological conditions in the watershed to provide for quality habitat for various bird species. Ecologically relevant components of river discharge include its magnitude, frequency, and duration, as well as the timing of particular discharges, rate of discharge change, and inter-annual (year-to-year) variability. In the study area more frequent and longer duration flood conditions has reduced aquatic plant diversity, resulting in a reduction in habitat quality for migrating water birds. Excessive inflows to aquatic areas increases sediment and nutrient loading affecting plant communities. Inter-annual variability within typical long term extremes helps produce the mosaic of habitats found on the Minnesota River, however increased year to year variability may affect the establishment of some species of plants and the availability of water fowl habitat in the aquatic-terrestrial transition zone.

Additionally, increased river discharges have the potential to effect the project from a flood risk management standpoint. One critical project constraint is to maintain the current level of flood risk in the study area.

Discharge data for the Minnesota River at Jordan, MN (USGS gage 05330000), which includes continuous, daily river flows from 1935 to present, was analyzed to determine if there are any patterns in discharge that might help in assessing future hydrologic conditions in the study area. The location of the Jordan gage is displayed in Figure 16**Error! Reference source not found.**. The drainage area encompassed by the Jordan gage is 16,200 square miles.

The study area is between the USGS gage at Jordan, MN (upstream of project) and the USGS gage at Savage, MN (downstream of project) Upstream of the study area, multiple large, USACE dams have been built. Table 8 below from the Minnesota River Integrated Watershed Study (2017), lists these upstream dams and the associated intervening drainage area between the dams and the USGS gage at Mankato, MN. The Minnesota River Integrated Watershed Study states that, “the USGS peak flow record for the Minnesota River at Mankato, MN USGS gage (05325000) does not indicate effects from upstream reservoir regulation and the intervening drainage area between the significant reservoirs and the Minnesota River at Mankato, MN USGS gage (05325000) is large. A large intervening drainage area between a reservoir and a gage lessens effects of dam operation. Consequently, any change points detected are not likely due to the construction of upstream reservoirs. Detected change points are likely due to effects of anthropogenic climate change, long-term natural fluctuations in climate, and/or changes to the hydrologic properties of the basin (example: land use changes, changes in channel geomorphology, changes in land cover, etc.)." This is subsequently valid for the USGS gage at Jordan and Savage, MN because these gages are downstream of the reservoirs and the Mankato gage. The drainage area associated with the Mankato gage is 14,900 square miles. There is over 1,000 square miles of additional drainage area between the Mankato gage and the USGS gage at Jordan. The intervening drainage area between the upstream headwaters reservoirs and the Minnesota River at Jordan is assumed to be sufficiently large and effects from regulation are assumed to be negligible.

Table 8: Select large dams within the Minnesota River Basin

DAM NAME	HUC 08 WATERSHED NAME	RIVER	YEAR COMPLETED	DAM LENGTH (FT)	MAX DISCHARGE (CFS)	MAX STORAGE (AC-FT)	NORMAL STORAGE (AC-FT)	DRAINAGE AREA (MI^2)	INTERVENING DRAINAGE AREA BETWEEN DAM AND MANKATO USGS GAGE (MI^2)
BIG STONE LAKE	UPPER MINNESOTA RIVER	MINNESOTA RIVER	1937	6,300	5,600	205,000	100,880	1,160	13,740
AARON LAKE	CHIPPEWA RIVER	CHIPPEWA RIVER - TRIB	1964	10	95	190,000	178,500	6.5	14,894
LAC QUI PARLE DAM	MINNESOTA RIVER	MINNESOTA	1939	4,327	35,000	122,800	29,700	6,100	8,800
HIGHWAY 75 DAM	UPPER MINNESOTA RIVER	MINNESOTA RIVER	1974	16,160	32,300	91,000	11,700	1,890	13,010
MARSH LAKE DAM	UPPER MINNESOTA RIVER	MINNESOTA	1942	9,700	2,700	91,000	12,050	2,908	11,992

The Minnesota River gage located at Savage, MN (Port Cargill Harbor; USGS Gage 05330890 USACE maintained) cannot be utilized for any of these analyses because it only records stage measurements because it only includes stage data from 1991-2018. The recommended minimum record length for hydrologic analysis is 30 years of record (ETL 1100-2-3).

A series of twelve different nonstationarity detection tests were carried out on the peak and average annual discharge record at Jordan. Discharge data for both variables were collected at USGS gage 05330000 Mississippi River at Jordan, MN. Nonstationarities were detected using the USACE Nonstationarity Detection Tool and the Time Series Tool Box. Nonstationarities were analyzed to determine if there is "strong" evidence of nonstationary conditions within the discharge record.

A "strong" change point is one for which there is a consensus among multiple change point detection methods, robustness between changes in statistical properties, and for which an operationally significant change in the magnitude of the statistical properties (mean/variance) associated with the record is determined (ETL 1100 2-3). See below for definitions on these three characteristics of a "strong" change point.

- Consensus: minimum of two or more of the tests targeting either changes in the mean, distributional characteristics or variance are detecting a change point.
- Robustness: tests targeting changes in two or more different statistical properties (mean, variance and/or overall distribution) of the dataset are indicating a statistically significant change point.
- Magnitude: difference between the means and variances associated with the subsets of data before and after the change points being used to parse the dataset are operationally significant.

5.2.4.1 High Flow Regime - Nonstationarity Detection Tests

The USACE nonstationarity detection tool is applied to assess the stationarity of the annual peak discharge record for the Minnesota River at Jordan, MN (USGS gage 05330000) from 1935-2014. Six of the twelve different nonstationarity detection tests applied for the high flow regime variable (peak annual discharge) indicate statistically significant nonstationarities. These tests are listed in Table 9 below. The Cramer-Von-Mises (CPM), Lombard Wilcoxon and Mann-Whitney (CPM) tests identified nonstationarities circa 1990. Two of the three nonstationarities detected occurred in 1990 and one (Lombard Wilcoxon) identified a breakpoint in 1989, so 1990 is selected as the breakpoint year. Because two tests are indicating a change in sample mean and an additional test is indicating a change in the overall distribution the nonstationarity identified in 1990 exhibits both consensus and robustness. Additionally, there is a significant increase in the mean associated with the data collected after 1990, relative to the data collected prior to 1990. Thus as shown in Figure 21 below, it can be concluded that there is an operationally significant nonstationarity in the flow record at this site (Friedman, *et al.* 2017). Figure 22 shows the Monotonic Trend Analysis for the entire period of record and statistical significant trends were detected showing a positive trend. A Monotonic Trend Analysis was completed for the timeframe 1990-2014 Figure 23 shows the Monotonic Trend Analysis for the 1990-2014 and that statistical significant trends are not detected.

Table 9: Nonstationarities Detected Using Maximum Annual Flow

Nonstationarities Detected Using Maximum Annual Flow	
Method	Year
Cramer-Von-Mises (CPM)	1990
Kolmogorov-Smirnov (CPM)	1942
Energy Divisive Method	1983
Lombard Wilcoxon	1989
Pettit	1982
Mann-Whitney (CPM)	1990

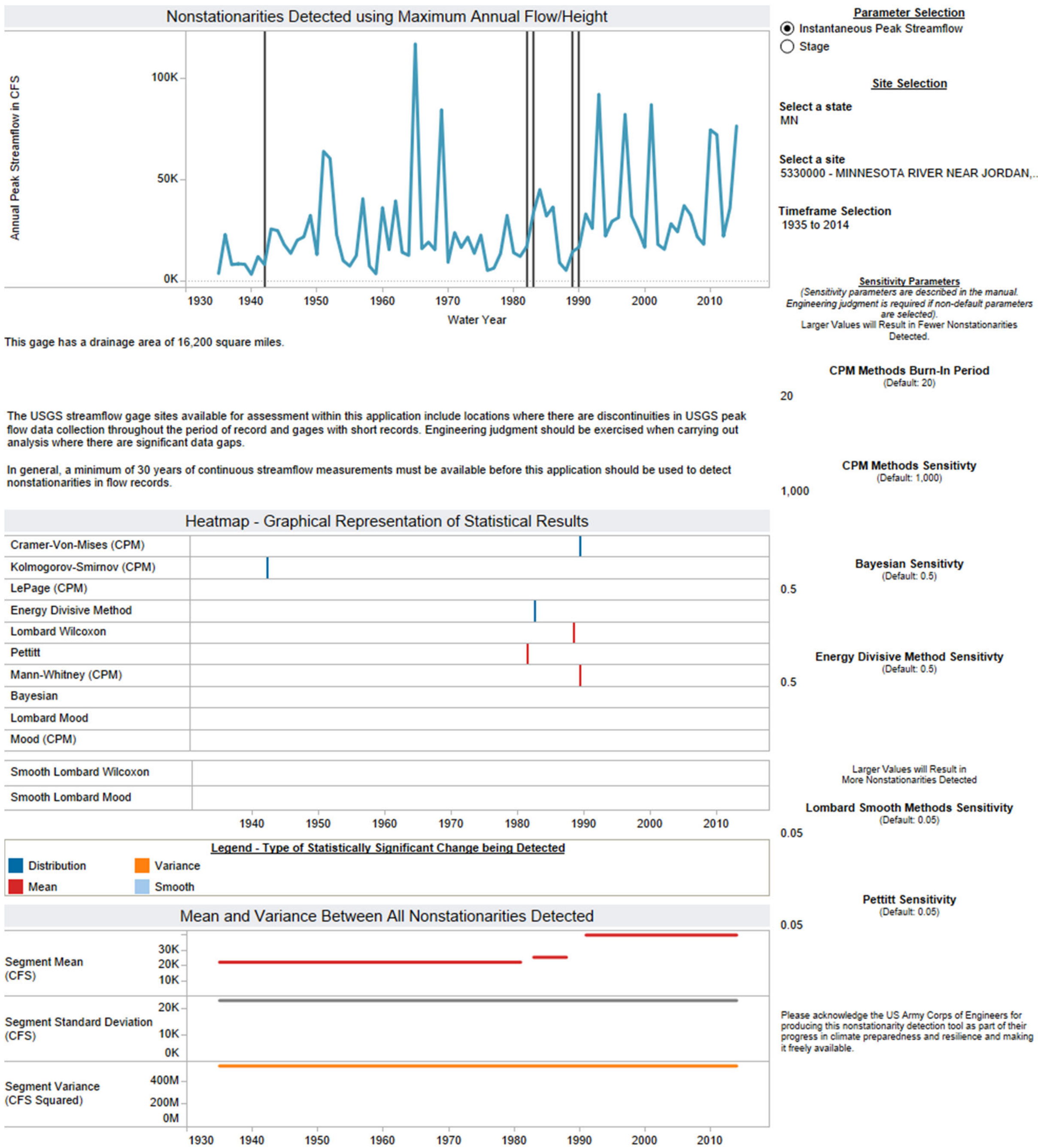
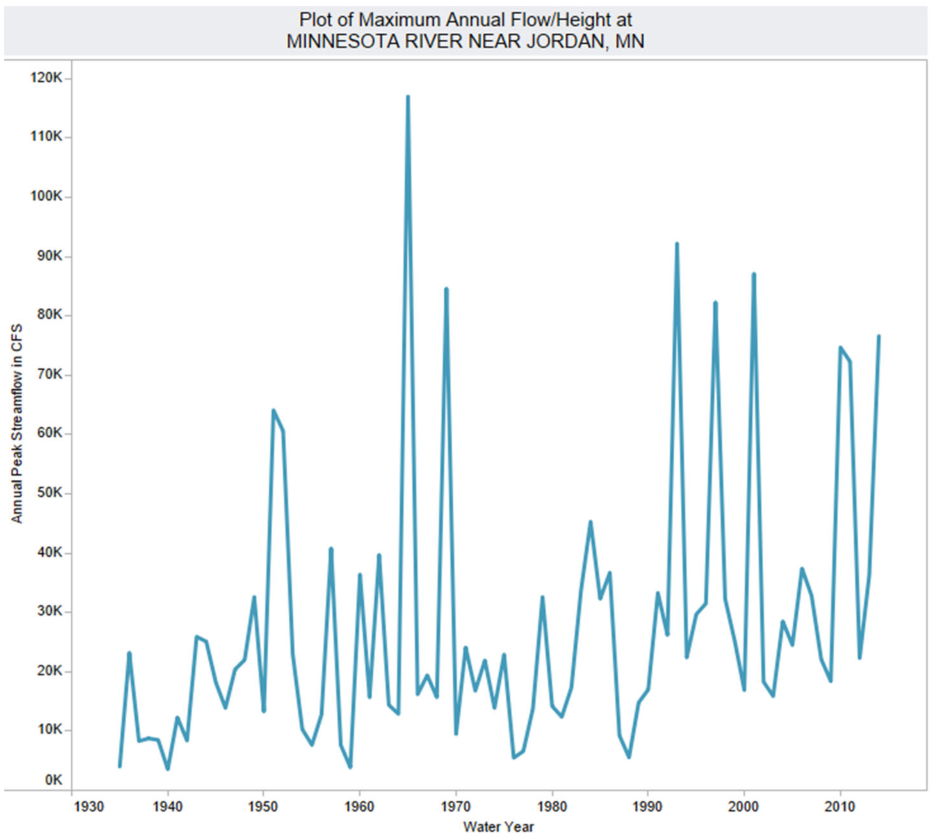


Figure 21: Nonstationary Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014



Timeframe Selection
1935 to 2018

Monotonic Trend Analysis

Is there a statistically significant trend?
Yes, using the Mann-Kendall Test at the .05 level of significance. The exact p-value for this test was less than 1e-3.
Yes, using the Spearman Rank Order Test at the .05 level of significance. The exact p-value for this test was less than 1e-3.

What type of trend was detected?
Using parametric statistical methods, **a positive trend** was detected.
Using robust parametric statistical methods (Sen's Slope), **Null** was detected.

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.

Figure 22: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014

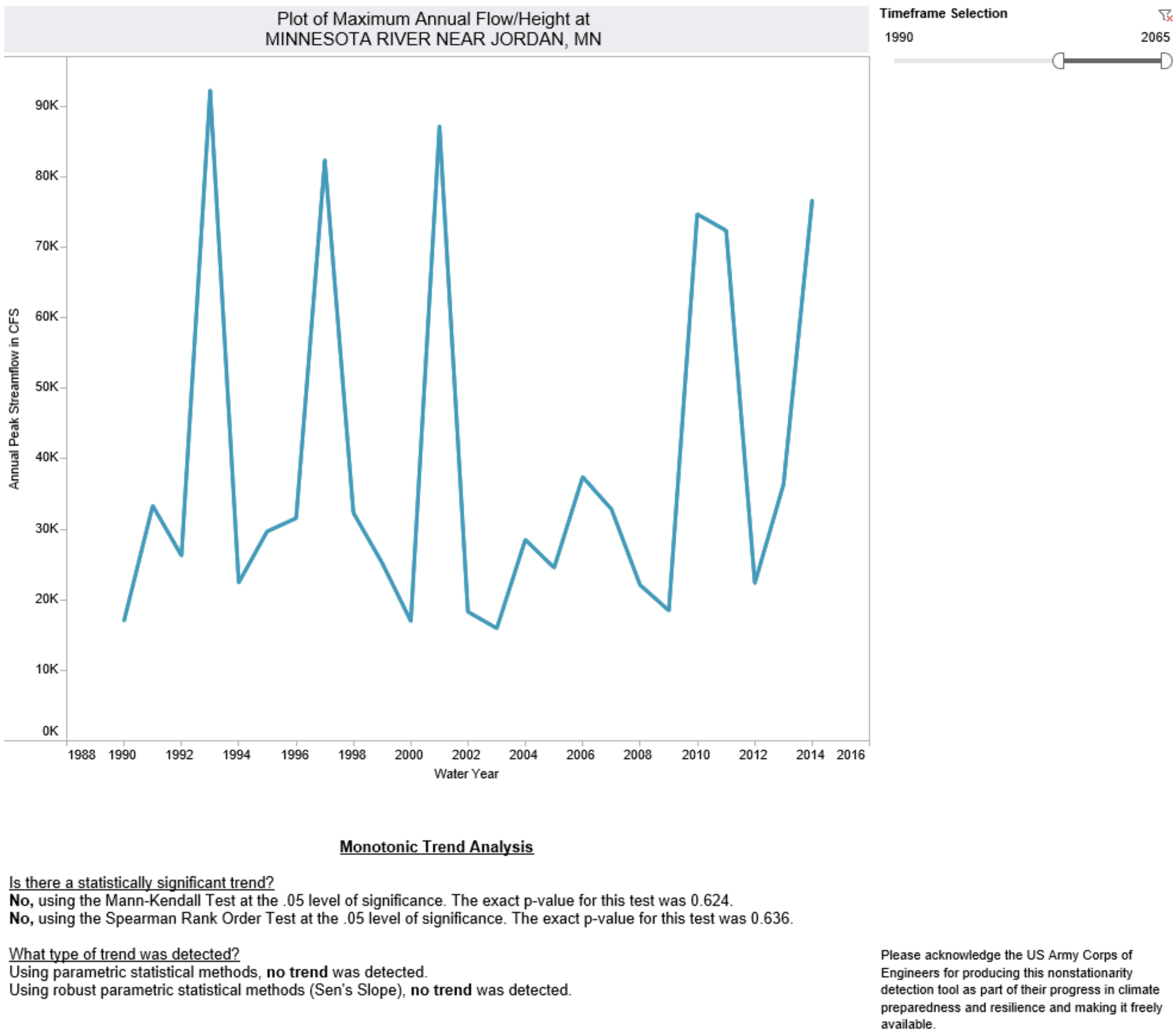


Figure 23: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1990 to 2014

Figure 24 shows the peak annual discharge at the USGS gage at Jordan, MN for the period of record from 1935 to 2017. Consistent with the results of the Monotonic trend analysis generated using the nonstationarity detection tool, there is a trend of increasing peak annual discharge for the entire period of record from 1935 to 2017 (p-value <0.05). Using the 1989 breakpoint to analyze subsets of the data prior to and after to the strong, nonstationarity detected in 1990, no statistically significant trends were found within the subsets of data in the timeframes 1935-1989 and 1990-2017 (see Figure 24 below for p-values).

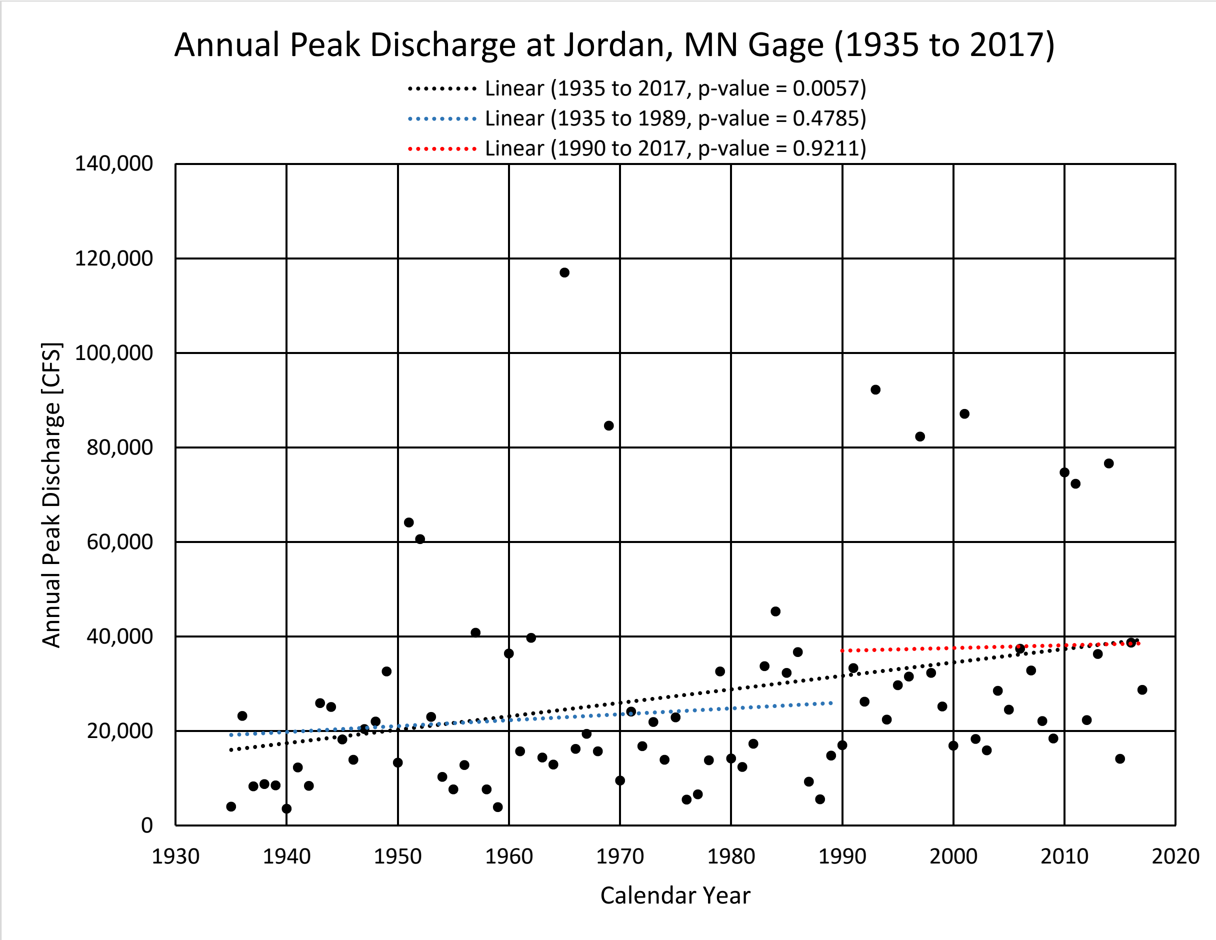


Figure 24: Peak Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017

5.2.4.2 Moderate Flow Regime- Nonstationarity Detection Tests

The USACE Time Series Toolbox application is applied to assess the stationarity of the annual average discharge record for the Minnesota River at Jordan, MN (USGS gage 05330000) from 1935 to 2017. As listed in Table 10 below, six of the twelve different nonstationarity detection tests for the moderate flow regime (average annual discharge) indicate statistically significant nonstationarities. The Cramer-Von-Mises (CPM), and Mann-Whitney (CPM) tests indicate nonstationarities in 1990. The Lombard Wilcoxon, Energy Divisive Method, LePage (CPM) and Smooth Lombard Wilcoxon method test indicate nonstationarities between 1980 and1982.

The nonstationarities detected in both the eighties and 1990 demark a significant increase in the mean of the average annual discharge. Tests indicating nonstationarities in overall distribution and sample mean flag both nonstationarities. Thus, there is a degree of robustness associated with both nonstationarities. Only the nonstationarity in the 1980s demonstrates consensus because multiple tests flagging a change in sample mean are indicating a statistically significant nonstationarity. It can be concluded that there are likely two operationally significant nonstationarities in the flow record at this site (Friedman, *et al.* 2017), as shown in Figure 25 below. The years 1990 and 1981 (middle of the 1980-1982 range) were the years chosen as the representative breakpoints. Figure 26 and Figure 27 show linear regression based trend analyses for the entire period of record and for subsets of data prior to and post the nonstationarities detected in 1981 and 1990. Within in the period of record from 1935 to 2017, there is a statistically significant positive trend (p-value <0.05) within the average annual flow record. There is no statistically significant trend in the 1981-2017 timeframe. This implies that that the record post 1981 is relatively homogenous. If a single nonstationarity is to be selected within the average annual flow record, it is justifiable to select 1981 as the year when there is the most evidence of a change in the properties of the flow record.

Table 10: Nonstationarities Detected Using Average Annual Flow

Nonstationarities Detected Using Average Annual Flow	
Method	Year
Lombard Wilcoxon	1980
Energy Divisive Method	1981
LePage (CPM)	1982
Smooth Lombard Wilcoxon	1981-1982
Cramer-Von-Mises (CPM)	1990
Mann-Whitney (CPM)	1990

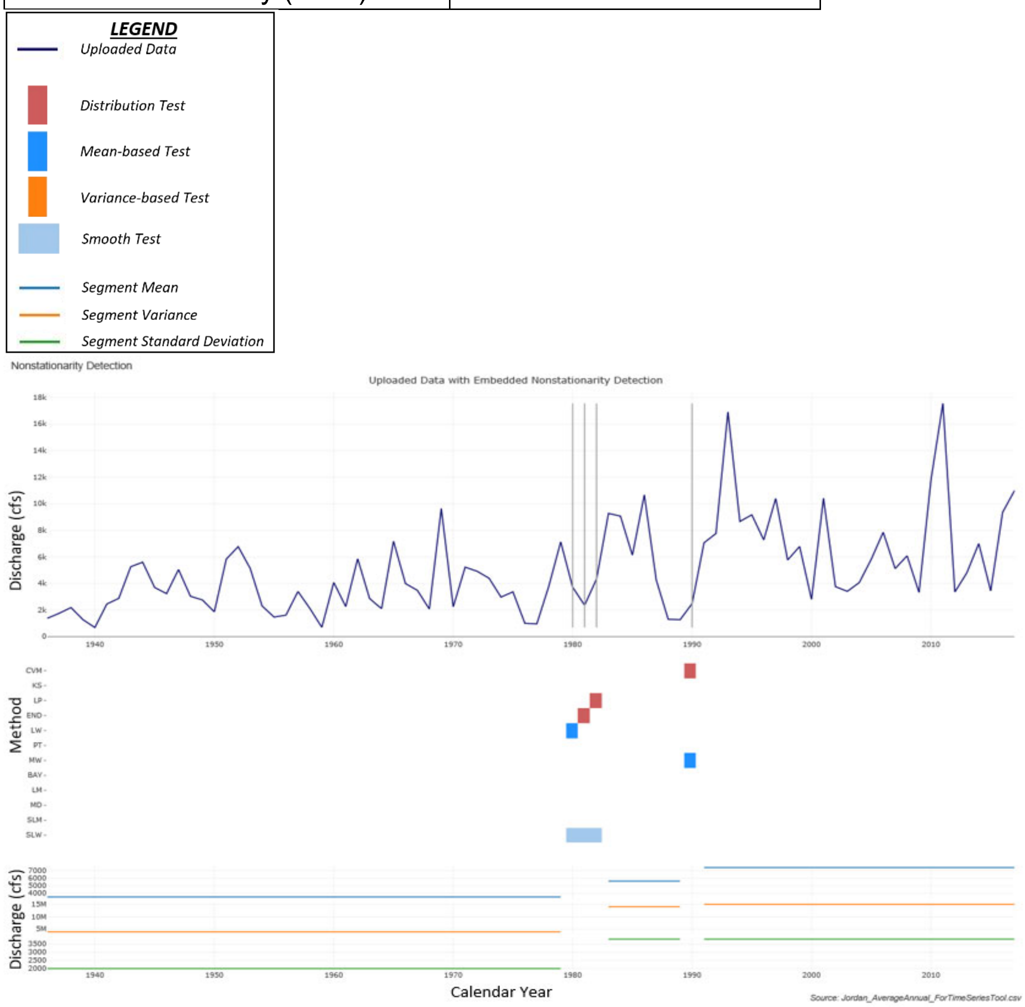


Figure 25: Nonstationary Analysis of Average Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2017 using the Time Series Toolbox

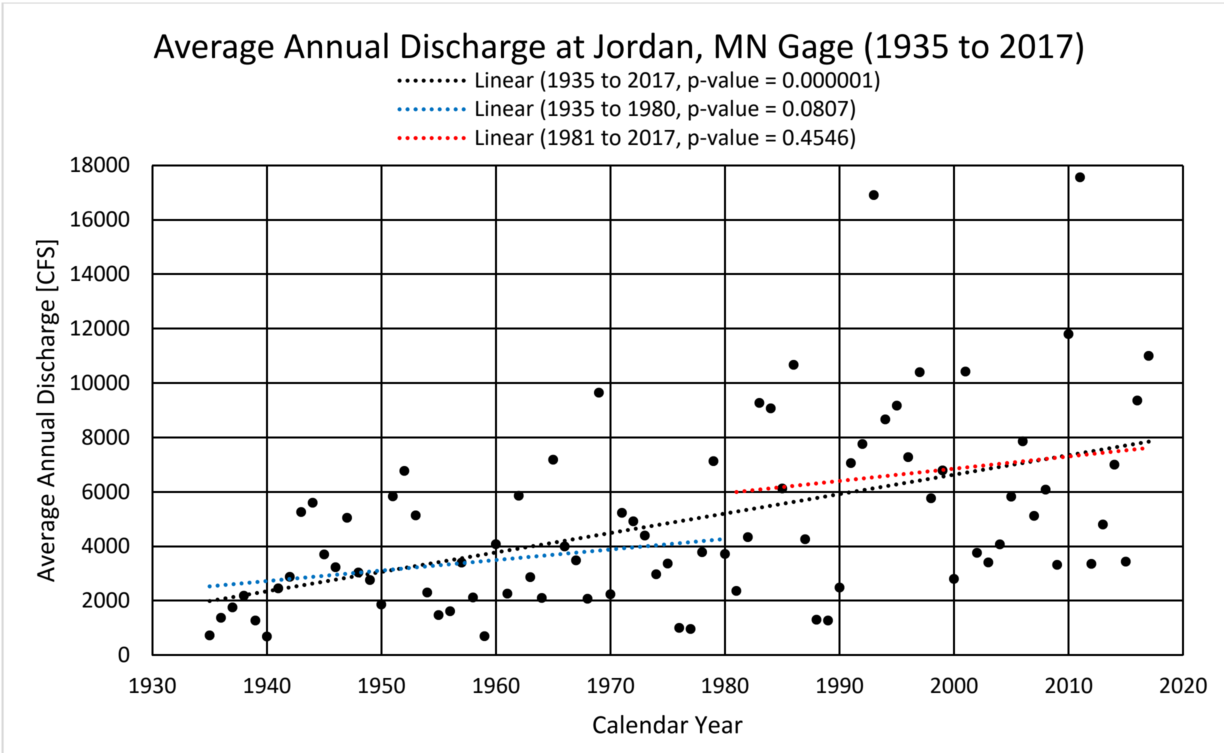


Figure 26: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1981 Breakpoint

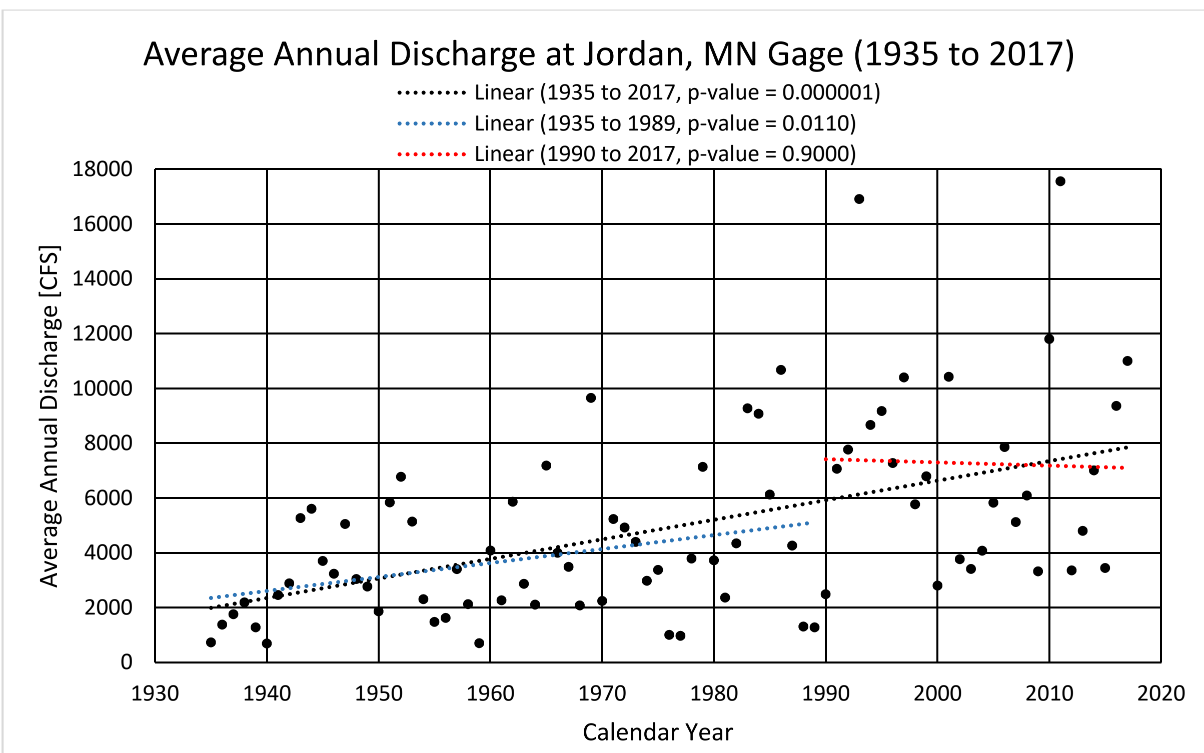


Figure 27: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1990 Breakpoint

5.2.5 First Order Statistical Analysis: Site Specific Trends in Observed Precipitation and Air Temperature Data

In addition to analyzing river discharge, ECB 2018-14 requires the climate change analysis to include information for other variables relevant to hydro-climatic conditions such as temperature, evaporation rates and precipitation. The qualitative analysis required by this ECB should focus on those aspects of climate and hydrology relevant to the project's problems, opportunities, and alternatives. The primary variables relevant to this project, besides discharge would include precipitation and air temperature. Trends in total annual precipitation and average annual air temperature are evaluated.

The data for these two variables is collected from the NOAA National Climatic Data Center (NCDC) station USW00014922 (Minneapolis St. Paul International Airport). The datasets cover 100% of the years between 1939 and 2017. The location of the station in relation to the project can be viewed in Figure 28. There is a climate station near Jordan, MN that includes data from 1942-2018, however this station has missing data which could result in inaccurate results.

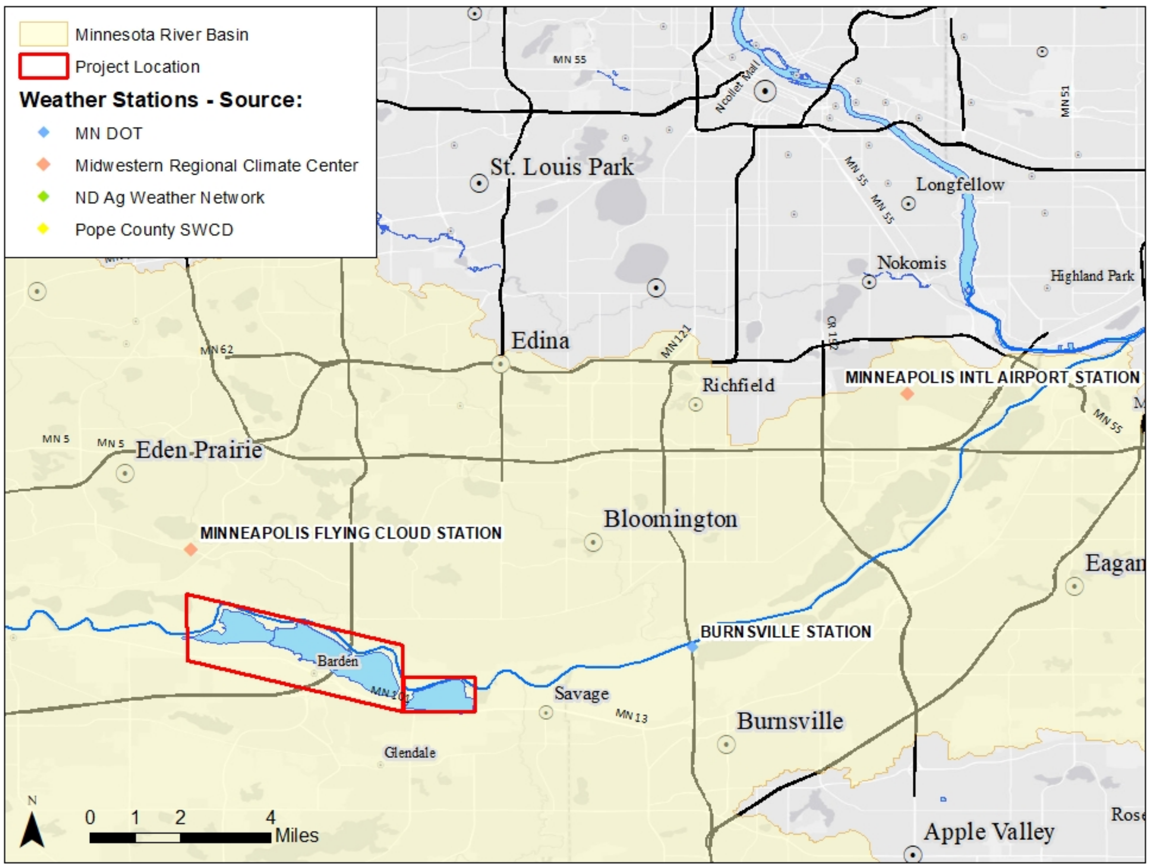


Figure 28: NOAA National Climatic Data Center MSP Station Location

5.2.5.1 First Oder Statistical Analysis – Total Annual Precipitation

The USACE Timeseries Toolbox application is used to assess the stationarity of the precipitation record recorded by the MSP gage near the Minnesota River Basin. Four of the twelve nonstationarity detection tests included within the Timeseries Toolbox indicate that there is a statistically significant, nonstationarity in the year 1976 (see Table 11, below). Two different statistical tests are indicating a change in mean and two tests are indicating a change in overall statistical distribution. Thus, there is consensus between tests. Because multiple tests, targeting different statistical properties are indicating a nonstationarity it can be considered robust. There is a significant increase in the magnitude of the mean if the data collected pre- and post- 1976 is compared. As shown in Figure 29, it can be concluded that there is an operationally significant nonstationarity in the total annual precipitation record at this site (Friedman, *et al.* 2017). Figure 30 shows the results of a linear trend analysis for the entire period of record and for the subsets of data collected prior to and post 1976. There is a statistical significant positive trend in the dataset collected between 1935 and 2017 (p-value<0.05). If the dataset is broken up into two subsets of data collected pre- and post- 1976 there are no statistically significant trends (p-values>0.05). The frequency of high precipitation years, where annual totals are at or above 35 inches, increases dramatically in the latter half of the precipitation record, occurring in one-quarter of the years after 1976, but less than one-tenth of the first 37 years of the record. Conversely, drought years (precipitation < 20 inches) are common before 1976 and rare after.

Table 11: Nonstationarities Detected Using Total Annual Precipitation

Nonstationarities Detected Using Total Annual Precipitation	
Method	Year
Cramer-Von-Mises (CPM)	1976
Energy Divisive Method	1976
Lombard Wilcoxon	1975
Mann-Whitney (CPM)	1976

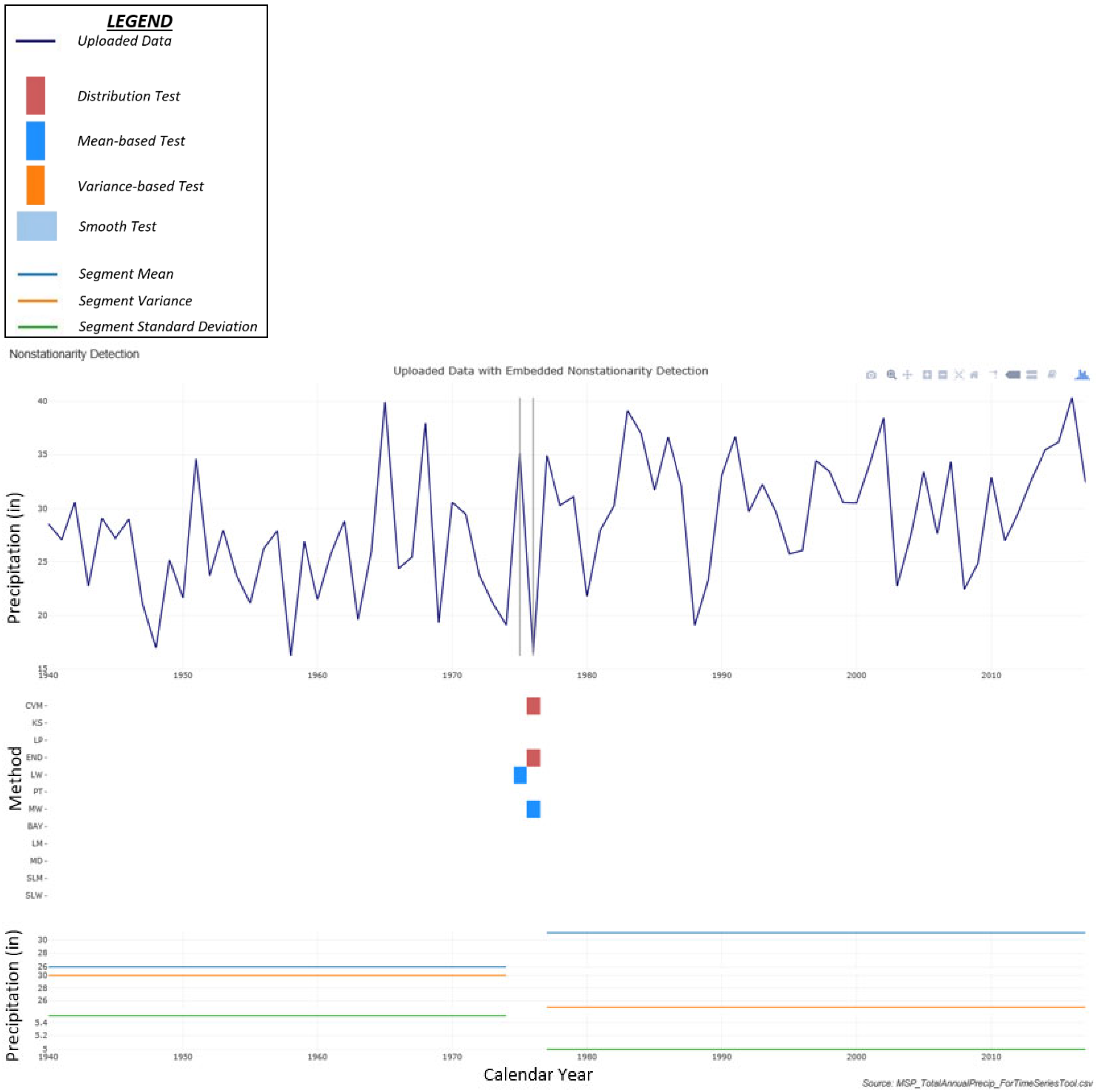


Figure 29: Nonstationary Analysis of Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox

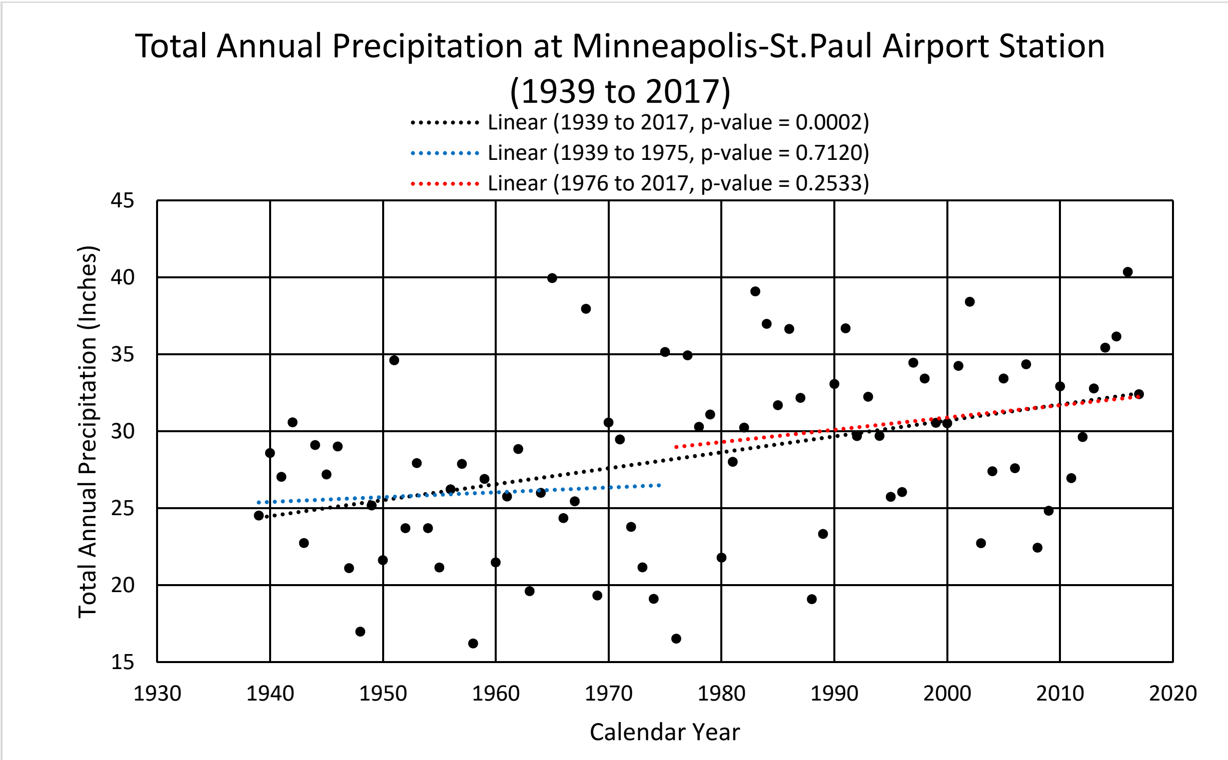


Figure 30: Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 & Subsets of Data Selected Based on the 1976 Nonstationarity.

5.2.5.2 Air Temperature Nonstationarity Detection Tests

The USACE Timeseries Toolbox application is used to assess the stationarity of the average annual air temperature record recorded by the MSP gage near the Minnesota River Basin. Six of the twelve different nonstationarity detection tests applied by the tool indicate a nonstationarity in 1997 (Table 12 below). The Cramer-Von-Mises (CPM), LePage (CPM), Energy Divisive Method, Lombard Wilcoxon, Mann-Whitney (CPM) and Bayesian tests detect nonstationarities in 1996 and 1997. The year 1997 appeared five times, so this was the year chosen for the breakpoint. Three different statistical tests are indicating a change in mean and three tests are indicating a change in overall statistical distribution. Thus, there is consensus between tests. Because multiple tests, targeting different statistical properties are indicating a nonstationarity it can be considered robust. There is a significant increase in the magnitude of the mean if the data collected pre- and post- 1997 is compared. As shown in Figure 31 below, it can be concluded that there is an operationally significant nonstationarity in the average annual air temperature record at this site (Friedman, *et al.* 2017). Figure 32 shows the results of a linear trend analysis for the entire period of record and for the subsets of data collected prior to and post 1997. There is a statistical significant positive trend in the dataset collected between 1935 and 2017 (p-value<0.05). If the dataset is broken up into two subsets of data collected pre- and post- 1997 there are no statistically significant trends (p-values>0.05). The frequency of higher average air temperature years, where average annual values are at or above 46 degrees, increases dramatically in the latter half of the air temperature record, occurring in 80% of the years after 1976, but only 20% of the first 59 years of the record.

Table 12: Nonstationarities Detected Using Average Annual Air Temperature

Nonstationarities Detected Using Average Annual Air Temperature	
Method	Year
Cramer-Von-Mises (CPM)	1997
LePage (CPM)	1997
Energy Divisive Method	1997
Lombard Wilcoxon	1996
Mann-Whitney (CPM)	1997
Bayesian	1997
Lombard Mood	1994

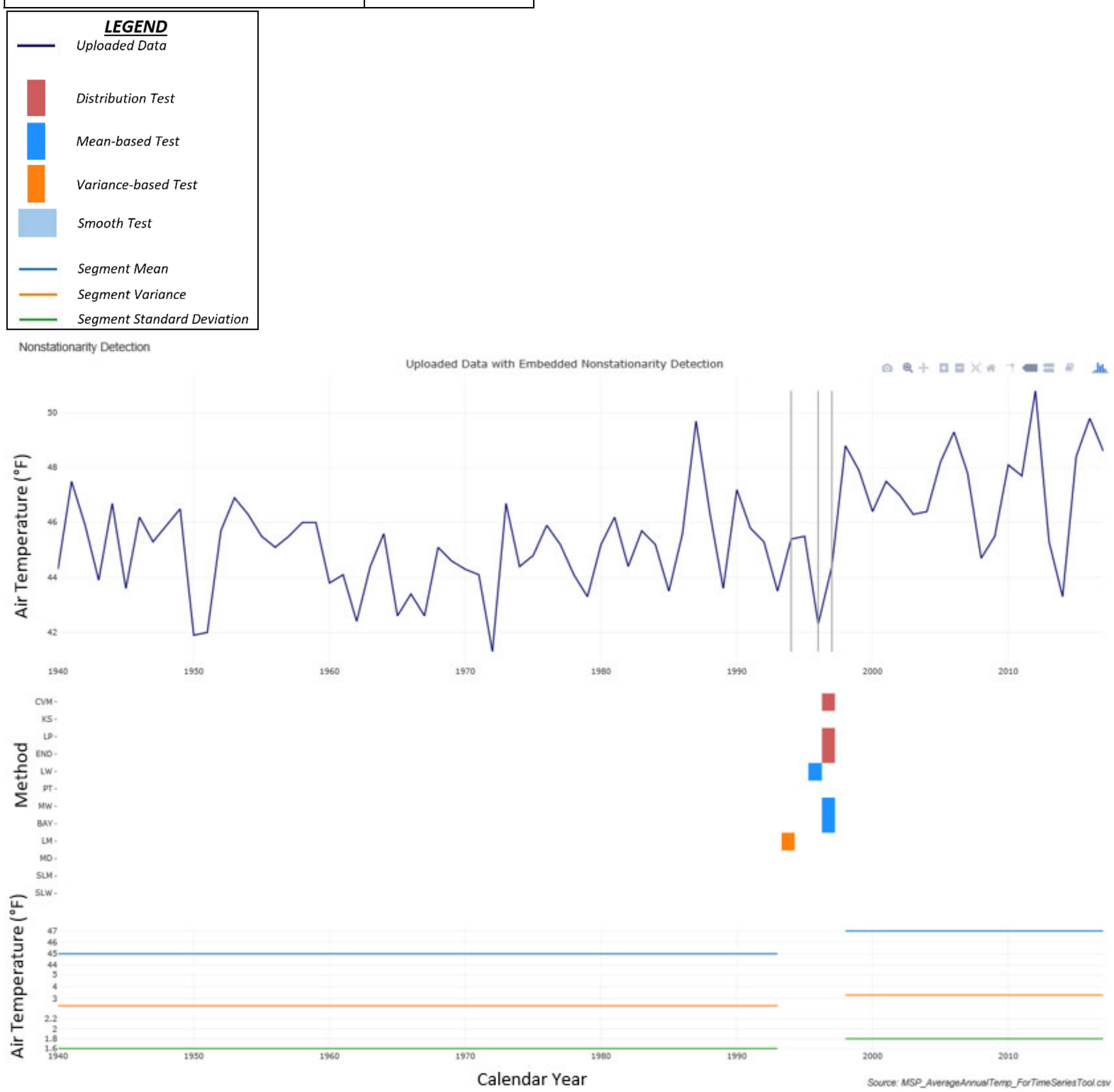


Figure 31: Nonstationary Analysis of Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox

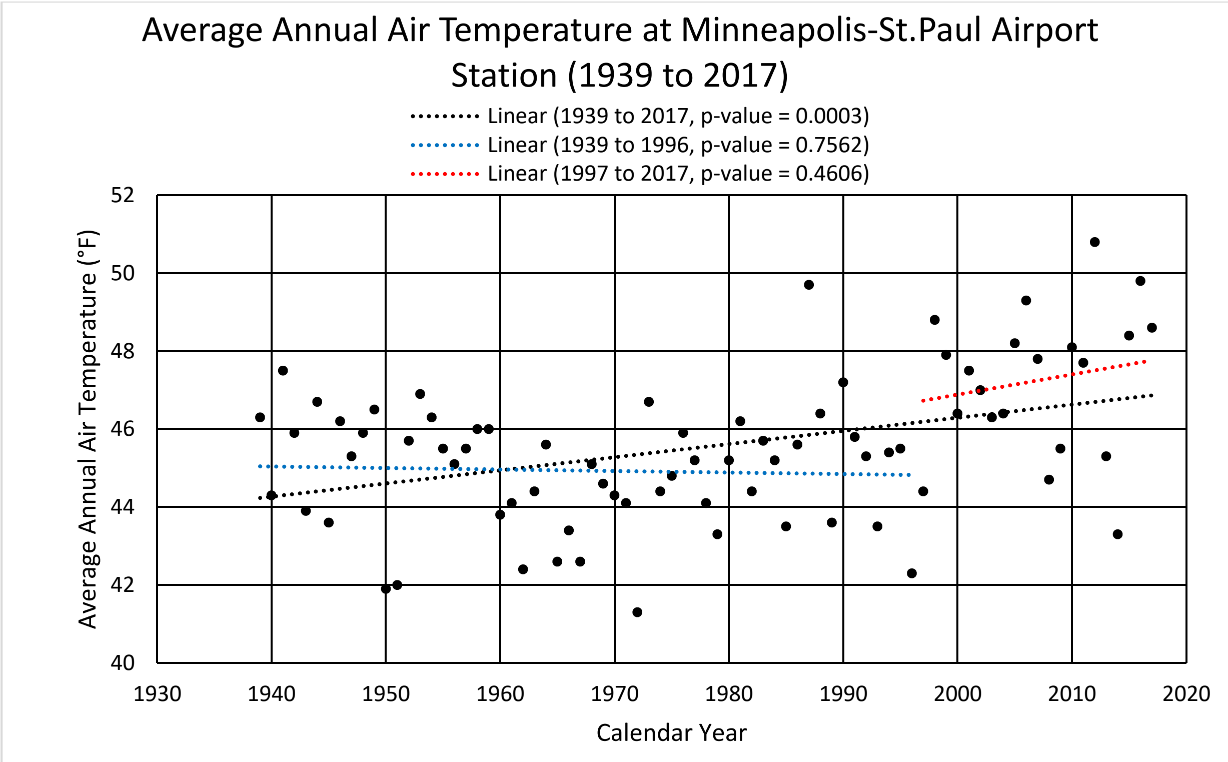


Figure 32: Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 with Trend Lines for the 1997 Breakpoint

5.2.6 Discussion of Trends in Historic Hydrometerological Variables

A "strong," statistically significant nonstationarity in annual peak flow is detected circa 1990 and operationally significant nonstationarities in annual mean flow are detected circa 1981 and 1990. Both correspond to an increase in streamflow. A "strong," statistically significant nonstationarity in annual precipitation totals can be observed in the late seventies. An increasing trend in precipitation is observed. The coincident trends in increasing streamflow and precipitation imply that changes in climate are at least partially responsible for changes in hydrologic response. Because increased high and moderate flows have the potential to undermine key project features/functionality and can have a negative impact on migratory bird/ water fowl habitat, the Recommended Plan was selected such that it reduces the potential for changes in streamflow/precipitation to negatively impact the study area. This could be accomplished by incorporating additional resilience into project features and including adaptive management principles in habitat management. The potential for temperature increases in the future can compound habitat degradation and further justifies the need for a project that is targeted at improving ecosystem function.

5.2.7 Summary/Conclusion

Despite the USACE Watershed Climate Vulnerability Tool indicating that the Minnesota River watershed is not highly vulnerable to the impacts of climate change on ecosystem restoration or flood risk management relative to other 201 HUC-04 watersheds in CONUS, available climate change literature suggests a wetter and warmer climate in the future. A first order statistical analysis using the USACE Climate Hydrology Assessment Tool, Nonstationarity Detection Tool and Timeseries Toolbox confirms that overall, observed flows have been increasing and will likely continue to increase in the Minnesota River Basin. Changing flow conditions further justify the need for the proposed project. If no changes are made to the study area, changing flow conditions would make effective drawdowns to support bird habitat difficult to accomplish and would continue to degrade the condition of existing water management features. With the proposed, more robust design of the water management structures, the project will be given the best chance at completing annual drawdowns.

The trends and nonstationarities detected in the annual peak flow and the average annual flow records cannot be attributed to a specific driver like the construction of a water management structure or a known, abrupt change in land use. Thus, trends and nonstationarities are likely caused by a less easily identifiable source like anthropogenic climate change, long-term, persistent natural fluctuations in climate or distributed changes to the basin's land cover/land use/geomorphology overtime.

Historic discharge data at the USGS gage at Jordan, Minnesota indicates a statistically significant trend of increasing average annual discharge ($p<0.05$) with strong nonstationarities detected in the years 1981 and 1990. There is also a statistically significant, increasing trend in annual peak streamflows over the period of record ($p<0.05$) and strong evidence of a statistically significant nonstationarity detected within the peak streamflow record in 1990. Historic total annual precipitation and average annual air temperature also indicate a statistically significant, increasing trend over the period of record ($p<0.05$) and strong evidence of a statistically significant nonstationarity detected in the years 1976 and 1997, respectively.

The high potential for increased river discharge in the future, as is evident within the historic and projected data considered as part of this analysis, was considered during the design of this project. Project features are designed to be able to handle projected changes in climate and hydrology in the basin. The TSP features include 5'x6' concrete stoplog structures, rocklined overflow channels, a ditch plug, and access roads. The project also includes a dredging plan for the existing channels that connect the structures. The rocklined overflow channels are relief points for the structures. These channels reduce the head differential during flood conditions and protect the structure from erosion/failure. There will be a rocklined overflow channel at each water level management structure. The ditch plug is located at Continental Grain Marsh. It is a rock armored ditch plug with a rock overflow channel as described earlier. The stoplog structures are designed to be larger than the current structures to facilitate more efficient drawdowns. The original goal was to design structures to complete a drawdown in at least 10 days. These structures were overdesigned (size-wise) to enable even faster drawdowns than 10 days and to prevent debris blockage. The structures will be able to draw the lakes down in four days when the adjacent Minnesota River elevation (RM 20) is at or below the full drawdown elevations of the lakes/marsh. The drawdown analysis in Section 8.3.1 explains this in more detail. Channel dredging will be completed to improve hydraulic conveyance to and from the structures. Increasing the capacity of the stoplog structures and channel dredging will enable the structures to quickly draw down the lakes during short breaks in flood events. Access roads to and around the structures will allow the USFWS to maintain conveyance through the structures by removing obstructive debris and sediment.

In addition to design modifications aimed at creating efficient and robust structures tolerant to higher flows, resilience will be built into the proposed project by using lessons learned from successful and stable ecosystem restoration projects all constructed between 1981 and 2015. The majority of lessons learned from these projects are listed in the *Upper Mississippi River Restoration* (*UMRR) Design Handbook*, 2012. However, the handbook has not been updated in several years and as a consequence, the effects of climate change on restorative features were not directly addressed in the handbook in great detail.

Additionally, increases in flow have the potential to stress project features and make it more difficult to fulfil management objectives in the future. Table 15 summarizes the residual risk due to climate change associated with the proposed project features identified as part of the RECOMMENDED PLAN.

Table 13: Bass Ponds Climate Risks

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Stoplog Structures	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes & peaks may occur more frequently	Flood waters may remain in the lake for longer durations making habitat management more difficult. Frequent High flows of longer duration have the potential to damage the structures. Larger floods may increase debris near the structure, potentially damaging the structure.	Moderate
Rock-lined overflow structure	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the rock-lined overflow structures for longer durations, and more frequently, potentially damaging the structures. Increased flood sizes increase water velocities over the structure, potentially damaging the structure.	Moderate
Ditch Plug	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the ditch plug for longer durations, and more frequently, potentially damaging the structure. Increased flood sizes increase velocities over the structure, potentially damaging the structure.	Moderate
Access Dredging	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Increased flood events and sedimentation in the Minnesota River Basin	Moderate
Access Roads	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the access roads for longer durations, and more frequently, potentially resulting in impassable roads/ roadway damage.	Moderate

6 Sedimentation

Sediment transport in the project area is affected by upstream sediment loads and channel floodplain-connectivity. Variation in upstream sediment loads occur due to annual patterns of precipitation and runoff, sediment erosion, and off-channel deposition. The majority of the sediment load in the Minnesota River and its tributaries comes from near channel sources such as bluffs, ravines, and channel banks as opposed to upland agricultural field sources (Belmont 2011, Gran 2011). Channel-floodplain connectivity is intermittent, occurring during high water events caused by snowmelt runoff in the spring and rainfall events that can occur anytime during the year. During low flow conditions, sediment is conveyed in the Minnesota River channel and bypasses the lakes in the project area (approximately river mile 15-21). For higher flow conditions, sediment enters the project lakes over the natural levees that separates the lakes from the Minnesota River channel. Overtopping of the natural levee at the project area occurs at discharge of 26,000 to 27,000 cfs (recorded at the USGS Gage at Jordan, MN), which is approximately a 39-percent annual exceedance probability (AEP) flood.

Bank erosion is occurring throughout the lower Minnesota River with significant channel widening observed over time. Lenhart et al. (2013), using aerial photographs, found that the Minnesota River had widened 52% between Mankato and St. Paul since 1938. A comparison of channel surveys completed between 2012 and 2014 by USACE personnel to earlier cross sections (circa. 1970 – 1990) for the lower 100 miles of the Minnesota River (approximately Mankato, MN to the mouth) indicated both reductions and increases in width (range = 158 feet reduction to 246 feet of increase). Overall, channel width had increased by 40 to 50 feet. Because of the uncertain vintage of the earlier cross sections, an average rate of widening could not be determined. Longitudinally, consistent channel widening occurred over the lower 55 miles of the river (approximately Belle Plaine, MN to the mouth), with more variability (primarily widening, but some narrowing) upstream of this. This geomorphic response, bank erosion, seems to correspond with the increase in average annual discharge during the period of record that was discussed in section 2.2.4 (Figures 21 and 22). If annual discharge continues to increase, more bank erosion can be expected. However if annual discharge stabilizes at the higher levels they are at now, future bank erosion may decrease though the time scale for achieving this is uncertain. Over a period of decades, channel enlargement in response to an increase in runoff may be self-limiting; the channels gradually adjust their size to a regime of larger floods (Gran et al., 2011).

While channel bank erosion is a significant source of sediment, the Lower Minnesota River from Jordan (RM 39.4) to the mouth is a net sink for sediment and nutrients (Groten et al. 2016, Lenhart 2013, James 2008). Groten et al. (2016), based on total sediment load measurements, estimated reductions from 289 tons/year/sq mi at the Jordan, Minnesota gage to 100 tons/year/sq mi at the gage at Ft. Snelling, Minnesota at the mouth of the river. Breaking this down by sediment size, fine sediments were reduced by 1.3 million tons per year and sand size sediments were reduced by 0.12 million tons per year from Jordan to Ft. Snelling. Part of the reduction in sand is due to the dredging that is done on the navigable reach of the Minnesota River (river miles 0 to 14.7) which had an average value of 20,000 cubic yards per year (0.026 million tons per year) for the years 1995 to 2017 (USACE Dredging Data). Dredging is variable from year to year, shows no upward or downward trend, and amounts to approximately 20-percent of the sand size sediment load reduction between Jordan and Ft. Snelling.

The lower Minnesota River is impaired for turbidity and is the subject of significant study and research by various government agencies and academia. A large amount of sediment data exists, however most of it is total suspended solids or turbidity data. An exception is the USGS gage at Mankato, Minnesota which is located 50 miles upstream of the project area. From 1968 to 1995, the USACE – St. Paul District provided funds to the USGS for the collection of water samples to determine the suspended sediment concentration (SSC) at this gage. The mean SSC at this gage was 166 mg/L over this time period. The Mankato data indicates that SSC, while variable, had not increased during this time period, but that suspended sediment loads had increased due to the fact that there was an upward trend in river discharge. The more recent 2011 to 2014 sediment measurements (Groten et al. 2016) indicates a mean SSC of 194 mg/L at Mankato, 274 mg/L at Jordan, and 222 mg/L at Ft. Snelling State Park. While the Bass Ponds project is not intended to change water quality on the Minnesota River, it is noteworthy that sediment concentrations are high enough to affect light penetration during flood events.

Fine sediments enter Blue, Fisher and Rice Lake over the natural levee during flood events. All three lakes are depositional, though localized erosive conditions can occur at the connecting channels between the lakes and the river and in places where infrastructure (e.g. roads & trails) cause higher velocities. Estimates of sediment deposition rates using different methods or from different studies are given in Table 14 below.

Table 14: Floodplain Sediment Deposition Estimates on the Lower Minnesota River Based on Four Different Methods or Studies

Method or Study	Description	Deposition Rate
Existing Rice Lake Inlet Channel Analysis	A comparison of existing conditions bathymetry to as-built drawings for the Rice Lake HREP dredge channel (construction completed in fall 1998) indicates about 0-6 inches of deposition from the structure to about 150' into the lake. The deposition increases to be more than 6" from 150' to the end of the dredge cut. If it is assumed that 6 inches of sediment accumulation occurred over the 20 year time period since project construction the annual deposition rate would be 0.3 inches/year (0.76 cm/year).	0.3 inches/year
Lenhart et al., 2014	In a recent study that used soil forensics to distinguish post-European settlement alluvial sediments from earlier deposits, mean deposition rates in channel boundaries (the natural levee) were estimated to be 0.80 cm/year, and then decreased with distance from the river bank having a mean rate of 0.17 cm/year in areas farther from the channel (Lenhart et al. 2013). These areas farther from the channel are typical of much of the project area and several of the study sites were near the project area.	0.07 inches/year
Jennings et al., 2018	Sediment cores obtained in backwater lakes several miles upstream of the project area were analyzed for fossil pollen and non-pollen microscopic fossils and were then correlated to major ecological shifts as indicated by pollen assemblages to dated horizons in nearby lakes (Jennings et al., 2018) The results indicate sediment deposition rates of 1.4 cm/year for the 1993 to 2018 time period, though the authors state that additional analysis including actually dating the cores needs to be done to reduce uncertainty in the deposition rates.	0.55 inches/year

Sediment Load Changes based on Groten et al, 2016	The USGS sediment monitoring that was done at Jordan and Ft. Snelling indicates that approximately 1.3 million tons per year of fine sediment deposited in the floodplain for each year from 2011 to 2014. If this sediment load was assumed to settle out uniformly in the floodplain with the channel corridor taken out of this area and if the deposits had a density of 80 lbs/ft3, the resulting deposition rate would be 0.38 in/yr (0.98 cm/yr).	0.38 inches/year

Future geomorphic change in the project area will continue to include bank erosion and off-channel sediment deposition - the magnitude of these processes depending on long-term hydrologic conditions. The first order statistical analysis presented earlier in Section 5.2 indicates statistically significant increasing average annual discharge since the mid-1930s and projected increases in flows during the project life of 50 year. However, the nonstationarity detection tests indicated statistically significant nonstationarities in 1990 and 1980 - 1982. Trend lines fitted to these shorter time periods do not indicate statistically significant upward trends, however the fact that the nonstationarities exist creates some uncertainty regarding Future Without Project Conditions. If river discharge trends are flat in the future, erosion of river banks and mobilization of sediment from other near channel sources will probably continue, though the river may reach dynamic equilibrium if discharge does not increase. If river discharge increases, additional bank erosion, overbank flooding, and sediment deposition in the lakes will occur.

Using the average sediment deposition rate of the four values in Table 14 (0.325 inches/year) and the maximum value (0.55 inches/year), a total of 16.25 and 27.5 inches of net deposition would occur over the next 50 years, respectively. The channels will be dredged to 692.5 feet which means post-net deposition results in channel inverts increased to between 693.9-694.8 feet. The full drawdown elevations range from 695-696.2 feet for the lakes/marsh. This suggests that project features such as the control structures and channel dredging should be effective for the entire project life.

7 Hydraulics

The hydraulic stressors affecting the Bass Ponds project area include high and increasing hydraulic connectivity (i.e. the amount of water conveyed) between the lakes and river channel, and an altered water level hydrograph.

7.1 Future without Project

Based on observation of existing structures in the project area, the existing structures are predicted to deteriorate within the next 50 years. The corrugated metal pipe culverts that are currently in place will rust and collapse. The Fisher Lake outlet structure is already collapsed which has caused erosion of the natural levee separating the lake and adjacent holding pond. The flow path has now diverted through a holding pond and outlets through an eroded DOT culvert/ditch with exposed fiber optic cable. This eroded DOT culvert/ditch is expected to continue to widen in the next 50 years.

The increased duration of full lake pool due to inefficient/inoperable water level management structures will continue to occur more often according to the climate change and major flooding analysis. This full lake pool results in poor emergent and submergent vegetation for migratory birds.

7.2 Flood Stage Impacts

Flood stage impacts due to proposed project features will be unchanged. The proposed features are in the existing features' footprint and control elevations are at or below the existing topographic/built elevations. Table 15 below compares the current top of water level management structure/road elevation to the proposed structure elevation. The proposed O&M maintenance roads will be constructed by removing existing in situ material and then adding the road materials up to the existing, in situ topographic elevations to ensure flood risk is not increased. The Continental Grain Marsh plug will be constructed to be even with adjacent land elevations at approximately 700.5 feet NAVD 88. The Continental Grain Marsh rocklined overflow structure will be constructed lower than the plug and adjacent, natural low land features at approximately 699 feet (NAVD 88). By designing project features to be at or below the current adjacent topography flood stages will not be increased by the project.

Table 15: Flood Stage Impacts: Existing and Proposed Structure

Flood Stage Impacts: Existing and Proposed Structure		
Structure Location	Existing Top of Structure	Proposed Top of Structure
	Elevation (Feet - NAVD 88)	
Blue Lake Outlet	708.1	700
Interlake (Blue-Fisher)	702	702
Fisher Lake Outlet	701.4	701
Rice Lake Outlet	704.6 (Top of Access Road)	704.6
Secondary Outlet (Fisher-Rice)	701	701
Continental Grain Marsh Outlet	701.5	701.5
Continental Grain Marsh Rock Overflow	700.5	699.0

7.3 Ground Water

USFWS have reported signs of groundwater inputs into the lakes/marsh especially Blue Lake and Continental Grain Marsh. The MNDNR spring inventory shows springs in Eagle Creek (east of Rice Lake). However, the dataset shows no springs effecting the project lakes. Figure 33 below shows the spring inventory dataset near the project area (spring data point shown in blue). There are probably other groundwater inputs that might have a small localized impact on water quality during low flow conditions, but during high flow events, the amount of river water that enters the lakes is orders of magnitude greater than groundwater inputs. Due to lack of data for the project area, groundwater is an unknown and was kept in mind during design.

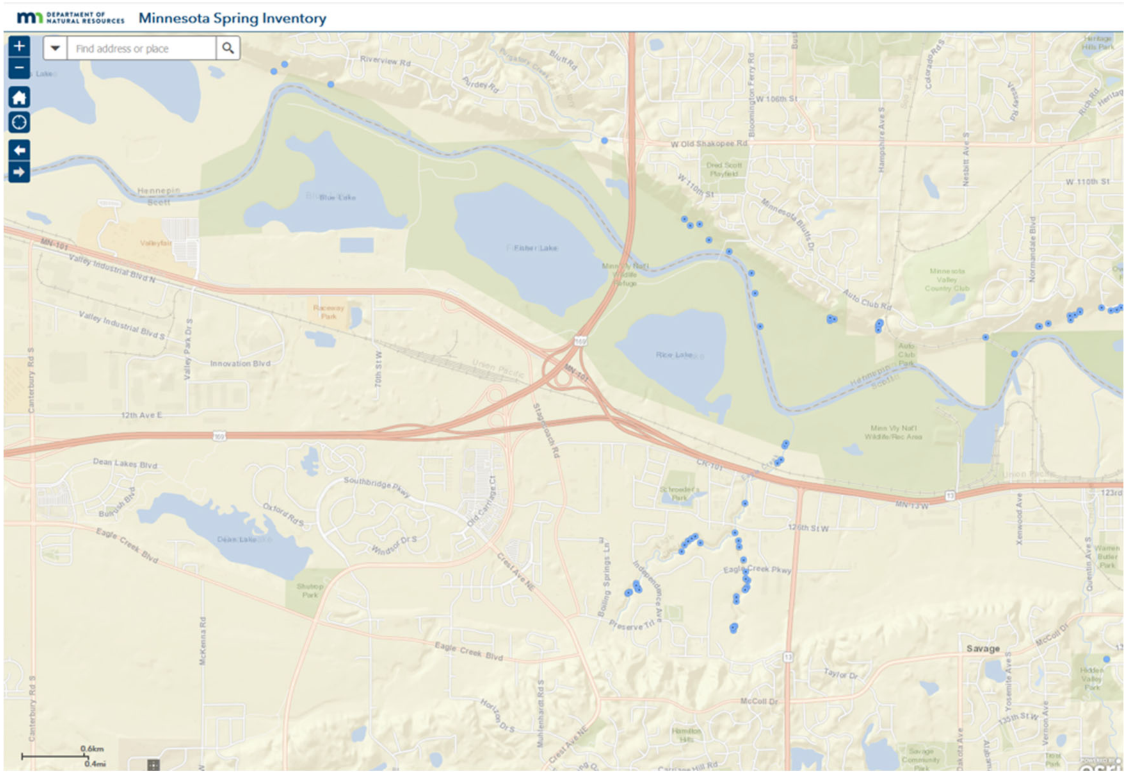


Figure 33: MNDNR Minnesota Spring Inventory for the Bass Ponds Project Area

8 Hydraulic Modeling/Design

Two-dimensional modeling was done using HEC-RAS (Hydrologic Engineering Corps Center – River Analysis System Version 5.0.4). The HEC-RAS model was used for multiple project components:

- To simulate the effects of the project on the observed 2012 and 2013 data from the Minnesota River USGS Gages at Jordan and Savage, MN.
- To compare existing structure staff gage data for the years 2012 and 2013 from the USFWS to the model results
- To estimate the maximum drawdown speed for the proposed structures.
- To complete an approximate frequency analysis for major flooding at the project area.
- To complete an approximate frequency analysis for the drawdown potential at the project area.

Modeling was completed throughout the planning stage to refine the project features. The culvert sizing was decided by maximizing the efficiency of the drawdown times. Three other scenarios were simulated using gate operations in HEC-RAS to better define the project's water level management capabilities.

This model is not calibrated and was only used for conceptual simulations. When simulating the 2012 and 2013 event, the relationship between the river and the lakes was of interest not specific values. The drawdown speed was modelled in a way that the lakes were independent from the river, so calibration was not needed. The frequency analyses for major flooding and drawdown potential are approximate to reiterate the project relevance and potential to achieve the project goals and objectives. The project is fairly close to Savage Gage, so the river water surface elevation profile should not be considerably off.

8.1 HEC-RAS Inputs

The HEC-RAS model is a fully 2D model that uses storage areas to model the lakes, storage area connections to model the propose structures, gate operations to model the stoplog operations and a 2D area mesh encompasses the remainder of the Minnesota River basin spanning from Jordan, MN and Savage, MN. The model boundary conditions are stage hydrographs from USGS gages on the MN River. The upstream boundary condition discharge hydrograph uses observed data from the USGS Gage at Jordan (converted to NAVD 88 from NGVD 29). The downstream boundary condition stage hydrograph uses observed data from the USGS Gage at Savage (converted to NAVD 88 from MSL12). US Fish and Wildlife Service (USFWS) staff gage data at Blue, Fisher and Rice Lake is available for the years 2012-2014. The 2012 and 2013 observed gage data at Jordan and Savage, MN was used for the May-October timeframe. Figure 35 shows the HEC-RAS geometry terrain and significant features of the model.

Though the river is the main contributor to the inundation of this system, precipitation was also gathered for this model to reflect a real-time situation. Precipitation was pulled from the USACE MVP water control site in grid form. The precipitation was then converted to table form with hourly precipitation data in inches.

The Blue Lake Waste Water Treatment Plant (WWTP) is located on the south end of Blue Lake that facilitates the discharge of groundwater from the modified wastewater treatment plant dewatering system (MNDNR Permit 2000-6095). The dewatering system typically discharges to Blue Lake as requested by USFWS, but can discharge to the Minnesota River if so directed by USFWS. Flow rates represented as millions of gallons per day (MGD) for the system is listed in Table 16 below. The WWTP average daily flow value of 5.44 MGD discharging into Blue Lake was used in the model.

Table 16: Wastewater Treatment Plant Input Values into Blue Lake

Condition	Flow Output (MGD)	Flow Output (cfs)
Typical river stage	1.45	2.69
10 year flood condition	17.38	32.29
Peak 100 year flood condition	40.45	75.16
Average daily flow	5.44	10.11

Accurate terrain and land cover data is essential when completing a 2D model. Bathymetry and assumed dredge cuts were added to the LiDAR data set to create an accurate and complete terrain dataset. Minnesota River cross sections surveyed in the years 2013 and 2015 were used for the Minnesota River channel bathymetry (see Figure 34 below). Lake Bathymetry was collected for all three lakes (Blue, Fisher and Rice) at the end of May, 2018 and is included in the terrain as well. Assumed structure dredge cuts were added to the terrain at the design elevation of 692.5 feet (NAVD 88).

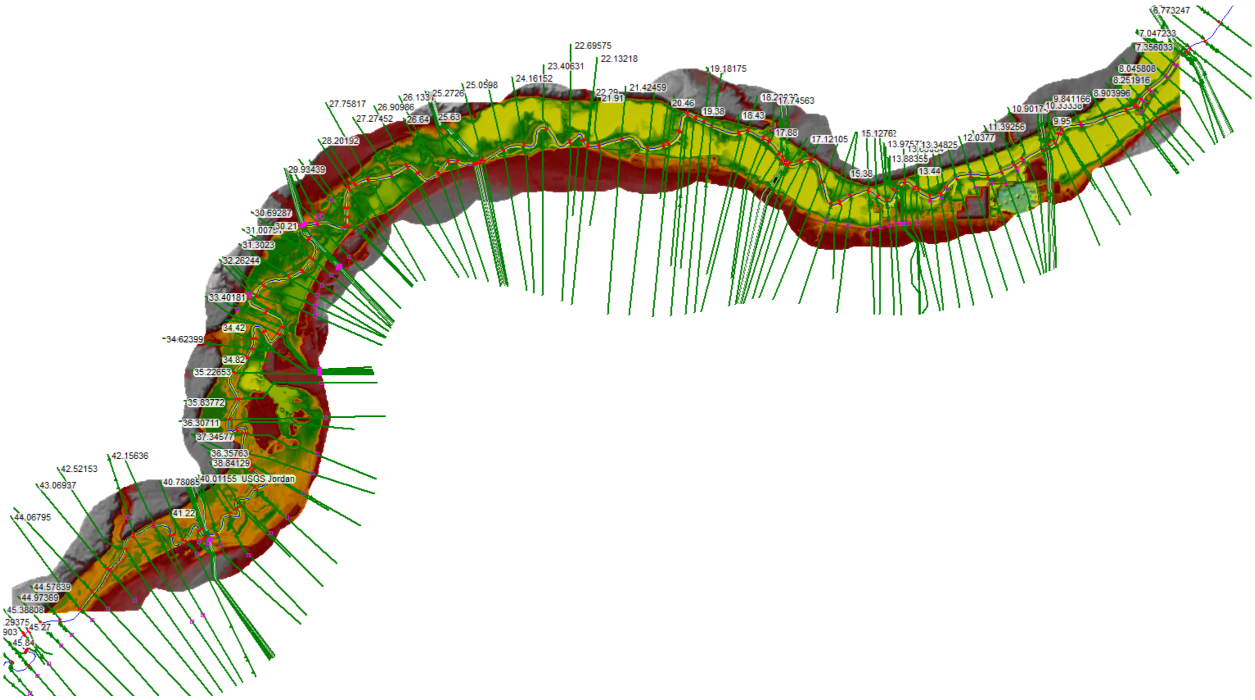


Figure 34: Minnesota River Cross Sections with Channel Bathymetry Surveyed in 2013 and 2015

The land cover dataset used was from the National Land Cover Database (NLCD 2011). The Manning's n values for each land type can be viewed in Table 17 below. As mentioned earlier in the report, the model was not calibrated which means these Manning's n values were not adjusted from the NLCD data. A sensitivity analysis using the Manning's n values could have been completed to assess the effect on the model of roughness values. At this time, a sensitivity analysis has not been completed. The relationship between the lakes and the river was of interest rather than specific water levels, so it was decided that a sensitivity analysis would not change the Recommended Plan. The main driver for the Recommended Plan was the model run "Normal Drawdown Operation River Receded Event" (Section 8.2.1). In this model run, the river and surrounding area is a non-factor to the drawdown time results of the lakes.

Table 17: HEC-RAS Input - NLCD Land Type Manning's n Values

NLCD Land Type Manning's n Values	
Land Type	Manning's n
barren land	0.030
cultivated crops	0.055
deciduous forest	0.170
developed, high intensity	0.065
developed, low intensity	0.050
developed, medium intensity	0.050
developed, open space	0.035
emergent herbaceous wetlands	0.070
evergreen forest	0.160
grasslands/herbaceous	0.070

mixed forest	0.190
open water	0.028
pasture/hay	0.060
shrub/scrub	0.100
woody wetlands	0.080

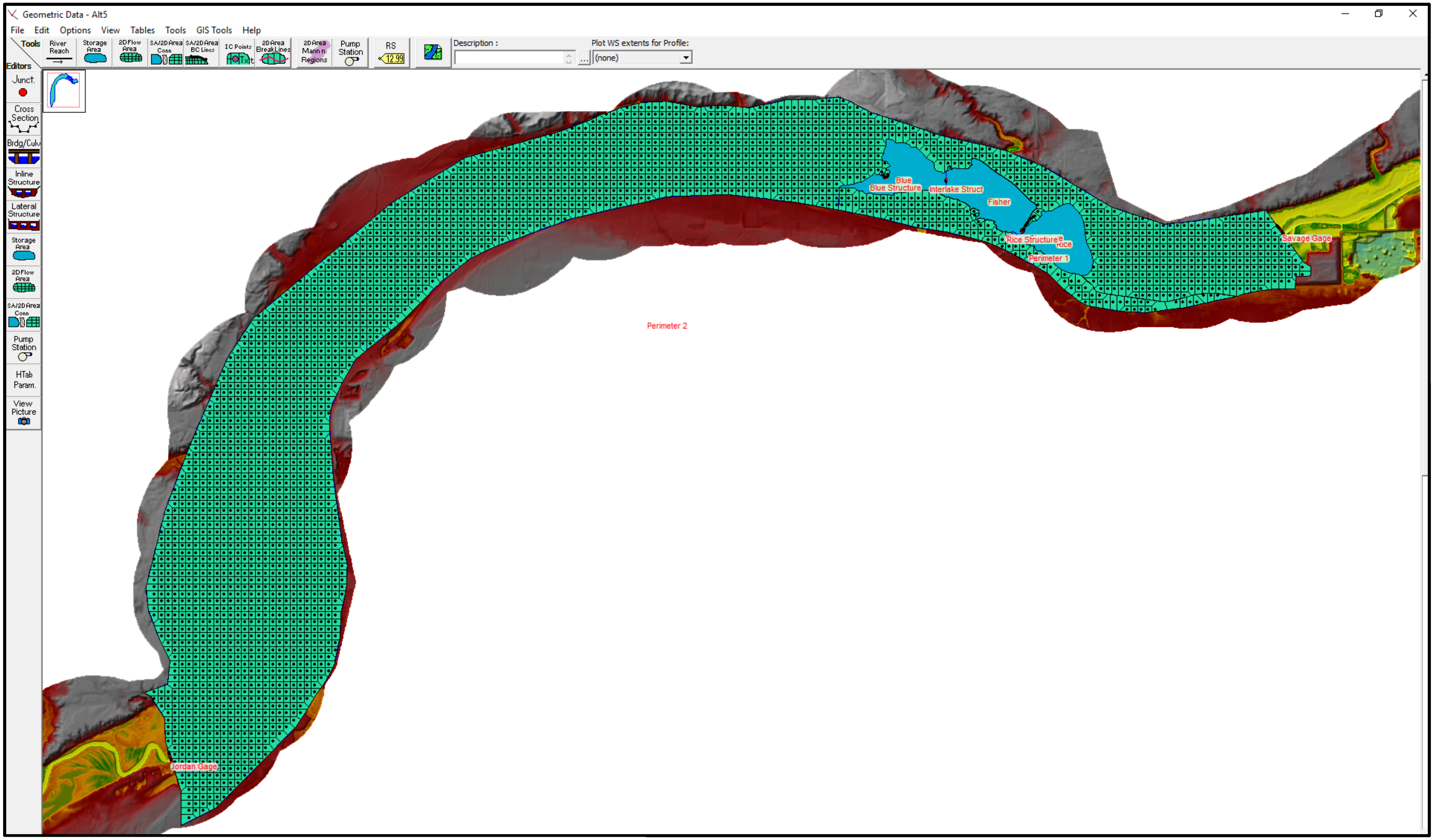


Figure 35: HEC-RAS 2D Model Layout

8.2 HEC-RAS Results

8.2.1 Blue, Fisher and Rice Lake Results/Operation

The drawdown period is defined by the lakes receding to the full drawdown elevation from its optimal pool elevation. The pool elevations were defined by the total percent of project area with surface water present. The surface water percentage goals for each pool condition is listed below.

- Optimal Pool: 80% of the project area is inundated
- Partial Drawdown: 50% of the project area is inundated
- Full Drawdown: <10% of the project area is inundated

The optimal pool, partial pool and full drawdown elevations were determined using historic staff gage data at the existing structures, LiDAR, bathymetry, imagery and USFWS operating goals. The optimal pool elevation is defined as the water surface elevation/depths that produce the most optimum habitat according to the USFWS goals. The optimal pool, partial drawdown and full drawdown elevations for the lakes are listed in Table 18 below. The volume of water discharged from the optimal pool elevation to a full drawdown elevation can be observed in Table 19. The bathymetry map with the optimal pool, partial drawdown and full drawdown elevation inundation areas can be observed in Figure 36.

Table 18: Lake Condition vs Lake Elevation

Lake Conditions vs Lake Elevation (NAVD 88)			
Condition	Blue Lake (ft)	Fisher Lake (ft)	Rice Lake (ft)
Optimal Pool	698.3	698.3	697
Partial Drawdown	697.4	697	696
Full Drawdown	696.2	696.2	695

Table 19: Volume of Water Discharged during Full Drawdown Scenario (Optimal Pool to Full Drawdown Elevation)

Volume Discharged during Full Drawdown Scenario		
Lake	Volume (acre-ft)	Volume (cubic feet)
Blue	173	7,523,763
Fisher	413	17,979,644
Rice	282	12,267,253

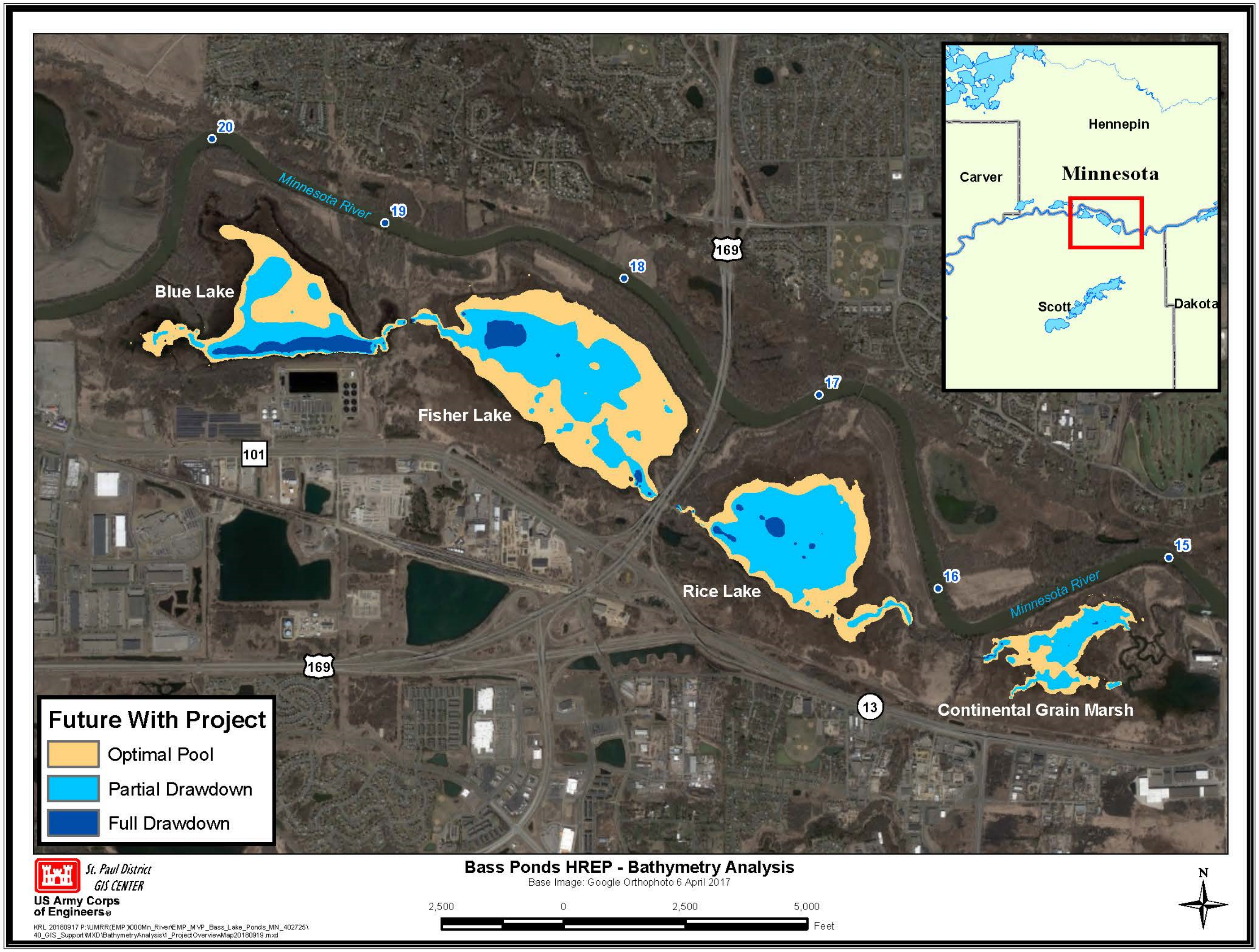


Figure 36: Bathymetry Map with Respect to Operating Conditions

There were five scenarios explored using HEC-RAS. These scenarios are listed below.

- Normal Drawdown Operation 2012 Event
- Normal Drawdown Operation 2013 Event
- Rice Fill Scenario 2012 Event
- Fisher Fill Scenario 2012 Event
- Normal Drawdown Operation River Receded Event

Normal Drawdown Operation 2012 Event
This event simulates the 2012 growing season (May 1st – September 30th). The gate operations of the water level management structures are operated to achieve a full drawdown as early and often as possible, so all gates remain open until a drawdown is achieved. A typical stoplog operation for a drawdown in the model is listed step-by-step below. This particular year, a full drawdown is achieved mid-May for approximately 10 days and in July for 30+ days. The drawdown time is dominated by the river receding rates. The river receding rate and lake drawdown rate are both approximately 6 inches per day. The 2012 growing season experienced no major flooding events and was a relatively moderate growing season (greater than 26,600 cfs at the Jordan, MN gage).

1. Wait for river level to drop to below structure channel (692.5 feet)
2. Remove stoplogs in all structures EXCEPT the Interlake Structure, so the water in the lakes can discharge to the full drawdown elevation
3. Replace all stoplogs to prevent backflow from the Minnesota River

Normal Drawdown Operation 2013 Event
This event simulates the 2013 growing season (May 1st – September 30th). The gate operations of the water level management structures are operated to achieve a full drawdown as early and often as possible, so all gates remain open until a drawdown is achieved. The stoplog operations for this event are the same as the operations above. This particular year, a full drawdown is achieved in both May and July for 30+ days (two different drawdowns). The river receding rate and lake-drawdown rate are both approximately 9 inches per day. The 2013 growing season experienced a major flooding event of 9 days at the end of June (greater than 26,600 cfs at the Jordan, MN gage).

Rice Fill Scenario 2012 Event
The goal for this scenario is to manipulate the stoplog operations of the Fisher, Rice and Secondary structures, so that Fisher outputs flow into Rice Lake. These stoplog operations are listed below. It is important to note that Blue Lake is not included in the operation because it is operating separately during this scenario. USFWS desires as much flexibility as possible when manipulating the series of lakes, so this scenario was tested hydraulically to ensure it was possible. The 2012 event is used for this simulation. The water surface elevation for all three lakes are shown in Figure 37 below. The step-by-step description of what is happening in the plot is listed in the figure. From Figure 37, this scenario proves to be hydraulically possible with Rice Lake achieving a full drawdown, then being filled using Fisher Lake outputs and finally Fisher Lake achieving a full drawdown.

1. Once the lakes are filled from precipitation and Minnesota River inputs, install all structures' stoplogs at optimal pool elevations (all lakes are at optimal pool).
2. Remove all stoplogs at the Secondary and Rice Structures (Rice Lake full drawdown).
3. Once Rice Lake is at the full drawdown elevation, install all stoplogs at the Secondary Structure (Rice Structure stoplogs still removed).
4. Remove all stoplogs at the Fisher Structure (moving water from Fisher to Rice Lake).
5. Once Rice Lake has achieved the desired elevation, install all stoplogs to prevent backflow.
6. Remove all stoplogs at the Secondary Structure and then remove all stoplogs at the Fisher Structure (Fisher Lake full drawdown).
7. Once Fisher Lake is at the full drawdown elevation, install all stoplogs at the Fisher Structure to prevent backflow.

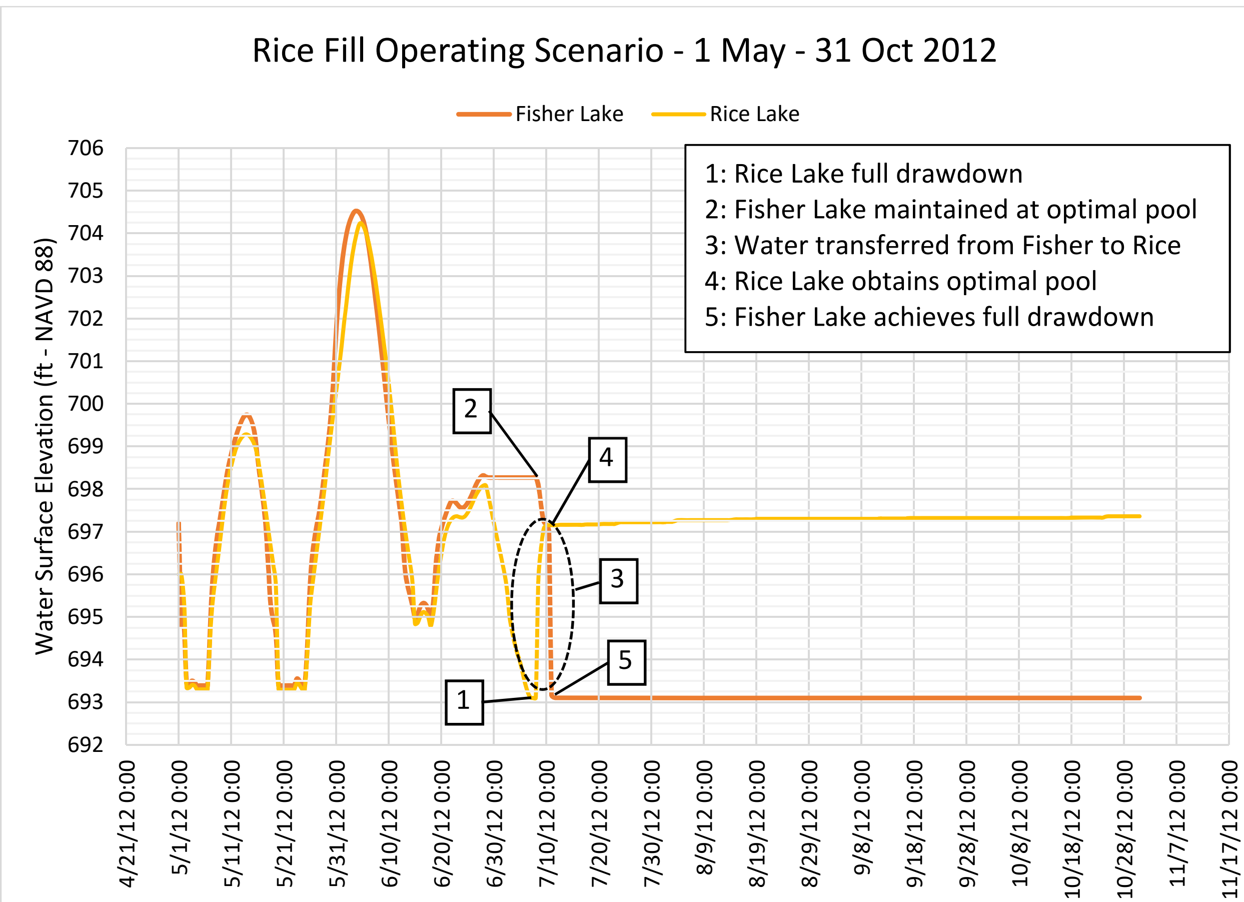


Figure 37: Rice Fill Operating Scenario using 2012 USGS Gage Data

Fisher Fill Scenario 2012 Event

Similarly to the Rice Fill Scenario, USFWS would like the ability to fill Fisher Lake from Blue Lake. This requires testing the stoplog operations in HEC-RAS to determine whether this is hydraulically possible. The stoplog operations of the Blue, Interlake and Fisher structures are adjusted, so that Blue flow is transferred to Fisher Lake. These stoplog operations are listed below. It is important to note that Rice Lake is not included in the operation because it is operating separately during this scenario. The water surface elevation for all three lakes are shown in Figure 38 below. This scenario proves to be hydraulically possible with Fisher Lake achieving a full drawdown, then being filled using Blue Lake outputs and finally Blue Lake achieving a full drawdown.

1. Once the lakes are filled from precipitation and Minnesota River inputs, install all structures' stoplogs at optimal pool elevations (all lakes are at optimal pool).
2. Remove all stoplogs at the Secondary and Fisher Structures (Fisher Lake full drawdown).
3. Once Fisher Lake is at the full drawdown elevation, install all stoplogs at the Fisher Structure.
4. Remove all stoplogs at the Interlake Structure (moving water from Blue to Fisher Lake).
5. Once Fisher Lake has achieved the desired elevation, install all stoplogs at the Interlake Structure.
6. Remove all stoplogs at the Blue Structure (Blue Lake full drawdown).
7. Once Blue Lake is at the full drawdown elevation, install all stoplogs at the Blue Structure to prevent backflow.

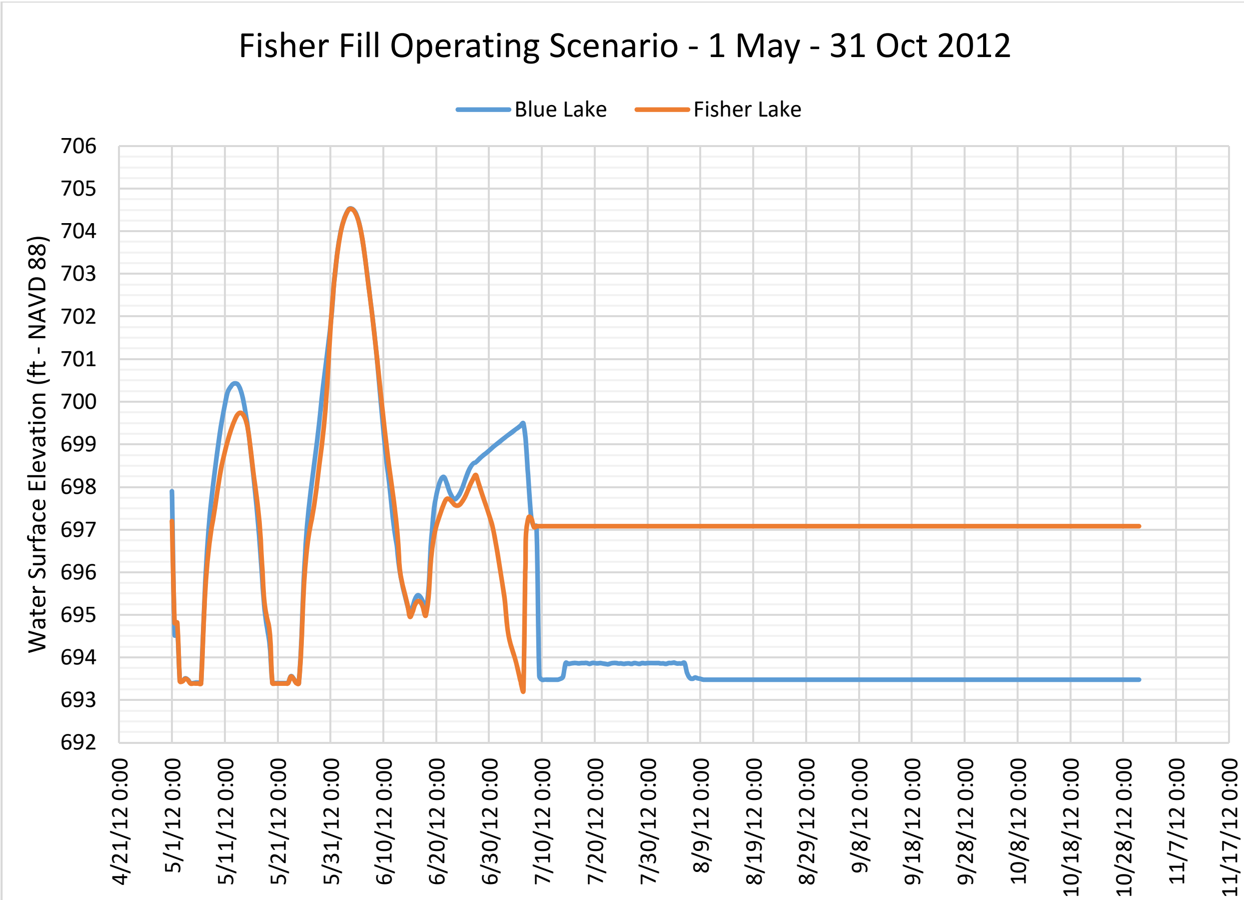


Figure 38: Fisher Fill Operating Scenario using 2012 USGS Gage Data

Normal Drawdown Operation River Receded Event
This event simulated the scenario where the river is already receded and is not affecting the lakes. The HEC-RAS model runs a single in-bank water surface elevation value at the Jordan and Savage gage throughout the simulation. The lakes initial water surface elevations are set at the optimal pool elevation. The drawdown then begins once the HEC-RAS model starts.

The HEC-RAS model results were checked using inlet and outlet control nomographs for concrete box culverts (Hydraulic Design of Highway Culverts FHWA Chart 8B and 15B, 2012) in an excel spreadsheet at 1 hour timesteps. The head differential was needed for the outlet control nomograph. The predetermined headwater value was used with the HEC-RAS corresponding tailwater value to determine the head differential. The Recommended Plan geometry in HEC-RAS resulted in slower drawdown times. This is due to the program's ability to take the outlet channel into consideration when running the simulation. The nomograph calculations are independent from the outlet channels. Adjusting the outlet channels in HEC-RAS to a constant slope resulted in a much closer drawdown time to the nomographs results.

The difference between the two geometries shown in Table 20 (HEC-RAS Recommended Plan Geometry and the HEC-RAS Channelized Outlets) is the outlet channels to the Minnesota River from the Secondary Structure and the Blue Lake Structure. The Recommended Plan geometry does not include any dredging in these two channels because the existing channels are less than 692.5 feet (planned channel invert of the other structure channels). The channelized outlet geometry assumes these outlet channels to the Minnesota River are a constant slope and a constant width. These channels were burned into the geometry terrain for each geometry. These two geometries were compared to test the effects of the channels in relation to the nomograph calculations.

The drawdown times and max simulation flow values are listed in Table 20 below. Due to the marginal difference in the drawdown times, the Blue and Secondary structure outlet channels to the Minnesota River will not be dredged.

Table 20: River Receded - HEC-RAS and Nomograph Results Comparison

River Receded – HEC-RAS and Nomograph Results Comparison				
Result	Location	HEC-RAS Recommended Plan Geometry	HEC-RAS Channelized Outlets Geometry	Nomograph
Drawdown Time (days)	Blue Lake	0.46	0.35	0.29
	Fisher Lake	3.0	1.7	1.5
	Rice Lake	3.7	1.9	1.6
Flow (cfs)	Blue Lake	308	308	350
	Fisher Lake	154	154	175
	Rice Lake	101	101	120

8.2.2 Continental Grain Marsh Results/Operation

The drawdown period is defined by the marsh receding to the full drawdown elevation from its optimal pool elevation. The optimal pool elevation was defined using the current Rice Lake HREP (completed in 1998) rocklined overflow channel invert. This invert of 698.4 feet is the maximum pool elevation of the marsh. The partial and full drawdown elevations were determined using historic staff gage data at the existing structures, LiDAR, bathymetry, imagery and USFWS operating goals. The optimal pool elevation is defined as the water surface elevation/depths that produce the most optimum habitat according to the USFWS goals. The optimal pool, partial drawdown and full drawdown elevations for the lakes are listed in Table 21 below.

Table 21: Marsh Conditions vs Marsh Elevation

Marsh Conditions vs Marsh Elevation (NAVD 88)	
Condition	Continental Grain Marsh
Optimal Pool	698.4
Partial Drawdown	697.5
Full Drawdown	696

The maximum structure drawdown potential was calculated using inlet and outlet control nomographs for concrete box culverts (Hydraulic Design of Highway Culverts FHWA Chart 8 and 15 B, 2012) in an excel spreadsheet at 1 hour timesteps. The maximum structure drawdown potential would occur if the marsh was held at optimal pool until the river receded to below the structure channel invert and then all of the structure stoplogs were removed. The typical stoplog operations for the normal drawdown scenario are listed below.

1. Wait for river level to drop to below structure channel (692.5’)
2. Remove all stoplogs, so the water in the lakes can discharge to the full drawdown elevation
3. Replace all stoplogs to prevent backflow from the Minnesota River

This would result in the fastest drawdown time possible for the structure. The marsh discharges the least amount of water for its full drawdown when compared to the lakes. The results for these calculations can be viewed in Table 22 below.

Table 22: Continental Grain Marsh Drawdown results using Culvert Nomographs

Continental Grain Marsh Drawdown Results		
Max Flow (cfs)	Drawdown Time (days)	Volume Discharged (cubic feet)
185	0.20	3,150,259 (72 acre-ft)

8.2.3 Project Operation Expectations

Blue, Fisher and Rice should be expected to complete the following scenarios when the river allows based on the results discussed above. The typical stoplog operations are listed step-by-step for each scenario.

- Normal drawdown at each lake
- Rice Fill Scenario
- Fisher Fill Scenario

Continental Grain Marsh should be expected to complete a normal drawdown when the river allows and hold water with the installation of the ditch plug.

8.3 Project Feature Potential – Drawdown, Drought and Major Flooding Analysis at Project Area

To assess the project potential and effectiveness, two analyses were completed using the flow record at the Jordan Gage. These two analyses included a major flooding analysis and drawdown analysis. The changing flow conditions of the Minnesota River concluded from the climate change analysis suggested a need to assess the project effectiveness with respect to trends in observed historic data.

This analysis assumes post-construction alternatives, so all Recommended Plan features are assumed to be constructed including the robustly designed water control structures. This rough assessment was carried out using, the 2D HEC-RAS model described in Section 8, as well, as the stage-discharge rating curve shown in Section 5.1. The HEC-RAS model results and the rating curve are applied to relate project elevations to discharges at the Jordan USGS gage. Based on the stage to flow relationship, the flow record at Jordan could be assessed to identify instances of critically high stage and prolonged durations of high stage, as well as to evaluate drawdown potential within the study area for the period of record at the Jordan gage (1935-2018). This analysis is approximate and was only used to assess the project feature’s potential to meet study objectives based on how the proposed project would have performed historically.

8.3.1 Critical Flow Equivalencies – Minnesota River at River Mile 20 versus Jordan, Minnesota

The quickest, most efficient drawdown time occurs once the Minnesota River recedes to an elevation 696.2 feet in the study area (River Mile 20). The drawdown elevation analysis is based on the assumption that in order for the lakes/marsh (Blue Lake, Fisher Lake, Rice Lake and Continental Grain Marsh) to complete a drawdown with maximum efficiency, the Minnesota River flows/stages have to be low enough to allow for Blue Lake to be drawdown. This elevation was assumed valid for the entire project area (including Continental Grain Marsh) due to the similar full drawdown elevations listed in Table 18 (lakes) and Table 21 (marsh). Please note that Rice Lake has a full drawdown invert of 695 feet rather than 696.2 feet. Due to the variability in elevation throughout the project area and the flow at the gage and the approximate nature of this analysis, using a Minnesota River elevation of 696.2 feet as the maximum allowable elevation to facilitate full drawdown was decided to be sufficient for Rice Lake as well.

When the water control structures are completely closed, flows from the Minnesota River begin flowing into the Blue, Fisher and Rice Lake study area via overtopping at the Blue Lake Control Structure at elevation 700 feet. A Minnesota River elevation of 700 feet at this location (RM 20) results in a loss of operating control. Continental Grain Marsh receives river discharges when the Minnesota River stages exceed 698.4 feet. This elevation is the Rice Lake HREP Rock Overflow structure invert (constructed 1998). A Minnesota River elevation of greater than 698.4 feet at this location (RM 15.5) results in a loss of operating control at the Continental Grain Marsh.

Using LiDAR and survey data, it was estimated that major flooding at the project area occurs when the western natural levee at Blue Lake is overtopped. This occurs when the Minnesota River stage at Blue Lake (River Mile 20) reaches approximately 704.5 feet NAVD 88. At this river stage, the natural levee between Blue and Fisher, the Fisher-MN River natural levee, the natural levee between Fisher and Rice, the Rice-MN River natural levee, the natural levee between Rice and Continental Grain Marsh and the Continental Grain Marsh-MN River natural levee are overtopped. At this elevation, the entire project area is essentially underwater and experiencing sheet flow. Figure 39 below shows the inundation area at the project location when the river stage at river mile 20 reaches 704.5 feet.

Once these elevations were established for the project location, these elevations were related to corresponding Minnesota River stage elevations at the Jordan Gage. An average river stage at Jordan was then converted to a flow discharge at Jordan using the rating curve in Figure 13. An approximate annual exceedance probability based on the discharge-frequency data in Table 2, above was also related to these discharges. These relationships are listed in Table 23 below.

Table 23. Period of Record Analysis Conditions

Period of Record Analysis Conditions					
Description	Project Elevation RM 20 (ft – NAVD 88)	Jordan Elevation (ft – NAVD 88)	Jordan Elevation (ft – NGVD 29)	Jordan Flow (cfs)	Approximate Annual Exceedance Probability (%)
Major Flooding @ Project	704.5	713.8	713.7	26,600	39%
Top of Structure at Blue Lake (upstream control point)	700	707.4	707.3	14,000	61%
Full Drawdown @ Project	696.2	704.1	704	10,000	78%
Channel Inverts @ Project	692.5	699.2	699.1	4,800	92%

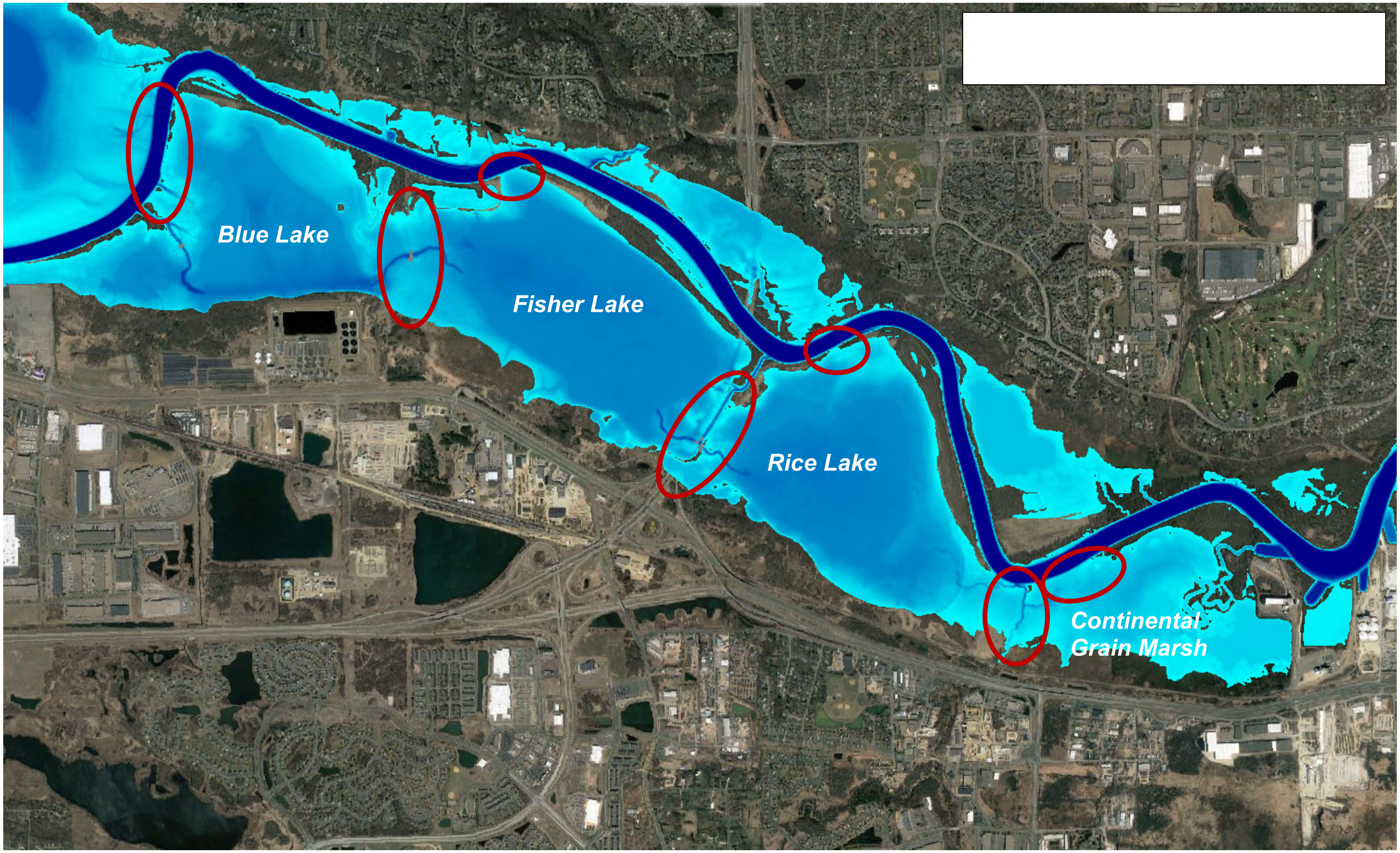


Figure 39: Inundation Area at the Project Area at River Stage 704.5 feet (RM 20) – Major Flooding Condition

8.3.2 Performance Analysis

The period of record mean daily discharge data from the USGS gage at Jordan, MN is plotted in Figure 40, below. This plot includes a reference line for the major flooding discharge. Data above this reference line indicate the days in the period of record with a mean flow value corresponding to major flooding at the project site. This river discharge value is explained in depth below. A green point on the graph indicates that a successful full drawdown could have been achieved that year if the functioning Recommended Plan features were in place. A successful full drawdown is defined as a 30 day duration drawdown achieved by mid-July. The specifics of these analyses are explained below.

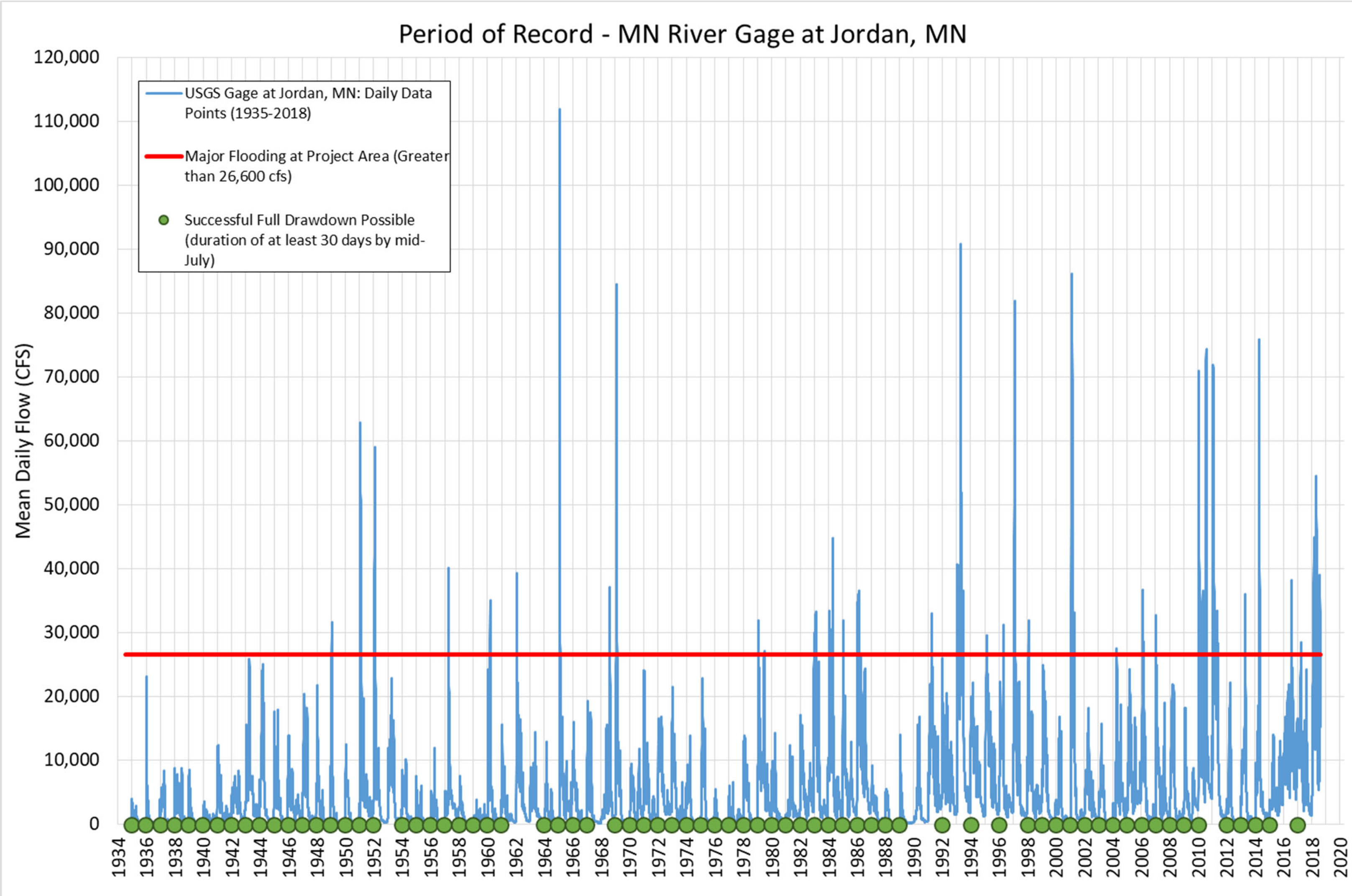


Figure 40: Period of Record Analysis (Mean Daily Data) with Major Flooding and Successful Full Drawdown Reference

8.3.2.1 Major Flood Stage Assessment

Mean daily discharge data at the Minnesota River at Jordan USGS Gage (1935-2018), is assessed to determine the annual, total number of major flood days at the project site, as well as the duration and number of independent flood events occurring on an annual basis. As described earlier, flooding at the project site is assumed to occur coincidentally with a discharge that exceeds 26,600 cfs at Jordan. Figure 41 shows the total number of major flood days each year, as well as the duration of independent high flow events occurring throughout year. The most flood events experienced in a single year is four. For example, in 2018, the study area experienced a total of 79 days of major flooding composed of four different events. The plot indicates that there has been an increase in major flooding in the project area.

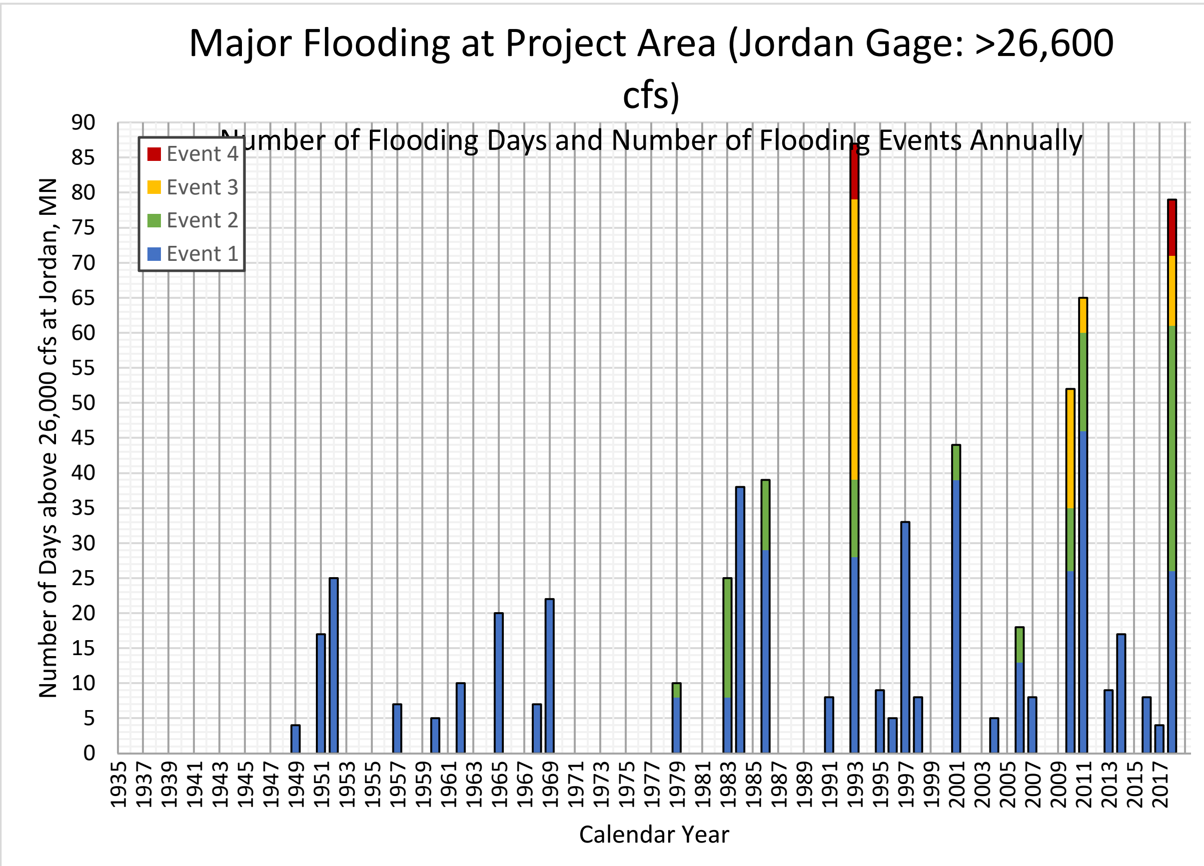


Figure 41: Number of days and events each year that the discharge at the Jordan, MN USGS gage (Gage Number 05330000) exceeded 26,600 cfs from 1935 to 2018

8.3.2.2 Drawdown Efficacy Evaluation

Mean daily discharge data at the Minnesota River at Jordan USGS gage (1935-2018), is assessed to determine if an effective drawdown could have been accomplished during the growing season (May 1st to Sept. 30th) each year. A successful drawdown is defined as a minimum 30 day drawdown by mid-July. It is assumed that drawdown can be reached when flows at Jordan are less than 10,000 cfs for 30-days or longer (Minnesota River is at 696.2 feet at River Mile 20 –study area). Accomplishing this drawdown target elevation for a 30-day (or longer) duration before mid-July, provides the best conditions for waterfowl nesting and the establishment of aquatic plant communities. Table 24 below lists the year and whether or not a successful 30 day duration drawdown by mid-July was achieved. Based on this table, a successful drawdown was achieved 72 out of 84 years (86% of years). A nonstationarity has been identified within the average annual discharge record at Jordan in 1981. Operationally significant increases in flow have been identified when the pre- and post- 191 average annual discharge records are compared.

Looking at the more recent relatively, homogenous portion of the period of record from 1981 to 2018, the incidence of a successful drawdown decreased to 79% of years. Although a 30-day duration drawdown before July is optimal for bird habitat formation/preservation in the study area, a 14-30 day drawdown anytime during the growing season provides some habitat benefits. Consequently, drawdowns of at least 14 days in duration, anytime during the growing season were also identified. When analyzing the data for drawdowns of at least 14 days in duration, it was found that a drawdown of this duration was achieved at least once every year (growing season months only) except for the year 1993. These results imply that with the construction of the project, the likelihood of an annual drawdown will still be high even with the potential for changing river conditions due to climate change and other potential drivers like land use/land cover changes and project unknowns (groundwater, Valley Fair Project effects, etc.).

Table 24: Successful Drawdown Summary (30-day Duration, prior to Mid-July) based on the period of record at the Jordan Gage

Summary Successful Drawdowns (30+ days) Achieved by Mid-July		Summary Successful Drawdowns (30+ days) Achieved by Mid-July	
Year	Success?	Year	Success?
1935	Yes	1977	Yes
1936	Yes	1978	Yes
1937	Yes	1979	Yes
1938	Yes	1980	Yes
1939	Yes	1981	Yes
1940	Yes	1982	Yes
1941	Yes	1983	Yes
1942	Yes	1984	Yes
1943	Yes	1985	Yes
1944	Yes	1986	Yes
1945	Yes	1987	Yes
1946	Yes	1988	Yes
1947	Yes	1989	Yes
1948	Yes	1990	No
1949	Yes	1991	No
1950	Yes	1992	Yes
1951	Yes	1993	No
1952	Yes	1994	Yes
1953	No	1995	No
1954	Yes	1996	Yes
1955	Yes	1997	No
1956	Yes	1998	Yes
1957	Yes	1999	Yes
1958	Yes	2000	Yes
1959	Yes	2001	Yes
1960	Yes	2002	Yes
1961	Yes	2003	Yes
1962	No	2004	Yes
1963	No	2005	Yes
1964	Yes	2006	Yes
1965	Yes	2007	Yes
1966	Yes	2008	Yes
1967	Yes	2009	Yes
1968	No	2010	Yes
1969	Yes	2011	No
1970	Yes	2012	Yes
1971	Yes	2013	Yes
1972	Yes	2014	Yes
1973	Yes	2015	Yes
1974	Yes	2016	No
1975	Yes	2017	Yes
1976	Yes	2018	No

The structures constructed as part of this HREP are robustly designed to give the USFWS the highest chance of completing a drawdown given the potential for changing river conditions in the future. Drawdown is carried out as quickly as possible to maximize habitat availability for the longest duration possible. When the Minnesota River is below 696.2 feet in the study area (elevation of 704.1 feet at Jordan), the amount of time it would take to drawdown the system if the Recommended Plan is executed is listed in Table 25 below.

Table 25: Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs or less at Jordan)

Maximized Drawdown Time	
Location	Drawdown Time (days)
Blue Lake	0.5
Fisher Lake	3
Rice Lake	4
Continental Grain Marsh	0.2

8.3.2.3 Drought Analysis

The conditions above were also used to estimate drought frequency. Drought conditions for Blue, Fish and Rice Lakes are defined as years where the lakes do not experience a river surge during the growing season (May 1st to Sept. 30th). A river surge is defined as a discharge which causes the pools to rise above the top of the Blue Lake control structure elevation (pool above>700 feet NAVD 88; flow >14,000 cfs at Jordan). Based on this assumption, a drought was estimated to occur every 1 out of every 8 years for the time period 1981-2018. The time period 1981-2018 is adopted based on the climate change nonstationarity analysis of average annual flow for the Minnesota River at Jordan.

Continental Grain Marsh was assumed to experience a drought if it did not receive an input larger than the full drawdown discharge (>10,000 cfs at Jordan). The full drawdown discharge of 10,000 cfs correlates to a water surface elevation of approximately 696.0 feet NAVD 88 at the Continental Grain Marsh. This drought assumption at Continental Grain Marsh is different from the assumption applied for Blue, Fish and Rice Lakes, because Continental Grain Marsh is operated independently. For Continental Grain Marsh a drought was estimated to occur every 1 out of 10 years for the time period 1981-2018.

9 Refuge Summary

9.1 Major Flooding

Major flooding at the project area begins at an assumed project elevation of 704.5 feet at river mile 20 of the Minnesota River (NAVD 88) just west of Blue Lake. At this elevation, the natural levees between the lakes and marsh as well as the natural levees between the project and the Minnesota River experience significant overtopping. As a result, the study area is completely inundated and flow essentially travels as sheet flow through the project area. This elevation correlates to a stage of approximately 713.8 feet and a flow of approximately 26,600 cfs at the USGS Gage at Jordan, MN. Table 26 references flood stages from the USGS Gage at Jordan on the National Weather Service (NWS) site (https://water.weather.gov/ahps2/hydrograph.php?wfo=mpx&gage=jdnm5).

Table 26 also shows when this project specifically begins to experience flood conditions as described by the NWS. When operating, the lake and marsh structures are initially overtopped at their respective low points when flows at the Jordan gage area approximately 14,000 cfs. This discharge results in a loss of operating control.

Table 26: NWS Flood Categories at USGS Gage at Jordan, MN

NWS Flood Categories (in feet)	Stage	Elevation (NGVD 29)	Elevation (NAVD 88)
Major Flood Stage:	34	724	724.1
Moderate Flood Stage:	28	718	718.1
Flood Stage:	25	715	715.1
*Project Major Flooding	23.7	713.7	713.8
Action Stage:	18	708	708.1
*Project Structure Overtopping	17.3	707.3	707.4

*Reference from the Major Flooding Analysis

9.2 Recommended Plan Structure Drawdown

The structures constructed as part of this HREP are robustly designed to give the USFWS the highest chance of completing a drawdown given changing river conditions. A full drawdown can be achieved once the Jordan gage decreases to a discharge of 10,000 cfs. This value correlates to a river surface elevation of approximately 696.2 feet (NAVD 88) at the study location (Minnesota River Mile 20). The optimal pool, partial drawdown and full drawdown elevations for each lake/marsh are listed in Table 27. These critical pool elevations are defined by the total percent of the project area inundated with surface water. Critical pool elevations are defined as follows:

- Optimal Pool: 80% of the project area is inundated
- Partial Drawdown: 50% of the project area is inundated
- Full Drawdown: <10% of the project area is inundated

The inundated areas associated with the optimal pool, partial drawdown and full drawdown water surface elevations are displayed in Figure 42. The quickest, most efficient drawdown time occurs when flows of 10,000 cfs or lower are observed at the Minnesota River gage at Jordan. The drawdown times when this condition occurs is listed in Table 28 below.

Table 27: Lake/Marsh Water Surface Elevations (Feet - NAVD 88)

Lake/Marsh Water Surface Elevations (Feet - NAVD 88)				
Condition	Blue Lake	Fisher Lake	Rice Lake	Continental Grain Marsh
Optimal Pool	698.3	698.3	697	698.4
Partial Drawdown	697.4	697	696	697.5
Full Drawdown	696.2	696.2	695	696

Table 28: Maximized Drawdown Time (River Receded to 10,000 cfs)

Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs at Jordan)	
Location	Drawdown Time (days)
Blue Lake	0.5
Fisher Lake	3
Rice Lake	4
Continental Grain Marsh	0.2

A successful drawdown is defined as a 30 day minimum drawdown occurring by mid-July. A period of record analysis indicates that if these structures were installed in the 1935-2018 timeframe, a successful drawdown could be achieved 86% of the years. Looking at a more current discharge regime for the years 1981-2018, a drawdown can be achieved 79% of the years. A 14 day minimum drawdown during the growing season (May 1st -September 30th) was also analyzed using the period of record and it was found that all years were able to achieve this duration of drawdown except for the year 1993.

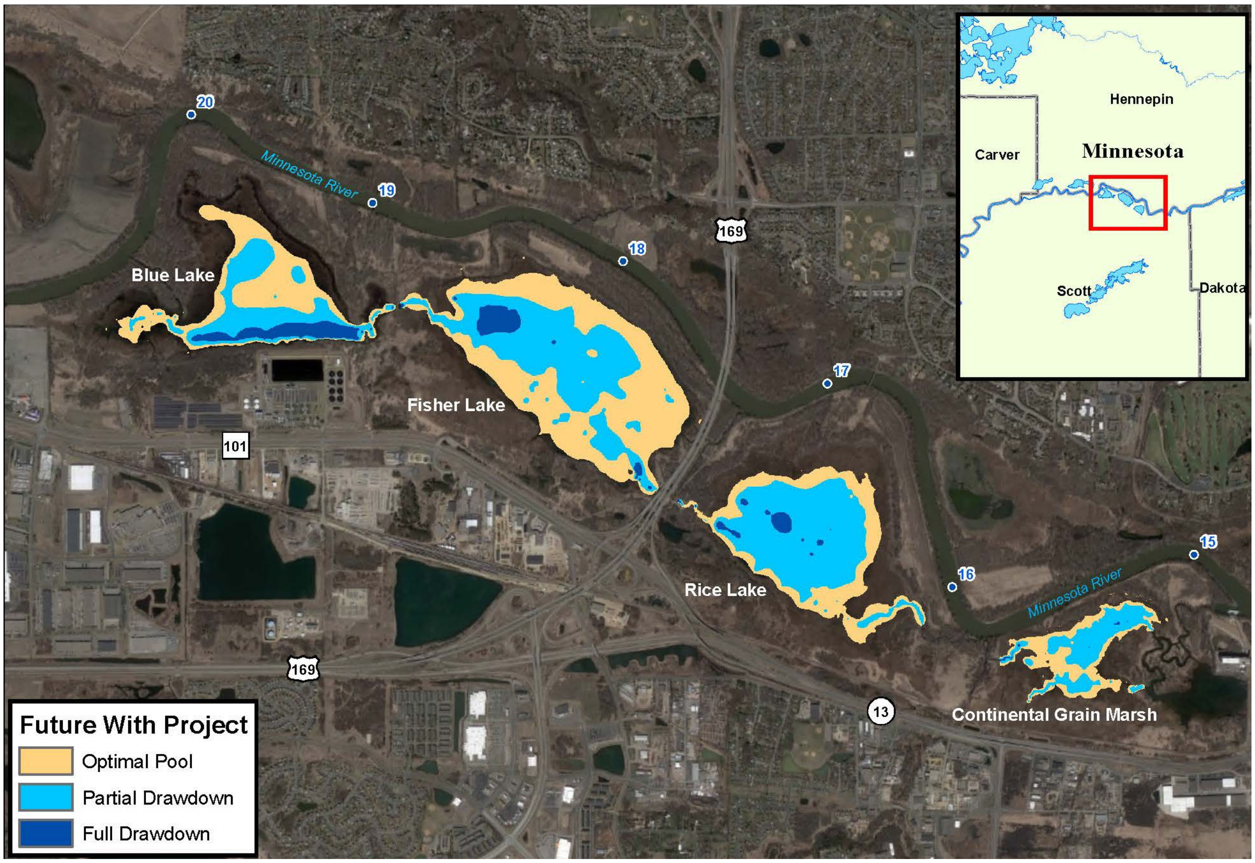


Figure 42: Operation Water Surface Elevation Inundation Areas

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Appendix G: Cost Engineering

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

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Table of Contents

Table of Contents 1
1. Introduction 1
2. Project Description 1
2.1. Stoplog Structures 1
2.2. Rock Lined Overflows 1
2.3. Dredging 1
2.4. Access Roads 2
2.5. Ditch Plugs 2
2.6. Other Work 2
2.6.1. Mobilization/Demobilization 2
3. Methodology 2
3.1. General 2
3.2. Acquisition Strategy 3
4. Cost Estimate 3
4.1. Direct Costs 3
4.1.1. Labor Rates Determination 3
4.1.2. Equipment Rates 3
4.1.3. Fuel Rates 3
4.1.4. Overtime 3
4.1.5. Taxes 3
4.1.6. Productivity 3
4.2. Indirect Costs 3
4.2.1. Job Office OverHead (JOOH) 4
4.2.2. Home Office OverHead (HOOH) 4
4.2.3. Profit 4
4.2.4. Bonds 5
4.3. Risk Management and Contingency 5
4.3.1. General 5
4.4. Escalation 5
4.5. Miscellaneous Assumptions 5
4.5.1. Government Furnished Materials 5
4.5.2. Site Access 5
4.5.3. Waste Disposal 6
5. Project Feature Accounts (CW-WBS) 6

5.1. (01) Lands and Damages 6
5.2. (02) Relocations 6
5.3. (06) Fish and Wildlife Facilities 6
5.4. (30) Planning, Engineering, and Design 6
5.5. (31) Construction Management 6
6. Project Schedule 6
7. Total Project Cost Summary (TPCS) 7
7.1. Project First Cost 7
7.2. Total Project Cost (Fully Funded) 7
8. References 7
9. Attachments 8

List of Tables

Table 1. Project First Cost (Federal and Non-Federal) Estimate for Alternative 11 (Recommended Plan) 7

List of Figures

Figure 1. Profit Calculation 5

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Appendix G: Cost Engineering

1. Introduction

This appendix contains a feasibility level project cost estimate and Total Project Cost Summary prepared for the Bass Ponds, Marsh, & Wetland Habitat Rehabilitation and Enhancement Project (Bass Ponds HREP). The project area includes Blue Lake, Fisher Lake, Rice Lake, and Continental Grain Marsh. The lakes and marsh are adjacent to the Minnesota River in Scott County, Minnesota. The area lies within the Minnesota Valley National Wildlife Refuge. The area is north of County Highway 101 and south of the Minnesota River, bounded by the Valley Fair property on the west and Cargill property on the east. The project area is bisected by a State Highway 169 bridge crossing.

2. Project Description

The objective of the project is to provide varied water levels within the lakes and marsh that will; increase the diversity and percent cover of desirable emergent aquatic plant species, increase the diversity and percent cover of desirable submergent aquatic plant species, and provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl.

The Recommended Plan consists of miscellaneous removals and the following improvements: stoplog structures, rock lined overflows, access dredging, operation and maintenance access roads between the lakes, and a rock armored ditch plug within the marsh.

2.1. Stoplog Structures

The Recommended Plan includes the demolition of the existing corrugated metal pipe culverts and end treatments and installation of cast-in-place concrete stoplog control structures between the lakes. The stoplog control structures are designed to give the refuge the capability to control water levels in Lakes Blue, Fisher, and Rice along with Continental Grain Marsh when the Minnesota River discharges are below bank full conditions. The structures include pre-formed scour holes on the upstream and downstream ends for energy dissipation and rock lined slopes upstream and downstream for erosion protection. Safety features include handrails along the wing walls for fall protection and guardrail across the culvert to protect stoplog bay equipment from collisions with heavy equipment and/or motored vehicles crossing the structure. Operation and Maintenance features include concrete pavement pads at each structure adjacent to one of the downstream wing walls to provide access for heavy equipment. Steel storage structures/containers are provided at each new structure to safely secure and store uninstalled stoplogs.

2.2. Rock Lined Overflows

Rock lined overflows are constructed for emergency overflows at each stoplog structure. The spillways provide a dedicated armored swale to prevent erosion in the event the structure is partially plugged due to debris and/or the stoplogs cannot be removed.

2.3. Dredging

Channel dredging is included with each new structure upstream and downstream in varied quantities depending on existing conditions. Dredging will improve hydraulic conveyance to and from the new structures providing control of water level elevations between the lakes and marsh. Dredged soil will be hauled off-site to disposal areas.

2.4. Access Roads

Improved and new access to each new structure is included. The access roads are excavated and constructed into existing topography/trails to minimize increasing the existing surface elevations. The excavated material that is excess and/or unsuitable for project use will be hauled off-site to disposal areas. The new access road cross-section consists of separation geotextile covered by 1-foot of compacted gravel. The access roads will provide improved, maintainable, and stable access to the control structures.

2.5. Ditch Plugs

Ditch plugs armored by rock lining for erosion protection are included in the Continental Grain Marsh area at Eagle Creek and near the Cargill facility at the beginning of the access road. The ditch plugs are constructed of compacted select impervious soil armored by engineered rock that is sized to prevent erosion at overflow crest elevations. The plugs provide a planned water elevation in the marsh area that is conducive to providing the migratory bird habitat objective.

2.6. Other Work

2.6.1. Mobilization/Demobilization

Mobilization/Demobilization is included as 5% of cost-to-prime construction costs. This percentage is based on industry standard percentages and assumptions for the type of work and equipment that will be used for the project. Based on reports and photos from the Longfellow project, the equipment used was small to medium sized. Data from Rice Lake HREP final report was also taken into consideration. The equipment will be itemized in calculation of mobilization going forward.

3. Methodology

3.1. General

This appendix summarizes the cost estimate prepared for the Recommended Plan. The estimate includes planning, engineering, design, construction, and construction management costs. The estimate was developed after the review of preliminary project schematics, project data, project requirements, and attending regular PDT meetings.

This estimate has been prepared to effective price levels of quarter 1 of FY2019. The costs are considered to be fair and reasonable to a well-equipped and capable contractor and include overhead and profit. The preparation of this estimate was created in accordance with Engineering Regulation (ER) 110-1-1300, Cost Engineering Policy and General Requirements (26 March 1993), ER 1110-2-1302, Civil Works Cost Engineering (30 June 2016), and Engineering Technical Letter (ETL) 1110-2-573, Construction Cost Engineering Guide for Civil Works. The FFE was completed in accordance with Engineering Manual (EM) 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS) (31 March 2018).

The estimate is organized in accordance with the Civil Works Work Breakdown Structure (CW - WBS). The estimate was developed using Micro Computer Aided Cost Estimate System MII v4.4 cost estimating software. Applicable crews and equipment were applied in the estimate to correspond with the work being performed. Material prices were developed using the MII Cost Book 2016, RSMeans references, and abstract data from similar projects. The midpoint of construction is anticipated to be the 1st quarter of 2021, which was used to determine the FFE.

3.2. Acquisition Strategy

This Project is assumed to be an unrestricted competitive bid. Although the possibility of a restricted Small Business type contract was discussed and accounted for during the Abbreviated Risk Analysis (ARA) process it is likely that a Low Price Technically Acceptable contract will be pursued.

4. Cost Estimate

4.1. Direct Costs

Direct costs are based on the anticipated material, equipment, and labor necessary to construct the Project based on the current scope of work. The excavation/backfill and other earthwork is assumed to be done by the Prime Contractor, with the dredging and concrete work being performed by subcontractors. It is assumed the Prime Contractor will perform the project coordination and oversight with construction work.

4.1.1. Labor Rates Determination

Based on 2018 Davis-Bacon Wage Rates General Decision MN180102, Heavy including water and sewer lines, dated 09/28/2018, for Scott County, MN.

4.1.2. Equipment Rates

All equipment costs are from MII Equipment Region 4 2016 and MII English Cost Book 2016.

4.1.3. Fuel Rates

Rates were updated as of August 2018. Current fuel prices are based on Midwest averages from www.eia.gov/petroleum/gasdiesel. This includes gasoline, on-road diesel, and off-road diesel.

4.1.4. Overtime

Normal working hours with no overtime applied to the estimate.

4.1.5. Taxes

Sales tax of 7% was applied to the material costs.

4.1.6. Productivity

Normal productivity (100%) was applied. User crews were created using the estimator's judgment. Crews selections and production rates were assisted by information received from the Contracting Officer Representative based on the actual construction final reports of Long Meadow Lake HREP and Rice Lake HREP.

4.2. Indirect Costs

Contractor assignments were determined after the formulation of the direct costs. The estimate includes work assignments for a single Prime Contractor and two subcontractors. Indirect markups are applied to the prime and subcontractors doing the work based on percentages of their own work and/or sub-contracted work as it is assigned. The following indirect costs are included in the estimate:

4.2.1. Job Office OverHead (JOOH)

JOOH are those indirect cost which occur specifically and only as a result of a particular project and hence are charged directly to the project. Cost contributors include, support vehicles, contractor's superintendent, small tools, site maintenance, and clean up.

JOOH was applied as a running percentage at 15% based on industry data from RSMeans Heavy Construction and assumptions taken from Long Meadow Lake HREP and Rice Lake HREP.

JOOH was applied as a running percentage at 10% for the subcontractors as it is assumed they have reduced burden for QA/QC, safety, signage, and site maintenance.

4.2.2. Home Office OverHead (HOOH)

HOOH are those expenses incurred by the contractor in the overall operation of the business which are not associated with a particular project. A certain percentage of these expenses are charged to each project. HOOH includes such items as office rental or ownership costs, utilities, office equipment, office staff, and insurance. The range of home office overhead can be quite broad and depends largely on the contractor's annual volume of work and the type of work that is generally performed by the contractor.

HOOH was applied as a running percentage at 8.6% based on calculations from data collected over time from contractors in the project area.

4.2.3. Profit

Profit is defined as a return on investment and provides the contractor with an incentive to perform the work as efficiently as possible. For the Recommended Plan estimate, profit was developed using the weighted guideline method, which considers the contractor's degree of risk, the relative difficulty of work, the monetary size of the job, the period of performance, the contractor's investment, assistance by the Government, and the amount of subcontracting. See profit calculation for the prime contractor below:

ER 1110-2-1302					
Table D-2					
Profit Factor					
		Rate (%)		Weight	Value
				(0.03 - 0.12)	
1	Degree of Risk	20	x	0.09	1.8
2	Difficulty of work	15	x	0.075	1.125
3	Size of Job	15	x	0.079	1.185
4	Period of performance	15	x	0.071	1.065
5	Contractor's Investment	5	x	0.07	0.35
6	Assistance by Government	5	x	0.12	0.6
7	Subcontracting	25	x	0.092	2.3
		100			
				Profit Factor	**8.4%**

Figure 1. Profit Calculation

Profit for subcontractors is applied at a running percentage of 10%.

4.2.4. Bonds

Bond contract costs are for performance and payment security bonds that protect the government from a non-performing contractor and subcontractors and suppliers from non-payment. The bond markup is applied only to the prime contractor's own work and the prime's subcontractor's work at 2%. This is an assumption based of industry standard data.

Bonding requirements are assumed to be the responsibility of the prime contractor and are not applied to the subcontractors.

4.3. Risk Management and Contingency

4.3.1. General

After review of the proposed project plan and documents and a meeting on August 8, 2018 with the project development team (PDT), an abbreviated risk analysis (ARA) was conducted resulting in the development of contingencies for major cost components of the project estimate. These contingencies were developed reflecting the uncertainty associated with each of the WBS work features. Risk elements in the 7 typical separate areas were contemplated. Discussions focused on 6 potential risk features specific to this project in each of the 7 risk element areas. The PDT's analysis arrived at an overall contingency of 31% for the project. The analysis and register are attached to this appendix.

4.4. Escalation

The project costs have been escalated to the midpoint of construction, assumed to be the 1st quarter of FY 2021. A 2-year construction contract is assumed due to adverse weather conditions and possible dredging during the winter season.

4.5. Miscellaneous Assumptions

4.5.1. Government Furnished Materials

There are no government furnished materials included in this estimate.

4.5.2. Site Access

Site covers a large area and is accessible from County Highway 101 at three separate points. One point is near Blue Lake Wastewater Treatment Plant directly adjacent to the east property line, another is under Highway 169 bridge crossing via CH 101 Trail, and the last is through Cargill's property using their property entrance on the extreme east end of the project area. Access roads are assumed to be constructed by improving existing trails which currently have 'wagon trail' type characteristics. Building a cross-section of geotextile and aggregate into existing topography will provide the stability to mobilize equipment for construction. The newly constructed access roads will remain when construction is completed. The County and State may require access permits to access to the site using a portion of the highway easements. No formal agreements have been reached with the State and/or County regarding access. It is assumed that a temporary construction easement and permanent access easement on the east boundary of the project area will be required from Cargill.

4.5.3. Waste Disposal

Excess soil not used for backfill and/or unsuitable soil is assumed to be disposed of off-site. It is assumed there will be no fill areas above existing grade. Costs for disposal hauling are included in the estimate.

5. Project Feature Accounts (CW-WBS)

5.1. (01) Lands and Damages

The estimated lands and damages is $60,800. This figure represents the Sponsor's costs for the necessary real estate interest (Temporary and Permanent Easement). It includes the incidental Saint Paul District's costs associated with acquiring the interest (survey, title, appraisal, negotiations, closing costs, administrative costs, etc.).

Real Estate cost is broken down in the Total Project Cost Summary (TPCS) as follows:

The $60,800 in real estate costs associated with the sponsor are located in the 01 LANDS AND DAMAGES row with the Real Estate's report 25% contingency of $15,200 added totaling $76,000 for this project.

5.2. (02) Relocations

The estimated Relocations cost is $40,000. This figure represents the Sponsor's costs to relocate existing utilities to accommodate the project features. Relocations costs including a 25% contingency amount to $50,000.

5.3. (06) Fish and Wildlife Facilities

The items included in this account are construction related costs for removals, access roads, stoplog structures, dredging, rock lined spillways, ditch plugs, and mobilization/demobilization.

5.4. (30) Planning, Engineering, and Design

The work covered under this account includes the project management, planning, engineering, and design costs spent to date as well as the remaining estimated costs that will be associated with the engineering and design for this project. Planning, Engineering, and Design is applied at 24.3% of the estimated construction cost. Additional information on the breakdown of Adaptive Management and Monitoring costs can be found in Appendix K.

5.5. (31) Construction Management

The work covered under this account includes the expected costs for contract supervision, contract and construction administration, technical management activities, district office supervision, and administration costs. Construction Management is applied at 12.5% of the estimated construction cost.

6. Project Schedule

The length of the schedule was determined to allow the contractor ample time to construct during low water conditions and/or winter construction 2020/2021. The project contract is assumed to be 2-year duration to complete the construction.

7. Total Project Cost Summary (TPCS)

7.1. Project First Cost

Table 1 showing the Project First Cost is shown below:

Table 1. Project First Cost (Federal and Non-Federal) Estimate for Alternative 11 (Recommended Plan)

Account	Item	Cost	Contingency	Project First Cost*
01	Lands and Damages	$61	$15	$76
02	Relocations (Utilities)	$40	$10	$50
06	Construction	$3,257	$994	$4,251
30	Planning, Engineering, and Design	$695	$212	$907
30	Adaptive Management and Monitoring	$98	$30	$128
31	Construction Management	$407	$124	$531
	Total	**$4,558**	**$1,385**	**$5,943**

*Amounts have been rounded to the nearest thousand; Totals may not add due to rounding.

7.2. Total Project Cost (Fully Funded)

The Total Project Cost (fully funded) is $6,290,000 (includes LEERDs, contingency, and escalation). See Section 6 in the main report for additional details.

Based on the construction schedule, work will commence in Fall, 2019. There is cost sharing on this project between the U.S. Army Corps of Engineers and U.S. Fish and Wildlife, the local Sponsor. The Total Project Cost Summary is attached to this appendix.

8. References

U.S. Army Corps of Engineers. ER 1110-1-1300, Cost Engineering Policy and Requirements Washington DC. March 26, 1993.

U.S. Army Corps of Engineers. ER 1110-2-1302, Civil Works Cost Engineering Washington DC. June 30, 2016.

U.S. Army Corps of Engineers. ER 1110-2-1304, Civil Works Construction Cost Index System Washington DC. March 31, 2018.

9. Attachments

MII Cost Report

Abbreviated Risk Analysis (ARA)

Total Project Cost Summary (TPCS)

Project Schedule

Basis of Estimate

Alternatives Summary

Bass Ponds HREP

BFR Alt 5 + CGM M2 = Tentatively Selected Plan (TSP) = Alternative 11 = Recommeded Plan

Estimated by	CEMVP
Designed by	CEMVP
Prepared by	Paul Hegre
Preparation Date	1/11/2019
Effective Date of Pricing	10/1/2018
Estimated Construction Time	524 Days

Description	Page
Project Notes	**i**
Alternative 11 (Alt 5 + CGM M2)	**1**
Fish and Wildlife Facilities	1
Alternative 11 (BFR5 + CGM M2)	1
Removals	1
Blue Lake	1
Interlake (Blue to Fisher)	1
Fisher-Rice Combined	1
Fisher Lake	1
Rice Lake	1
Fisher Lake	1
Access Roads	1
Blue Lake	1
Interlake (Blue to Fisher)	1
Fisher Lake	1
Rice Lake	1
CGMarsh	1
Stoplog Structures	1
Blue Lake (2 Bays)	1
Temporary Bypass Conveyance	1
Shoring and Dewatering	1
Excavation and Backfill	1
Preformed Scour Holes	1
Upstream	1
Downstream	1
Stone Erosion Protection	1
Structural Concrete	1
Guardrail	1
Handrail	1
Grating	1
Stoplogs and Channels	1
Storage Structure	1
Storage Structure	2
Turf Restoration	2
Interlake (1 Bay)	2
Temporary Bypass Conveyance	2
Shoring and Dewatering	2
Excavation and Backfill	2
Preformed Scour Holes	2
Upstream	2
Downstream	2
Stone Erosion Protection	2
Structural Concrete	2
Guardrail	2

Description	Page
Handrail	2
Grating	2
Stoplogs and Channels	2
Storage Structure	2
Turf Restoration	2
Fisher (1 Bay)	2
Temporary Bypass Conveyance	2
Shoring and Dewatering	2
Excavation and Backfill	2
Preformed Scour Holes	2
Upstream	2
Downstream	2
Stone Erosion Protection	2
Structural Concrete	2
Guardrail	2
Handrail	2
Grating	2
Stoplogs and Channels	2
Storage Structure	2
Storage Structure	3
Turf Restoration	3
Rice (1 Bay)	3
Temporary Bypass Conveyance	3
Shoring and Dewatering	3
Excavation and Backfill	3
Preformed Scour Holes	3
Upstream	3
Downstream	3
Stone Erosion Protection	3
Structural Concrete	3
Guardrail	3
Handrail	3
Grating	3
Stoplogs and Channels	3
Storage Structure	3
Turf Restoration	3
SecondaryStructures	3
CG Marsh (1 Bay)	3
Temporary Bypass Conveyance	3
Shoring and Dewatering	3
Excavation and Backfill	3
Preformed Scour Holes	3
Upstream	3
Downstream	3

Description	Page
Stone Erosion Protection	3
Structural Concrete	3
Guardrail	3
Handrail	3
Grating	3
Stoplogs and Channels	3
Stoplogs and Channels	4
Storage Structure	4
Turf Restoration	4
Secondary Outlet (1 Bay)	4
Temporary Bypass Conveyance	4
Shoring and Dewatering	4
Excavation and Backfill	4
Preformed Scour Holes	4
Upstream	4
Downstream	4
Stone Erosion Protection	4
Structural Concrete	4
Guardrail	4
Handrail	4
Grating	4
Stoplogs and Channels	4
Storage Structure	4
Turf Restoration	4
Dredging	4
Blue Lake	4
Interlake (Blue to Fisher)	4
Fisher Lake	4
Rice Lake	4
CGMarsh	4
Rock Lined Spillways	4
Blue Lake	4
Rock Lined Overflow	4
Interlake (Blue to Fisher)	4
Rock Lined Overflow	4
Fisher Lake	4
Rock Lined Overflow	4
Rock Lined Overflow	5
Rice Lake	5
Rock Lined Overflow	5
CGMarsh	5
Rock Lined Overflow at Structure	5
Plug with Rock Lined Overflow	5
Shoring and Dewatering	5

Description	Page
Secondary Outlet	5
Rock Lined Overflow	5
Mobilization/Demobilization	5

Description	Quantity	UOM	ContractCost
Alternative 11 (Alt 5 + CGM M2)			**3,256,749**
Fish and Wildlife Facilities	**1.0**	**JOB**	**3,256,749**
Alternative 11 (BFR5 + CGM M2)	**1.0**	**LS**	**3,256,749**
Removals	**1.0**	**LS**	**88,981**
Blue Lake	**1.0**	**LS**	**34,368**
Interlake (Blue to Fisher)	**1.0**	**LS**	**5,840**
Fisher-Rice Combined	**1.0**	**LS**	**14,023**
Fisher Lake	**1.0**	**LS**	**11,583**
Rice Lake	**1.0**	**EA**	**11,583**
Fisher Lake	**1.0**	**LS**	**11,583**
Access Roads	**1.0**	**LS**	**754,771**
Blue Lake	**1.0**	**LS**	**365,100**
Interlake (Blue to Fisher)	**1.0**	**LS**	**99,888**
Fisher Lake	**1.0**	**LS**	**45,726**
Rice Lake	**1.0**	**LS**	**27,321**
CGMarsh	**1.0**	**LS**	**216,738**
Stoplog Structures	**1.0**	**LS**	**1,300,057**
Blue Lake (2 Bays)	**1.0**	**LS**	**394,796**
Temporary Bypass Conveyance	**30.0**	**DAY**	**42,131**
Shoring and Dewatering	**30.0**	**DAY**	**84,015**
Excavation and Backfill	**1.0**	**LS**	**7,915**
Preformed Scour Holes	**1.0**	**LS**	**20,933**
Upstream	**1.0**	**EA**	**10,466**
Downstream	**1.0**	**EA**	**10,466**
Stone Erosion Protection	**1.0**	**LS**	**38,691**
Structural Concrete	**88.3**	**CY**	**112,707**
Guardrail	**27.0**	**LF**	**3,688**
Handrail	**99.0**	**LF**	**17,747**
Grating	**27.0**	**SF**	**3,245**
Stoplogs and Channels	**1.0**	**LS**	**36,772**

Description	Quantity	UOM	ContractCost
Storage Structure	1.0	LS	10,687
Turf Restoration	1.0	LS	16,265
Interlake (1 Bay)	1.0	LS	301,753
Temporary Bypass Conveyance	23.0	DAY	32,301
Shoring and Dewatering	23.0	DAY	61,935
Excavation and Backfill	1.0	LS	6,546
Preformed Scour Holes	1.0	LS	4,174
Upstream	1.0	EA	2,087
Downstream	1.0	EA	2,087
Stone Erosion Protection	1.0	LS	38,691
Structural Concrete	68.5	CY	91,573
Guardrail	17.0	LF	2,322
Handrail	87.0	LF	15,596
Grating	15.0	SF	2,181
Stoplogs and Channels	1.0	LS	19,482
Storage Structure	1.0	LS	10,687
Turf Restoration	1.0	LS	16,265
Fisher (1 Bay)	1.0	LS	301,753
Temporary Bypass Conveyance	23.0	DAY	32,301
Shoring and Dewatering	23.0	DAY	61,935
Excavation and Backfill	1.0	LS	6,546
Preformed Scour Holes	1.0	LS	4,174
Upstream	1.0	EA	2,087
Downstream	1.0	EA	2,087
Stone Erosion Protection	1.0	TON	38,691
Structural Concrete	68.5	CY	91,573
Guardrail	17.0	LF	2,322
Handrail	87.0	LF	15,596
Grating	15.0	SF	2,181
Stoplogs and Channels	1.0	LS	19,482

Description	Quantity	UOM	ContractCost
Storage Structure	1.0	LS	10,687
Turf Restoration	1.0	LS	16,265
Rice (1 Bay)	1.0	LS	301,753
Temporary Bypass Conveyance	23.0	DAY	32,301
Shoring and Dewatering	23.0	DAY	61,935
Excavation and Backfill	1.0	LS	6,546
Preformed Scour Holes	1.0	LS	4,174
Upstream	1.0	EA	2,087
Downstream	1.0	EA	2,087
Stone Erosion Protection	1.0	TON	38,691
Structural Concrete	68.5	CY	91,573
Guardrail	17.0	LF	2,322
Handrail	87.0	LF	15,596
Grating	15.0	SF	2,181
Stoplogs and Channels	1.0	LS	19,482
Storage Structure	1.0	LS	10,687
Turf Restoration	1.0	LS	16,265
SecondaryStructures	1.0	LS	603,507
CG Marsh (1 Bay)	1.0	LS	301,753
Temporary Bypass Conveyance	23.0	DAY	32,301
Shoring and Dewatering	23.0	DAY	61,935
Excavation and Backfill	1.0	LS	6,546
Preformed Scour Holes	1.0	LS	4,174
Upstream	1.0	EA	2,087
Downstream	1.0	EA	2,087
Stone Erosion Protection	1.0	TON	38,691
Structural Concrete	68.5	CY	91,573
Guardrail	17.0	LF	2,322
Handrail	87.0	LF	15,596
Grating	15.0	SF	2,181

Description	Quantity	UOM	ContractCost
Stoplogs and Channels	**1.0**	**LS**	**19,482**
Storage Structure	**1.0**	**LS**	**10,687**
Turf Restoration	**1.0**	**LS**	**16,265**
Secondary Outlet (1 Bay)	**1.0**	**LS**	**301,753**
Temporary Bypass Conveyance	**23.0**	**DAY**	**32,301**
Shoring and Dewatering	**23.0**	**DAY**	**61,935**
Excavation and Backfill	**1.0**	**LS**	**6,546**
Preformed Scour Holes	**1.0**	**LS**	**4,174**
Upstream	**1.0**	**EA**	**2,087**
Downstream	**1.0**	**EA**	**2,087**
Stone Erosion Protection	**1.0**	**TON**	**38,691**
Structural Concrete	**68.5**	**CY**	**91,573**
Guardrail	**17.0**	**LF**	**2,322**
Handrail	**87.0**	**LF**	**15,596**
Grating	**15.0**	**SF**	**2,181**
Stoplogs and Channels	**1.0**	**LS**	**19,482**
Storage Structure	**1.0**	**LS**	**10,687**
Turf Restoration	**1.0**	**LS**	**16,265**
Dredging	**1.0**	**LS**	**112,757**
Blue Lake	**1,073.0**	**CY**	**11,914**
Interlake (Blue to Fisher)	**3,630.0**	**CY**	**40,306**
Fisher Lake	**2,745.0**	**CY**	**30,479**
Rice Lake	**1,545.0**	**CY**	**17,155**
CGMarsh	**1,162.0**	**CY**	**12,902**
Rock Lined Spillways	**1.0**	**LS**	**241,593**
Blue Lake	**1.0**	**EA**	**40,791**
Rock Lined Overflow	**1.0**	**LS**	**40,791**
Interlake (Blue to Fisher)	**1.0**	**EA**	**40,791**
Rock Lined Overflow	**1.0**	**LS**	**40,791**
Fisher Lake	**1.0**	**EA**	**0**

Description	Quantity	UOM	ContractCost
Rock Lined Overflow	**1.0**	**LS**	**0**
Rice Lake	**1.0**	**EA**	**40,791**
Rock Lined Overflow	**1.0**	**LS**	**40,791**
CGMarsh	**1.0**	**EA**	**78,430**
Rock Lined Overflow at Structure	**1.0**	**LS**	**0**
Plug with Rock Lined Overflow	**1.0**	**LS**	**78,430**
Shoring and Dewatering	**23.0**	**DAY**	**7,461**
Secondary Outlet	**1.0**	**EA**	**40,791**
Rock Lined Overflow	**1.0**	**LS**	**40,791**
Mobilization/Demobilization	**1.0**	**LS**	**155,083**

Abbreviated Risk Analysis

Bass Lake Ponds

Feasibility (Recommended Plan)

Meeting Date: 8-Aug-18

PDT Members

Note: PDT involvement is commensurate with project size and involvement.

Represents	Name
Project Management:	Kelli Phillips
Planner:	Angela Deen
Study Manager:	Tom Novak
Contracting:	Kevin Henricks
Real Estate:	Stephanie Dupey
Technical Lead:	Tony Fares
Geotech:	Luke Schmidt
H&H	Kacie Opat
Civil:	Paul Morken
Structural:	Tony Fares
Cost Engineering:	Paul Hegre
Construction:	Anthony Horacek
Environmental:	Eric Hanson

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Alternative: **Recommended Plan (Alt 11)**

Project Development Stage/Alternative: **Feasibility (Recommended Plan)**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date: **8/8/2018**

Total Estimated Construction Contract Cost = $ 3,256,749

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 60,800		25%	$ 15,200	$ 76,000
	02 RELOCATIONS	Utilities	$ 40,000		25%	$ 10,000	$ 50,000
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 88,981		30%	$ 26,681	$ 115,662
2		Access Roads	$ 754,771		30%	$ 226,316	$ 981,088
3		Stoplog Structures	$ 1,300,057		31%	$ 397,550	$ 1,697,607
4		Secondary Structures	$ 603,507		31%	$ 184,549	$ 788,056
5		Dredging	$ 112,757		38%	$ 43,206	$ 155,963
6		Rock Lined Spillways	$ 241,593		30%	$ 72,441	$ 314,034
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 155,083	5.0%	28%	$ 42,730	$ 197,813
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design (PED)	$ 792,986		31%	$ 241,901	$ 1,034,886
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 407,012		31%	$ 124,159	$ 531,171
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ 60,800	25%	$ 15,200	$ 76,000
Relocations: Utilities	$ 40,000	25%	$ 10,000	$ 50,000
Total Construction Estimate	$ 3,256,749	31%	$ 993,473	$ 4,250,222
Total Planning, Engineering & Design	$ 792,986	31%	$ 241,901	$ 1,034,886
Total Construction Management	$ 407,012	31%	$ 124,159	$ 531,171
Total Excluding Real Estate and Relocations	**$ 4,456,747**	**31%**	**$ 1,359,533**	**$ 5,816,280**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$4,457k	$5,272k	$5,816k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.	

Bass Lake Ponds TSP (Alternative 11)

Feasibility (Recommended Plan)

Abbreviated Risk Analysis

Meeting Date: 8-Aug-18

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Management & Scope Growth				**Maximum Project Growth**		**40%**
PS-1	Removals	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-2	Access Roads	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-3	Stoplog Structures	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-4	Secondary Structures	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-5	Dredging	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-6	Rock Lined Spillways	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-12	Remaining Construction Items	Main component of remaining items is mob/demob which is calculated at standard 5% of direct construction cost for the TSP.	PDT agreed to apply overall construction contingency to element 12.	Negligible	Unlikely	N/A
PS-13	Planning, Engineering, & Design (PED)	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
PS-14	Construction Management	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

Acquisition Strategy

Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Removals	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-2	Access Roads	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-3	Stoplog Structures	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-4	Secondary Structures	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-5	Dredging	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-6	Rock Lined Spillways	Likely a Low Price Technically Acceptable contract.	Possibility of a small business set-aside but likely a Low Price Technically Acceptable contract. The difference could have a marginal impact on costs.	Marginal	Possible	1
AS-12	Remaining Construction Items	Main component of remaining items is mob/demob which is calculated at standard 5% of direct construction cost for the TSP.	A Small business set-aside would likely introduce additional subcontracts and affect certainty of mobilization/demobilization costs.	Moderate	Possible	2
AS-13	Planning, Engineering, & Design (PED)	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Possible	N/A
AS-14	Construction Management	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Possible	N/A

Construction Elements					**Maximum Project Growth**	**15%**
CE-1	Removals	Likely constructed during cold weather months that may require working with frost and frozen materials. Water levels may impact construction if done in summer months. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3
CE-2	Access Roads	Likely constructed during cold weather months that may require working with frost and frozen materials. Design development regarding alignment location, surface elevations, passing/turnout points, and lengths are at preliminary stage. Minimal survey information available at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3
CE-3	Stoplog Structures	Likely constructed during cold weather months that may require working with frost and frozen materials. Cold weather concrete plan will likely be required. Geotechncial information at specific locations has not yet been obtained thus relying on approximate information from previous projects nearby. Magnitude of dewatering requirements is unkown at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. If specific geotechnical data collected in the future varies from current assumptions it's possible that it would have a significant impact on costs.	Significant	Possible	3
CE-4	Secondary Structures	Likely constructed during cold weather months that may require working with frost and frozen materials. Cold weather concrete plan will likely be required. Geotechncial information at specific locations has not yet been obtained thus relying on approximate information from previous projects nearby. Magnitude of dewatering requirements is unkown at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. If specific geotechnical data collected in the future varies from current assumptions it's possible that it would have a significant impact on costs.	Significant	Possible	3
CE-5	Dredging	Season of construction could influence type of dredging (mechanical or hydraulic). No information on which to base the extents of dredging. Permit acquisition may have construction delay impact.	The assumption is mechanical dredging during winter months but it is possible that hydraulic dredging will be done during the summer months. The difference in methods could have a moderate effect on the construction cost and schedule.	Moderate	Possible	2
CE-6	Rock Lined Spillways	Likely constructed during cold weather months that may require working with frost and frozen materials. Water levels in summer months could impact construction. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3
CE-12	Remaining Construction Items	Main component of remaining items is mob/demob which is calculated at standard 5% of direct construction cost for the TSP.	Assumed construction procedures and equipment to be common to local area contractors therefore would have a negligible impact.	Negligible	Possible	0
CE-13	Planning, Engineering, & Design (PED)	Habitat maintenance (eagle nests), access points and staging areas, and water diversion (bypass and dewater) are undefined requirements of project.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
CE-14	Construction Management	Likely constructed during cold weather months that may affect QA/QC requirements.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
Specialty Construction or Fabrication					**Maximum Project Growth**	**50%**
SC-1	Removals			Negligible	Unlikely	N/A
SC-2	Access Roads			Negligible	Unlikely	N/A
SC-3	Stoplog Structures			Negligible	Unlikely	N/A
SC-4	Secondary Structures			Negligible	Unlikely	N/A

SC-5	Dredging	Possibility of hydraulic dredging. Possibility of difficult site access.	Current assumption is mechanical dredging. Change to hydraulic dredging would require subcontracting and moderate impact on costs.	Significant	Possible	3
SC-6	Rock Lined Spillways			Negligible	Unlikely	N/A
SC-12	Remaining Construction Items	Main component of remaining items is mob/demob which is calculated at standard 5% of direct construction cost for the TSP.	Depending on the type of dredging and weather during structure construction there may be additional specialized mobilization costs.	Moderate	Possible	2
SC-13	Planning, Engineering, & Design (PED)	Stoplogs sole source to match LML?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
SC-13a	#REF!	Real estate plan is not fully developed.	Will not dictate specialty construction.	Negligible	Unlikely	N/A
SC-14	Construction Management	Hydraulic dredging experience?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

Technical Design & Quantities				Maximum Project Growth		20%
T-1	Removals	Have minimal survey information at this point. Working with preliminary lengths and general assumptions.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-2	Access Roads	Have minimal survey information at this point. Working with preliminary lengths and general assumptions on design.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-3	Stoplog Structures	Working with approximate geotechnical information.	Quantities for structures are well developed from previous projects using similar structures. Possible quantity changes due to future geotechncial and survey investigations.	Moderate	Possible	2
T-4	Secondary Structures	Working with approximate geotechnical information.	Quantities for structures are well developed from previous projects using similar structures. Possible quantity changes due to future geotechncial and survey investigations.	Moderate	Possible	2
T-5	Dredging	General assumptions made on the extents of dredging needed.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-6	Rock Lined Spillways	General design assumptions and survey information is needed.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-12	Remaining Construction Items		PDT agreed to apply overall construction contingency to element 12.	Negligible	Unlikely	N/A
T-13	Planning, Engineering, & Design (PED)	Will detailed survey and geotechnical data change design?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
T-14	Construction Management		PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

Cost Estimate Assumptions

Maximum Project Growth **25%**

EST-1	Removals	Site access and seasonal work may influence productivity.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-2	Access Roads	Site access and seasonal work may influence productivity.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-3	Stoplog Structures	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-4	Secondary Structures	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-5	Dredging	Weather conditions due to seasonal work may influence productivity and type of dredging performed.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-6	Rock Lined Spillways	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-12	Remaining Construction Items	Main component of remaining items is mob/demob which is calculated at standard 5% of direct construction cost for the TSP.	Current estimate utilizes standard percentages for mob/demob. Itemizing mobilization costs with more detail on production rates, subcontracting, and schedule will likely	Moderate	Likely	3

EST-13	Planning, Engineering, & Design (PED)	Use of "rule of thumb" percentages of construction cost.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
EST-14	Construction Management	Use of "rule of thumb" percentages of construction cost.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

External Project Risks					Maximum Project Growth	20%
EX-1	Removals	No concerns.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-2	Access Roads	No concerns.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-3	Stoplog Structures	Tariffs may influence cost on steel and/or aluminum and other materials.	Volatility of steel and aluminum prices due to recent tariffs could have a moderate influence on construction costs. Steel prices have risen 20% since the beginning of the year and an additional 13% is predicted by the end of 2018.	Moderate	Possible	2
EX-4	Secondary Structures	Tariffs may influence cost on steel and/or aluminum and other materials.	Volatility of steel and aluminum prices due to recent tariffs could have a moderate influence on construction costs. Steel prices have risen 20% since the beginning of the year and an additional 13% is predicted by the end of 2018.	Moderate	Possible	2
EX-5	Dredging	No concerns, support is strong for project. Single season funding is expected to be sufficient for the project.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-6	Rock Lined Spillways	No concerns, support is strong for project. Single season funding is expected to be sufficient for the project.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	N/A
EX-13	Planning, Engineering, & Design (PED)	Will there be a change in the current level of support for the project over time if there is an extended period before funding is available. Real estate plan is not fully developed.	Extending the schedule will not likely change the level of support for the project. There are unknowns regarding location of structures and utilities primarily under the Hwy 169 bridge that may affect MOU's, permanent easements, and possible relocations. Fee title not likely as the project is located on federal property but there will be Real Estate acquisition costs associated with permanent easements. Easement requirements will require some coordination with other agencies.	Marginal	Likely	2
EX-14	Construction Management		PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

Bass Lake Ponds TSP (Alternative 11)
Feasibility (Recommended Plan)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Management & Scope Growth	Acquisition Strategy	Construction Elements	Specialty Construction or Fabrication	Technical Design & Quantities	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	Real Estate								$53
02 RELOCATIONS	Utilities								$40
06 FISH AND WILDLIFE FACILITIES	Removals	0	1	3	N/A	3	3	0	$89
0	Access Roads	0	1	3	N/A	3	3	0	$755
0	Stoplog Structures	0	1	3	N/A	2	3	2	$1,300
0	Secondary Structures	0	1	3	N/A	2	3	2	$604
0	Dredging	0	1	2	3	3	3	0	$113
0	Rock Lined Spillways	0	1	3	N/A	3	3	0	$242
All Other	Remaining Construction Items	N/A	2	0	2	N/A	3	N/A	$155
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design (PED)	N/A	N/A	N/A	N/A	N/A	N/A	2	$793
31 CONSTRUCTION MANAGEMENT	Construction Management	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$407
									$4,457
Risk		$ -	$ 233	$ 318	$ 19	$ 135	$ 225	$ 63	**$993**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ -	$ 233	$ 318	$ 19	$ 135	$ 225	$ 63	**$993**
								Total	**$5,450**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Bass Ponds HREP** DISTRICT: **Saint Paul (MVP)** PREPARED: **3/24/2019**
PROJECT NO: **402725**
LOCATION: **Minnesota River, Scott County, MN** POC: **CHIEF, COST ENGINEERING, James Sentz**

This Estimate reflects the scope and schedule in report; Bass Ponds, Marsh, and Wetland HREP Feasibility Report and Integrated EA

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
						Program Year (Budget EC):				2019					
						Effective Price Level Date:				1-Oct- 18					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	REMAINING COST ($K)	Spent Thru: 17-Oct-18 ($K)	**TOTAL FIRST COST ($K)**	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
06	FISH & WILDLIFE FACILITIES	$3,257	$994	31%	$4,251		$3,257	$994	$4,251		$4,251	5.6%	$3,439	$1,049	$4,488
			-			-						-			
			-			-						-			
			-			-						-			
	CONSTRUCTION ESTIMATE TOTALS:	$3,257	$994		$4,251		$3,257	$994	$4,251		$4,251	5.6%	$3,439	$1,049	$4,488
01	LANDS AND DAMAGES	$61	$15	25%	$76		$61	$15	$76		$76	1.5%	$62	$15	$77
02	RELOCATIONS	$40	$10	25%	$50		$40	$10	$50		$50	4.0%	$42	$10	$52
30	PLANNING, ENGINEERING & DESIGN	$793	$242	31%	$1,035		$793	$242	$1,035		$1,035	6.3%	$843	$257	$1,100
31	CONSTRUCTION MANAGEMENT	$407	$124	31%	$531		$407	$124	$531		$531	7.8%	$439	$134	$573
	PROJECT COST TOTALS:	$4,558	$1,385	30%	$5,943		$4,558	$1,385	$5,943		**$5,942**	5.8%	$4,824	$1,466	$6,290

______________________ CHIEF, COST ENGINEERING, James Sentz

______________________ PROJECT MANAGER, Tom Novak

______________________ CHIEF, REAL ESTATE, Kevin Sommerland

______________________ CHIEF, PLANNING, Aaron Snyder

______________________ CHIEF, ENGINEERING, Tom Sully

______________________ CHIEF, OPERATIONS, Kevin Baumgard

______________________ CHIEF, CONSTRUCTION, Mark Koenig

______________________ CHIEF, CONTRACTING, Kevin Henricks

______________________ CHIEF, PM-PB, xxxx

______________________ CHIEF, DPM, Judy DesHarnais

ESTIMATED TOTAL PROJECT COST:		**$6,290**
ESTIMATED FEDERAL COST:	100%	$6,290
ESTIMATED NON-FEDERAL COST:		
22 - FEASIBILITY STUDY (CAP studies):		**$813**
ESTIMATED FEDERAL COST:		$813
ESTIMATED NON-FEDERAL COST:		
ESTIMATED FEDERAL COST OF PROJECT		**$7,103**

Filename: CAP Bass Ponds Recommended Plan TPCS Alternative 11_Updated Real Estate.xlsx
TPCS

**** TOTAL PROJECT COST SUMMARY ****

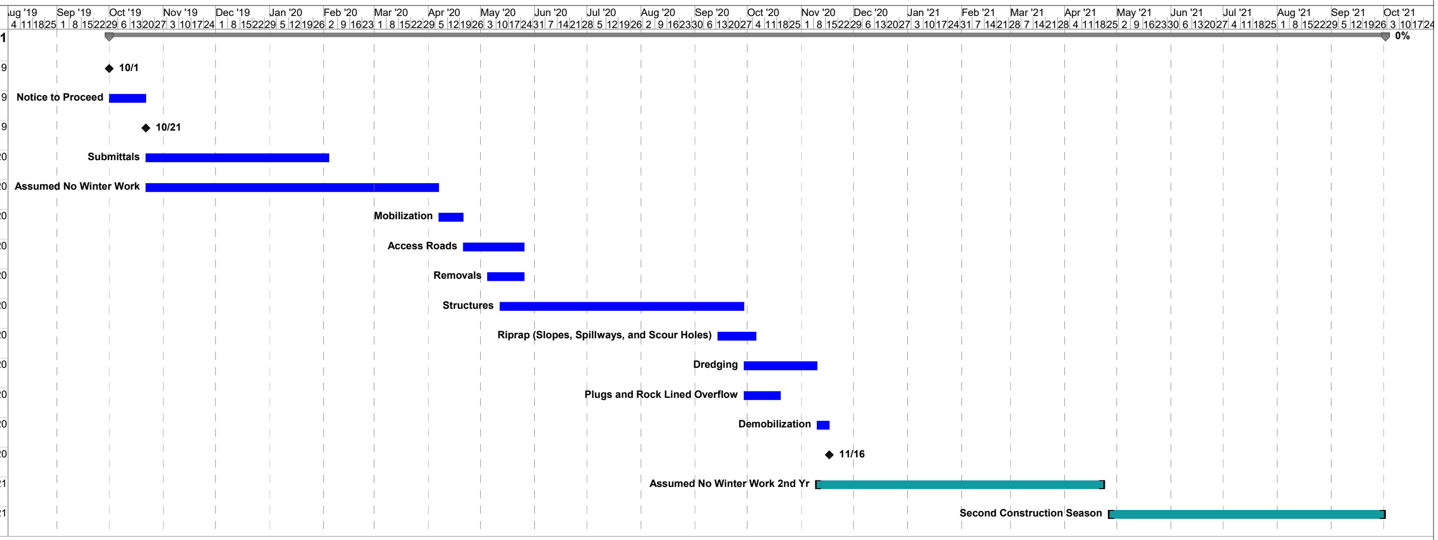
**** CONTRACT COST SUMMARY ****

PROJECT: Bass Ponds HREP
LOCATION: Minnesota River, Scott County, MN
This Estimate reflects the scope and schedule in report; Bass Ponds, Marsh, and Wetland HREP Feasibility Report and Integrated EA

DISTRICT: Saint Paul (MVP) PREPARED: 3/24/2019
POC: CHIEF, COST ENGINEERING, James Sentz

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 8-Aug-18 Estimate Price Level: 1-Oct-18				Program Year (Budget EC): 2019 Effective Price Level Date: 1 -Oct-18								
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	RISK BASED CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	ESC (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Alternative 11													
06	FISH & WILDLIFE FACILITIES	$3,257	$994	31%	$4,251		$3,257	$994	$4,251	2021Q1	5.6%	$3,439	$1,049	$4,488
	CONSTRUCTION ESTIMATE TOTALS:	$3,257	$994	31%	$4,251		$3,257	$994	$4,251			$3,439	$1,049	$4,488
01	LANDS AND DAMAGES	$61	$15	25%	$76		$61	$15	$76	2019Q4	1.5%	$62	$15	$77
02	RELOCATIONS	$40	$10	25%	$50		$40	$10	$50	2020Q3	4.0%	$42	$10	$52
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$81	$25	31%	$106		$81	$25	$106	2019Q3	2.0%	$83	$25	$108
1.0%	Planning & Environmental Compliance	$33	$10	31%	$43		$33	$10	$43	2019Q3	2.0%	$34	$10	$44
12.0%	Engineering & Design	$391	$119	31%	$510		$391	$119	$510	2019Q3	2.0%	$399	$122	$520
1.0%	Reviews, ATRs, IEPRs, VE	$33	$10	31%	$43		$33	$10	$43	2019Q3	2.0%	$34	$10	$44
	Life Cycle Updates (cost, schedule, risks)			31%										
1.0%	Contracting & Reprographics	$33	$10	31%	$43		$33	$10	$43	2021Q1	7.8%	$36	$11	$46
3.0%	Engineering During Construction	$98	$30	31%	$128		$98	$30	$128	2021Q1	7.8%	$106	$32	$138
0.8%	Planning During Construction	$26	$8	31%	$34		$26	$8	$34	2019Q3	2.0%	$27	$8	$35
3.0%	Adaptive Management & Monitoring	$98	$30	31%	$128		$98	$30	$128	2026Q1	29.5%	$127	$39	$165
	Project Operations			31%										
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$326	$99	31%	$425		$326	$99	$425	2021Q1	7.8%	$351	$107	$459
	Project Operation:			31%										
2.5%	Project Management	$81	$25	31%	$106		$81	$25	$106	2021Q1	7.8%	$87	$27	$114
	CONTRACT COST TOTALS:	$4,558	$1,385		$5,943		$4,558	$1,385	**$5,943**			$4,824	$1,466	**$6,290**

ID	Task Name	Duration	Start	Finish
0	**Bass Ponds HREP**	**4 days?**	**Tue 10/1/19**	**Fri 10/1/21**
1	Project Award	0 days	Tue 10/1/19	Tue 10/1/19
2	Notice to Proceed	15 days	Tue 10/1/19	Mon 10/21/19
3	Preconstruction Meeting	0 days	Mon 10/21/19	Mon 10/21/19
4	Submittals	75 days?	Tue 10/22/19	Mon 2/3/20
5	Assumed No Winter Work	120 days	Tue 10/22/19	Mon 4/6/20
6	Mobilization	10 days?	Tue 4/7/20	Mon 4/20/20
7	Access Roads	25 days	Tue 4/21/20	Mon 5/25/20
8	Removals	15 days	Tue 5/5/20	Mon 5/25/20
9	Structures	100 days	Tue 5/12/20	Mon 9/28/20
10	Riprap (Slopes, Spillways, and Scour Holes)	16 days	Mon 9/14/20	Mon 10/5/20
11	Dredging	30 days	Tue 9/29/20	Mon 11/9/20
12	Plugs and Rock Lined Overflow	15 days	Tue 9/29/20	Mon 10/19/20
13	Demobilization	5 days?	Tue 11/10/20	Mon 11/16/20
14	Substantial Completion	0 days	Mon 11/16/20	Mon 11/16/20
15	Assumed No Winter Work 2nd Yr	120 days	Mon 11/9/20	Fri 4/23/21
16	Second Construction Season	115 days	Mon 4/26/21	Fri 10/1/21



Project: Bass Ponds HREP
Date: Fri 1/11/19

Critical	Split	Baseline Milestone	Project Summary	Inactive Summary	Manual Summary	External Milestone	
Critical Split	Task Progress	Milestone	External Tasks	Manual Task	Start-only	Deadline	
Critical Progress	Baseline	Summary Progress	External Milestone	Duration-only	Finish-only		
Task	Baseline Split	Summary	Inactive Milestone	Manual Summary Rollup	External Tasks		

Basis of Estimate - Estimate & Scope Information

District:	St. Paul
Project Name:	Bass Ponds - HREP
Project Location:	Burnsville, MN
Basis of Estimate for:	Tentatively Selected Plan (Alternative 11)
Estimate Type:	Baseline Cost Estimate
Date:	October 2018
FY:	FY2019
Cost Engineer & Phone:	Paul Hegre @ 651-290-5269
Cost QC Reviewer & Phone:	James Sentz @ 651-290-5625
Technical Lead & Phone:	Tony Fares @ 651-290-5568
Project Manager & Phone:	Angela Deen @ 651-290-5293
Project File Location:	X:\PROJECTS\UMRR(EMP)\000Mn_River\EMP_MVP_Bass_Lake_Ponds_MN_402725\01_Feasibility\
Class of Estimate:	Class 3 - Baseline (Feasibility/DPR/LRR)
Reference for Scope Basis:	Bass Ponds, Marsh, and Wetland Habitat Rehab and Enhancement Feasibility Report
Supporting Documentation:	UMRR_Bass_Ponds_Factsheet.pdf

Cost & Schedule

- Basis of Estimate Complete
- Cost, Schedule, CSRA, and TPCS Complete & Correlate

Cost Engineer (Sign & Date)

Paul Hegre HEGRE.PAUL.D.JR.1538722770

Digitally signed by HEGRE.PAUL.D.JR.1538722770
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=HEGRE.PAUL.D.JR.1538722770
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QC Review

- Quality Control Review of Cost, Schedule, Risk, and TPCS Complete

Quality Control Reviewer (Sign & Date)

BRAY.MATTHEW.M.1231206651

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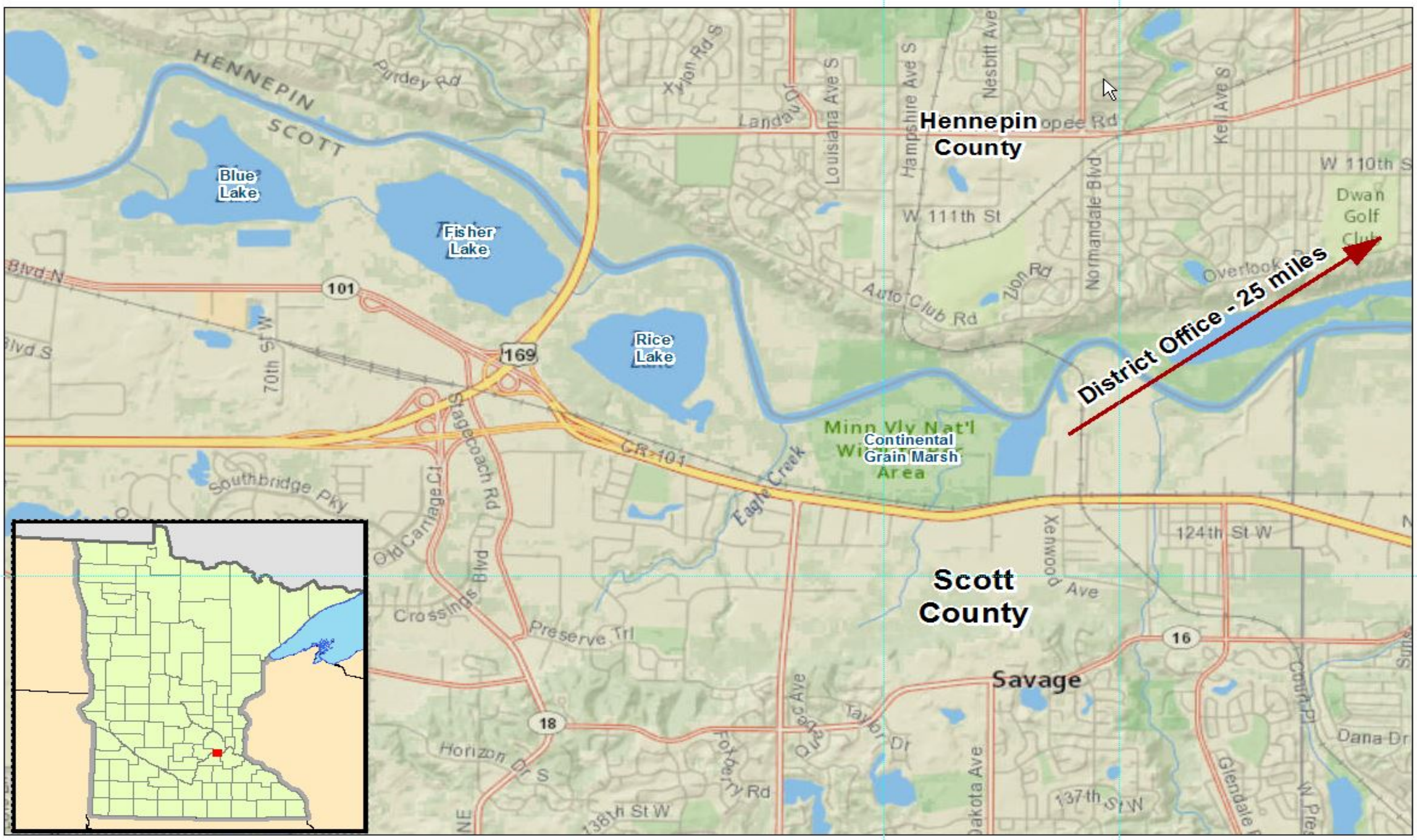
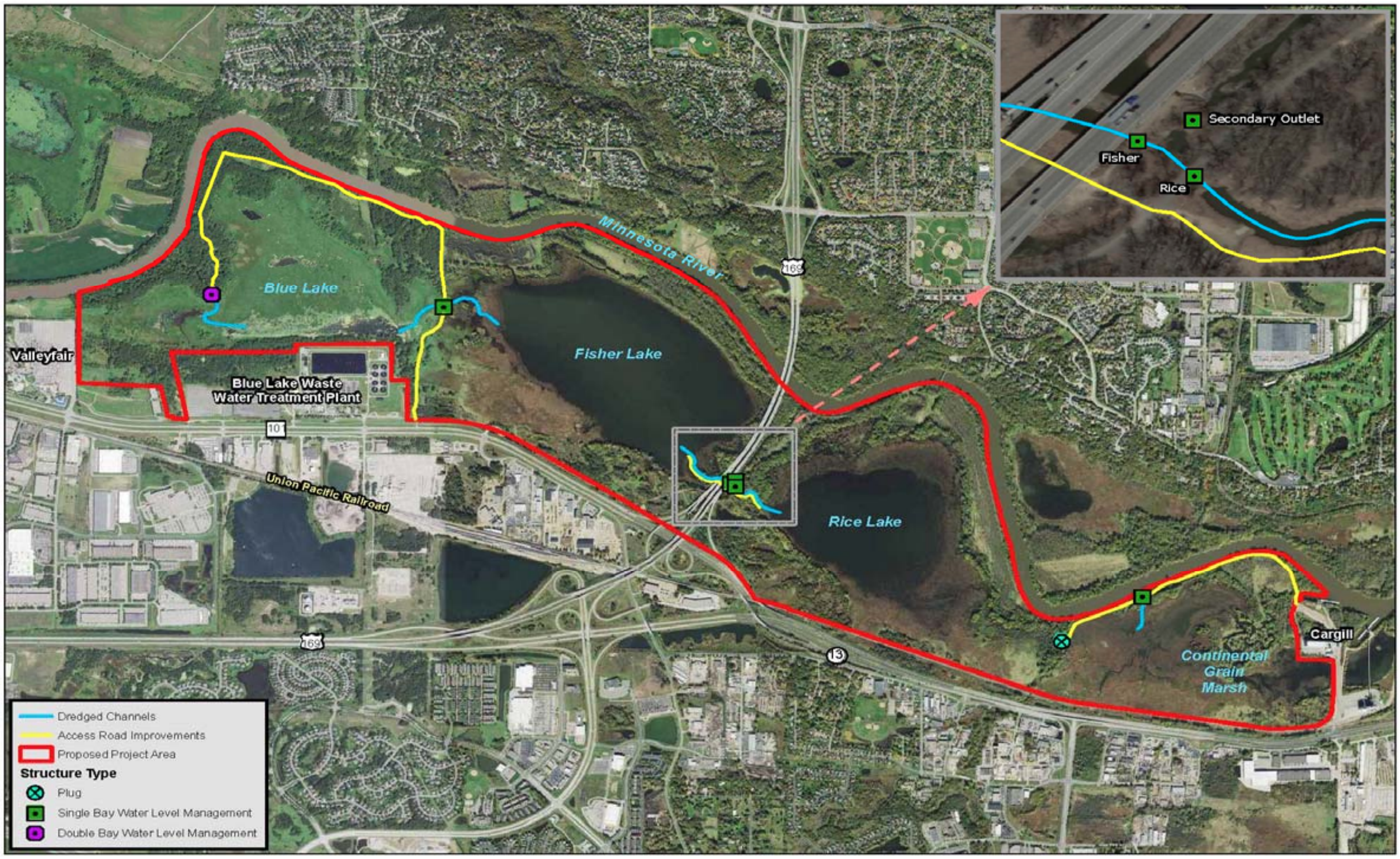
LOCATION MAP



Tentatively Selected Plan (TSP)



Estimator's Questions & Answers

Key Outstanding Questions/Issues:

No.	Question	Response	Reference
1	Has the survey for all dredging areas been completed?		
2	Do we know what type of easements Cargill may require?	Contact has been made and discussions are ongoing.	PDT meeting Nov 14, 2018
3	Have the utilities within MNDOT corridor been located?	Only visually.	PDT meeting Nov 14, 2018
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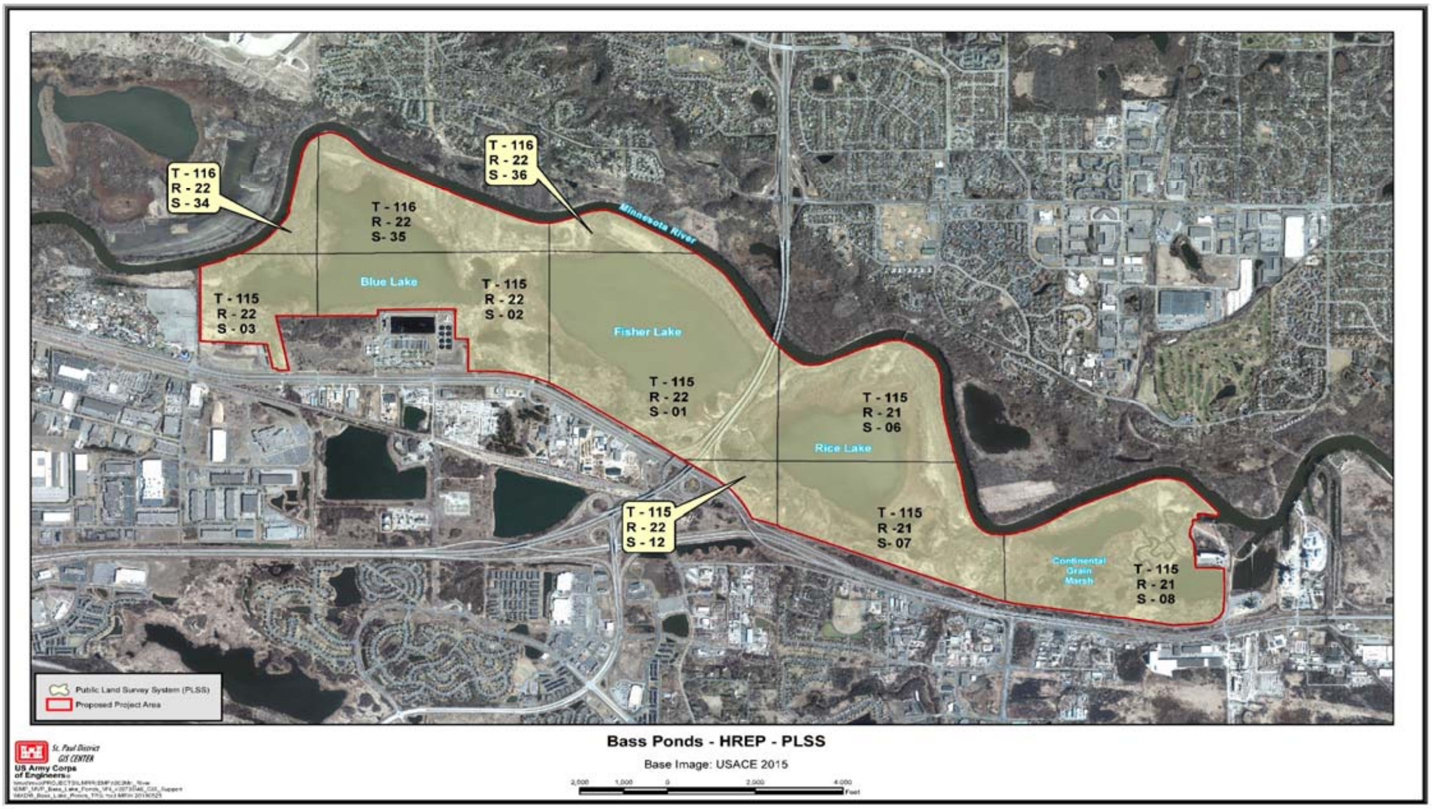
Real Estate

Discussion:

Data taken from \\mvd\mvp\PROJECTS\UMRR(EMP)\000Mn_River\EMP_MVP_Bass_Lake_Ponds_MN_402725\01_Feasibility\Discipline_Working_Folders\Real Estate\

Representative Drawings/Photos:



Cost Estimate

Exhibit A - Real Estate Base Cost Estimate			
01 LANDS AND DAMAGES			
Description	**# Tracts**	**Cost per Tract**	**Total Cost**
Appraisal	1	$3,500.00	$3,500.00
Survey - Surveys for easement legal descriptions.	1	$3,000.00	$3,000.00
Title Search - Ownership and encumbrance search for each property	1	$1,500.00	$1,500.00
Attorney Fees - Due to the lower value of the acquisition it is estimated that less time is required for acquisition. Time for this property(s) is estimated to be 20 hours at $140 per hour.	1	$2,800.00	$2,800.00
Federal Partner's Labor Costs - Forty hours per tract is estimated at $110 per hour for labor costs by the Federal Partner	1	$4,400.00	$4,400.00
USACE Labor Costs - Forty hours per tract is estimated at $110 per hour for labor costs.	1	$4,400.00	$4,400.00
Total Estimated Federal Administrative Costs			$19,600.00
25% Contingency			$4,900.00
TOTAL ESTIMATED FEDERAL ADMINISTRATIVE COSTS			**$24,500.00**
Permanent Road Easement (Rounded from $41,191.63)			$41,200.00

25% Contingency			$10,300.00
TOTAL ESTIMATED LANDS COSTS			**$51,500.00**
TOTAL 01 LANDS AND DAMAGES			**$76,000.00**
02 RELOCATIONS			
Fiber Optic Cable - Fisher Culvert Area (Consolidated Communications w/in the MN DOT ROW)	1	$ 40,000.00	$40,000.00
25% Contingency			$10,000.00
TOTAL 02 RELOCATIONS			**$50,000.00**
TOTAL ESTIMATED PROJECT LERRD COSTS			**$126,000.00**

Utility Impacts

Description	Location	Design Intentions	Notes
MNDOT corridor (HWY 169)			
Fiber Optics	Secondary Outlet	Horizontally Directionally Drilled (HDD)	Currently exposed.
Interlake Area (Blue-Fisher)			
Natural Gas Pipeline	Interlake Structure	Adjust dredging limits for no impact	

Development of Alternatives

		H&H Drawdown Analysis (Alts 1-9)									Separable Increments	
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9	M2 Alt	M1 Alt
		Biggest Lake Plan						Smallest	Smallest			**Smallest Plan**
	Meaures	BFR	BFR	BFR	BFR	BFR	BFR	BFR	BFR	BFR	CGM	CGM plug only
Blue Lake	New WLM structure	4 bays	4 bays	2 bays	4 bays	2 bays	1 bays	1 bays	4 bays	1 bays		
	Old Culvert Removal	x	x	x	x	x	x	x	x	x		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	rock overflow	x	x	x	x	x	x	x	x	x		
	Improve Access Rd	x	x	x	x	x	x	x	x	x		
Interlake (Blue to Fisher)	New WLM structure	2 bay	2 bay	2 bay	1 bay	1 bay	1 bay	1 bay	2 bay	remove		
	Dredge cut	x	x	x	x	x	x	x	x			
	rock overflow	x	x	x	x	x	x	x	x			
Secondary Outlet	New WLM structure	2 bay	1 bay	1 bay	1 bay	1 bay	1 bay	remove	remove	1 bay		
	rock overflow	x	x	x	x	x	x			x		
Fisher	New WLM structure	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay		
	Culvert Removal (fiber optic)	x	x	x	x	x	x	x	x	x		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	rock overflow	x	x	x	x	x	x	x	x	x		
	Access to structure	x	x	x	x	x	x	x	x	x		
Rice	New WLM structure	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay	1 bay		
	Dredge cut	x	x	x	x	x	x	x	x	x		
	Access to structure	x	x	x	x	x	x	x	x	x		
CGMarsh	Plug										x	x
	rock overflow										x	x
	New WLM structure										x	
	Dredge cut										x	
	Improve Access Rd										x	x
CONST TOTAL	**w/32% contingency**	**$ 3,242,979**	**$ 3,150,246**	**$ 2,950,106**	**$ 3,057,514**	**$ 2,857,374**	**$ 2,764,642**	$ 2,455,806	$ 2,841,411	$ 2,199,297	$ 694,702	$ 316,875

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Alternative: **1**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date: **8/8/2018**

Total Estimated Construction Contract Cost = **$ 2,450,903**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 1,113,446		36%	$ 396,158	$ 1,509,604
4		Secondary Structures	$ 275,841		36%	$ 98,143	$ 373,984
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 222,809	*10.0%*	0%	$ -	$ 222,809
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 331,540		32%	$ 106,093	$ 437,633
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 176,911		32%	$ 56,611	$ 233,522

Totals	Estimated Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,450,903	32%	$ 792,076	$ 3,242,979
Total Planning, Engineering & Design	$ 331,540	32%	$ 106,093	$ 437,633
Total Construction Management	$ 176,911	32%	$ 56,611	$ 233,522
Total Excluding Real Estate	**$ 2,959,354**	**32%**	**$ 954,780**	**$ 3,914,134**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,959k	$3,532k	$3,914k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** — **Alternative: 2**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = **$ 2,380,834**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 1,113,446		36%	$ 396,158	$ 1,509,604
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 216,439	*10.0%*	0%	$ -	$ 216,439
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 322,062		32%	$ 103,060	$ 425,122
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 171,853		32%	$ 54,993	$ 226,846

Totals	Estimated Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,380,834	32%	$ 769,412	$ 3,150,246
Total Planning, Engineering & Design	$ 322,062	32%	$ 103,060	$ 425,122
Total Construction Management	$ 171,853	32%	$ 54,993	$ 226,846
Total Excluding Real Estate	**$ 2,874,749**	**32%**	**$ 927,465**	**$ 3,802,214**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,875k	$3,431k	$3,802k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** — **Alternative: 3**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = **$ 2,229,608**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 975,967		36%	$ 347,244	$ 1,323,211
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 202,692	*10.0%*	0%	$ -	$ 202,692
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 301,605		32%	$ 96,514	$ 398,119
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 160,937		32%	$ 51,500	$ 212,437

Totals	Estimated Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,229,608	32%	$ 720,498	$ 2,950,106
Total Planning, Engineering & Design	$ 301,605	32%	$ 96,514	$ 398,119
Total Construction Management	$ 160,937	32%	$ 51,500	$ 212,437
Total Excluding Real Estate	**$ 2,692,150**	**32%**	**$ 868,512**	**$ 3,560,662**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,692k	$3,213k	$3,561k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** — **Alternative: 4**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = **$ 2,310,766**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 1,049,747		36%	$ 373,494	$ 1,423,241
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 210,070	*10.0%*	0%	$ -	$ 210,070
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 312,584		32%	$ 100,027	$ 412,610
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 166,795		32%	$ 53,374	$ 220,170

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,310,766	32%	$ 746,749	$ 3,057,514
Total Planning, Engineering & Design	$ 312,584	32%	$ 100,027	$ 412,610
Total Construction Management	$ 166,795	32%	$ 53,374	$ 220,170
Total Excluding Real Estate	**$ 2,790,145**	**32%**	**$ 900,150**	**$ 3,690,295**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,790k	$3,330k	$3,690k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** — **Alternative: 5**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = $ 2,159,540

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 912,269		36%	$ 324,580	$ 1,236,849
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 196,322	*10.0%*	0%	$ -	$ 196,322
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 292,127		32%	$ 93,481	$ 385,607
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 155,880		32%	$ 49,881	$ 205,761

Totals	Estimated Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,159,540	32%	$ 697,835	$ 2,857,374
Total Planning, Engineering & Design	$ 292,127	32%	$ 93,481	$ 385,607
Total Construction Management	$ 155,880	32%	$ 49,881	$ 205,761
Total Excluding Real Estate	**$ 2,607,546**	**32%**	**$ 841,197**	**$ 3,448,743**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,608k	$3,113k	$3,449k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: 6

Meeting Date: 8/8/2018

Total Estimated Construction Contract Cost = $ 2,089,471

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 848,570		36%	$ 301,917	$ 1,150,487
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ 189,952	*10.0%*	0%	$ -	$ 189,952
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 282,648		32%	$ 90,448	$ 373,096
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 150,822		32%	$ 48,263	$ 199,085

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,089,471	32%	$ 675,171	$ 2,764,642
Total Planning, Engineering & Design	$ 282,648	32%	$ 90,448	$ 373,096
Total Construction Management	$ 150,822	32%	$ 48,263	$ 199,085
Total Excluding Real Estate	**$ 2,522,942**	**32%**	**$ 813,882**	**$ 3,336,823**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,523k	$3,011k	$3,337k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** **Alternative: 7**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = **$ 1,856,114**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 848,570		36%	$ 301,917	$ 1,150,487
4		Secondary Structures	$ -		0%	$ -	$ -
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 168,738	*10.0%*	0%	$ -	$ 168,738
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 251,082		32%	$ 80,346	$ 331,428
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 133,978		32%	$ 42,873	$ 176,851

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 1,856,114	32%	$ 599,692	$ 2,455,806
Total Planning, Engineering & Design	$ 251,082	32%	$ 80,346	$ 331,428
Total Construction Management	$ 133,978	32%	$ 42,873	$ 176,851
Total Excluding Real Estate	**$ 2,241,174**	**32%**	**$ 722,911**	**$ 2,964,085**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,241k	$2,675k	$2,964k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds** — **Alternative: 8**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 8/8/2018**

Total Estimated Construction Contract Cost = $ 2,147,477

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 5,719		35%	$ 2,001	$ 7,720
2		Access Roads	$ 554,381		35%	$ 193,949	$ 748,330
3		Stoplog Structures	$ 1,113,446		36%	$ 396,158	$ 1,509,604
4		Secondary Structures	$ -		0%	$ -	$ -
5		Dredging	$ 162,538		38%	$ 61,184	$ 223,722
6		Rock Lined Spillways	$ 116,168		35%	$ 40,641	$ 156,810
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	Remaining Construction Items	$ 195,225	*10.0%*	0%	$ -	$ 195,225
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 290,495		32%	$ 92,958	$ 383,454
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 155,009		32%	$ 49,603	$ 204,612

Totals	Estimated Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 2,147,477	32%	$ 693,933	$ 2,841,411
Total Planning, Engineering & Design	$ 290,495	32%	$ 92,958	$ 383,454
Total Construction Management	$ 155,009	32%	$ 49,603	$ 204,612
Total Excluding Real Estate	**$ 2,592,981**	**32%**	**$ 836,494**	**$ 3,429,476**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$2,593k	$3,095k	$3,429k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Alternative: 9

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date: **8/8/2018**

Total Estimated Construction Contract Cost = **$ 1,662,631**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ 4,291		35%	$ 1,501	$ 5,792
2		Access Roads	$ 464,988		35%	$ 162,675	$ 627,663
3		Stoplog Structures	$ 636,428		36%	$ 226,438	$ 862,865
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 106,507		38%	$ 40,092	$ 146,599
6		Rock Lined Spillways	$ 87,126		35%	$ 30,481	$ 117,607
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ 151,148	*10.0%*	0%	$ -	$ 151,148
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 224,909		32%	$ 71,971	$ 296,879
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 120,012		32%	$ 38,404	$ 158,416

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 1,662,631	32%	$ 536,666	$ 2,199,297
Total Planning, Engineering & Design	$ 224,909	32%	$ 71,971	$ 296,879
Total Construction Management	$ 120,012	32%	$ 38,404	$ 158,416
Total Excluding Real Estate	**$ 2,007,552**	**32%**	**$ 647,041**	**$ 2,654,592**

	Base	**50%**	**80%**
Confidence Level Range Estimate ($000's)	$2,008k	$2,396k	$2,655k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Alternative: **M2 CGM**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date: **8/8/2018**

Total Estimated Construction Contract Cost = **$ 525,171**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ -		0%	$ -	$ -
2		Access Roads	$ 178,786		35%	$ 62,548	$ 241,333
3		Stoplog Structures	$ -		0%	$ -	$ -
4		Secondary Structures	$ 212,143		36%	$ 75,479	$ 287,622
5		Dredging	$ 46,728		38%	$ 17,590	$ 64,319
6		Rock Lined Spillways	$ 39,772		35%	$ 13,914	$ 53,686
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ 47,743	*10.0%*	0%	$ -	$ 47,743
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 71,041		32%	$ 22,733	$ 93,775
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 37,908		32%	$ 12,131	$ 50,038

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 525,171	32%	$ 169,531	$ 694,702
Total Planning, Engineering & Design	$ 71,041	32%	$ 22,733	$ 93,775
Total Construction Management	$ 37,908	32%	$ 12,131	$ 50,038
Total Excluding Real Estate	**$ 634,121**	**32%**	**$ 204,395**	**$ 838,515**

	Base	**50%**	**80%**
Confidence Level Range Estimate ($000's)	$634k	$757k	$839k

* 50% based on base is at 5% CL.

Abbreviated Risk Analysis

Project (less than $40M): **Bass Lake Ponds**

Alternative: **M1 CGM**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date: **8/8/2018**

Total Estimated Construction Contract Cost = **$ 240,413**

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0%	$ -	$ -
1	06 FISH AND WILDLIFE FACILITIES	Removals	$ -		0%	$ -	$ -
2		Access Roads	$ 178,786		35%	$ 62,548	$ 241,333
3		Stoplog Structures	$ -		0%	$ -	$ -
4		Secondary Structures	$ -		0%	$ -	$ -
5		Dredging	$ -		0%	$ -	$ -
6		Rock Lined Spillways	$ 39,772		35%	$ 13,914	$ 53,686
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	**Remaining Construction Items**	**$ 21,856**	*10.0%*	0%	$ -	$ 21,856
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 32,521		32%	$ 10,407	$ 42,928
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 17,353		32%	$ 5,553	$ 22,907

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 240,413	32%	$ 76,462	$ 316,875
Total Planning, Engineering & Design	$ 32,521	32%	$ 10,407	$ 42,928
Total Construction Management	$ 17,353	32%	$ 5,553	$ 22,907
Total Excluding Real Estate	**$ 290,288**	**32%**	**$ 92,422**	**$ 382,710**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$290k	$346k	$383k

* 50% based on base is at 5% CL.

Bass Lake Ponds

Alternative Formulation

Abbreviated Risk Analysis

Meeting Date: 8-Aug-18

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Management & Scope Growth				**Maximum Project Growth**		**40%**
PS-1	Removals	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-2	Access Roads	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-3	Stoplog Structures	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-4	Secondary Structures	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-5	Dredging	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-6	Rock Lined Spillways	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	Single year funding should be adequate to fully fund project regardless of construction year. Features of the project are well defined without much concern for scope growth.	Negligible	Unlikely	0
PS-12	Remaining Construction Items			Negligible	Unlikely	N/A
PS-13	Planning, Engineering, & Design	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
PS-14	Construction Management	Period of time to solicitation date. New expectations or requests from stakeholders if too much time passes from Recommended Plan to P, E, & D.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Removals	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1
AS-2	Access Roads	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1

AS-3	Stoplog Structures	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1
AS-4	Secondary Structures	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1
AS-5	Dredging	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1
AS-6	Rock Lined Spillways	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	Likely will be small business IFB (competitive) but do not rule out RFP (negotiated). The difference could have a marginal impact on costs. The current assumption is IFB.	Marginal	Possible	1
AS-12	Remaining Construction Items			Negligible	Unlikely	N/A
AS-13	Planning, Engineering, & Design	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Possible	N/A
AS-14	Construction Management	Likely a small Business set-aside. Could undefined funding result in phasing or multiple contracts?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Possible	N/A
Construction Elements					**Maximum Project Growth**	**15%**
CE-1	Removals	Likely constructed during cold weather months that may require working with frost and frozen materials. Water levels may impact construction if done in summer months. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3
CE-2	Access Roads	Likely constructed during cold weather months that may require working with frost and frozen materials. Design development regarding alignment location, surface elevations, passing/turnout points, and lengths are at preliminary stage. Minimal survey information available at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3
CE-3	Stoplog Structures	Likely constructed during cold weather months that may require working with frost and frozen materials. Cold weather concrete plan will likely be required. Geotechncial information at specific locations has not yet been obtained thus relying on approximate information from previous projects nearby. Magnitude of dewatering requirements is unkown at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. If specific geotechnical data collected in the future varies from current assumptions it's possible that it would have a significant impact on costs.	Significant	Possible	3
CE-4	Secondary Structures	Likely constructed during cold weather months that may require working with frost and frozen materials. Cold weather concrete plan will likely be required. Geotechncial information at specific locations has not yet been obtained thus relying on approximate information from previous projects nearby. Magnitude of dewatering requirements is unkown at this point. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. If specific geotechnical data collected in the future varies from current assumptions it's possible that it would have a significant impact on costs.	Significant	Possible	3
CE-5	Dredging	Season of construction could influence type of dredging (mechanical or hydraulic). No information on which to base the extents of dredging. Permit acquisition may have construction delay impact.	The assumption is mechanical dredging during winter months but it is possible that hydraulic dredging will be done during the summer months. The difference in methods could have a moderate effect on the construction cost and schedule.	Moderate	Possible	2
CE-6	Rock Lined Spillways	Likely constructed during cold weather months that may require working with frost and frozen materials. Water levels in summer months could impact construction. Permit acquisition may have construction delay impact.	Weather conditions (cold or wet, winter or summer) during construction likely will have an impact on the construction elements of the project. Construction delays could have moderate impact on the cost of construction.	Moderate	Likely	3

CE-12	Remaining Construction Items			Negligible	Unlikely	N/A
CE-13	Planning, Engineering, & Design	Habitat maintenance (eagle nests), access points and staging areas, and water diversion (bypass and dewater) are undefined requirements of project.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
CE-14	Construction Management	Likely constructed during cold weather months that may affect QA/QC requirements.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
Specialty Construction or Fabrication				**Maximum Project Growth**		**50%**
SC-1	Removals			Negligible	Unlikely	N/A
SC-2	Access Roads			Negligible	Unlikely	N/A
SC-3	Stoplog Structures			Negligible	Unlikely	N/A
SC-4	Secondary Structures			Negligible	Unlikely	N/A
SC-5	Dredging	Possibility of hydraulic dredging. Possibility of difficult site access.	Current assumption is mechanical dredging. Change to hydraulic dredging would require subcontracting and moderate impact on costs.	Moderate	Possible	2
SC-6	Rock Lined Spillways			Negligible	Unlikely	N/A
SC-12	Remaining Construction Items			Negligible	Unlikely	N/A
SC-13	Planning, Engineering, & Design	Stoplogs sole source to match LML?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
SC-14	Construction Management	Hydraulic dredging experience?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
Technical Design & Quantities				**Maximum Project Growth**		**20%**
T-1	Removals	Have minimal survey information at this point. Working with preliminary lengths and general assumptions.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-2	Access Roads	Have minimal survey information at this point. Working with preliminary lengths and general assumptions on design.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-3	Stoplog Structures	Working with approximate geotechnical information.	Quantities for structures are well developed from previous projects using similar structures. Possible quantity changes due to future geotechncial and survey investigations.	Moderate	Possible	2
T-4	Secondary Structures	Working with approximate geotechnical information.	Quantities for structures are well developed from previous projects using similar structures. Possible quantity changes due to future geotechncial and survey investigations.	Moderate	Possible	2
T-5	Dredging	General assumptions made on the extents of dredging needed.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-6	Rock Lined Spillways	General design assumptions and survey information is needed.	Likely quantity changes due to future survey investigations would have moderate impact on costs.	Moderate	Likely	3
T-12	Remaining Construction Items			Negligible	Unlikely	N/A

T-13	Planning, Engineering, & Design	Will detailed survey and geotechnical data change design?	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
T-14	Construction Management		PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
Cost Estimate Assumptions					**Maximum Project Growth**	**25%**
EST-1	Removals	Site access and seasonal work may influence productivity.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-2	Access Roads	Site access and seasonal work may influence productivity.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-3	Stoplog Structures	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-4	Secondary Structures	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-5	Dredging	Weather conditions due to seasonal work may influence productivity and type of dredging performed.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3

EST-6	Rock Lined Spillways	Site access and seasonal work may influence productivity. Heavy use of abstract data from similar projects.	Assumptions are Prime would do the removals, earthwork, and access construction with the rest of the elements done by subcontractors. Productivity could be impacted by the season of construction and water levels. Water levels could impact site accessibility. Current estimate relies on abstracts and historical data. Further development of design with commensurate change in detail of cost estimate is likely to change cost moderately.	Moderate	Likely	3
EST-12	Remaining Construction Items			Negligible	Unlikely	N/A
EST-13	Planning, Engineering, & Design	Use of "rule of thumb" percentages of construction cost.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
EST-14	Construction Management	Use of "rule of thumb" percentages of construction cost.	PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A
External Project Risks				**Maximum Project Growth**		**20%**
EX-1	Removals	No concerns.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-2	Access Roads	No concerns.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-3	Stoplog Structures	Tariffs may influence cost on steel and/or aluminum and other materials.	Volatility of steel and aluminum prices due to recent tariffs could have a moderate influence on construction costs. Steel prices have risen 20% since the beginning of the year and an additional 13% is predicted by the end of 2018.	Moderate	Possible	2
EX-4	Secondary Structures	Tariffs may influence cost on steel and/or aluminum and other materials.	Volatility of steel and aluminum prices due to recent tariffs could have a moderate influence on construction costs. Steel prices have risen 20% since the beginning of the year and an additional 13% is predicted by the end of 2018.	Moderate	Possible	2
EX-5	Dredging	No concerns, support is strong for project. Single season funding is expected to be sufficient for the project.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-6	Rock Lined Spillways	No concerns, support is strong for project. Single season funding is expected to be sufficient for the project.	Support is strong for project. Single season funding is expected to be sufficient for the project.	Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	N/A
EX-13	Planning, Engineering, & Design	Real estate plan is not fully developed. Will there be a change in the current level of support for the project over time if there is an extended period before funding is available.	There are unknowns regarding location of structures and utilities primarily under the Hwy 169 bridge that may affect MOU's and possible relocations. The project is located on federal property.	Marginal	Possible	1
EX-14	Construction Management		PDT agreed to apply overall construction contingency to elements 13 and 14.	Negligible	Unlikely	N/A

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

APPENDIX H

REAL ESTATE PLAN

FINAL

REAL ESTATE DIVISION
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
March 2019

Table of Contents

1.0 PURPOSE AND GENERAL PROJECT INFORMATION....4
1.1 Report Purpose....4
1.2 Project Authority....5
1.3 Project Location....5
1.4 Project Description....6
2.0 PROJECT LANDS, EASEMENTS, RIGHT-OF-WAY, RELOCATIONS AND DISPOSAL/BORROW AREAS (LERRD)....8
2.1 Project LERRD....8
3.0 FEDERAL PARTNER LERRD....9
3.1 Federal Partner-Owned Lands or Other Lesser Interest....9
4.0 ESTATES TO BE ACQUIRED....9
4.1 Non-Standard Estates....9
4.2 Recommended Estates....9
5.0 EXISTING FEDERAL OR OVERLAPPING PROJECTS....10
5.1 Federal Projects....10
6.0 FEDERALLY OWNED LANDS OR OTHER INTEREST....11
6.1 Federally-Owned LERRD....11
7.0 NAVIGATION SERVITUDE....11
7.1 LERRD Subject to Navigation Servitude....11
8.0 PROJECT MAP....11
8.1 Project Real Estate Map....11
9.0 INDUCED FLOODING....12
9.1 Flooding Resulting from Project Implementation....12
10.0 BASELINE COST ESTIMATE FOR REAL ESTATE (BCERE)....13
10.1 Total Estimated Real Estate Cost....13
11.0 RELOCATION ASSISTANCE BENEFITS, PUBLIC LAW 91-646(PL 91-646)....13
11.1 Total Estimated PL 91-646 Payments....13
12.0 MINERAL ACTIVITY....13
12.1 Mineral Activity in the Project Area....13
13.0 FEDERAL PARTNER REAL ESTATE ACQUISITION CAPABILITIES ASSESSMENT....13
13.1 Federal Partner Assessment....13
14.0 ZONING ORDINANCE REQUIREMENTS....14

Table of Contents (Cont.)

14.1 Application or Enactment of Zoning Ordinances. 14

15.0 PROJECT SCHEDULE 14

15.1 Real Estate Acquisition Milestones 14

16.0 PUBLIC UTILITY OR FACILITY RELOCATIONS, ALTERATIONS, OR REPLACEMENT 15

16.1 Relocation Requirements 15

17.0 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW) 16

17.1 HTRW Assessment 16

18.0 LANDOWNER OPPOSITION/PUBLIC CONCERNS 17

18.1 Landowner Opposition 17

19.0 LERRD ACQUISITION PRIOR TO PROJECT MEMORANDUM OF AGREEMENT (MOA) EXECUTION 17

19.1 Federal Partner LERRD Acquisition Prior to MOA Execution 17

20.0 OTHER RELEVANT REAL ESTATE ISSUES 18

LIST OF FIGURES

Figure 1. Recommended Plan Overview 6

Figure 2. Continental Grain Marsh - Cargill Structure Location 7

Figure 3. Real Estate Map 12

Figure 4. Identified Utilities 16

LIST OF TABLES

Table 1. Real Estate Milestones 14

LIST OF EXHIBITS

Exhibit A – Baseline Cost Estimate for Real Estate (BCERE) 19

Exhibit B – Risk Letter 20-21

1.0 PURPOSE AND GENERAL PROJECT INFORMATION.

1.1 This Real Estate Plan (REP) supports the Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project (HREP) Feasibility Report with Integrated Environmental Assessment (EA), including the Finding of No Significant Impact (FONSI).

The purpose of the feasibility report is to evaluate the proposal for the Upper Mississippi River Restoration program (UMRR). The U.S. Army Corps of Engineers (USACE) developed this report with the U.S. Fish and Wildlife Service (USFWS), the Federal project partner.

The study area includes three interconnected backwater lakes (Blue, Rice, and Fisher) and Continental Grain Marsh, situated southwest of St. Paul, Minnesota adjacent to the Minnesota River.

The project lies mostly within the USFWS's Minnesota Valley National Wildlife Refuge (Refuge), established by Congress to provide habitat for a large number of migratory waterfowl, waterbirds, fish, and other wildlife species threatened by commercial and industrial development in addition to public educational and recreational opportunities.

Changes in climate and land use have altered the hydrology of the study area. Currently the lakes, wetlands, and marshes experience prolonged full pool conditions with depths of 3-to-4 feet throughout the year. The lack of seasonal variability in water levels has resulted in a degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity, and the availability of quality habitat for migratory waterbirds and waterfowl.

The objectives of the project are to:

- Provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl.
- Increase the diversity and percent cover of desirable emergent aquatic plant species.
- Increase the diversity and percent cover of desirable submergent aquatic plant species.

The Recommended Plan would partially restore the lake and marsh habitats by providing water level management capability to improve habitat of emergent and submergent aquatic vegetation, and the habitat for water birds.

This REP has been prepared to identify the overall real estate requirements and provide estimated real estate costs for the recommended plan as proposed. The information in the REP is based on preliminary data and is subject to change even after approval of the REP. No prior REP has been submitted for the project.

1.2 Congress authorized the UMRR program in Section 1103 of the 1986 Water Resources Development Act (WRDA) (Public Law 99-662), codified at 33 U.S.C. § 652. Congress reauthorized the UMRR program in WRDA 1999 (Public Law 106-53).

Section 509 of WRDA 1999 would fund the proposed planning, design, and construction of the project.

1.3 The study area is located in Scott County, Minnesota, between Minnesota River Mile 15-21, at the convergence of the cities of Eden Prairie, Bloomington, Shakopee, and Savage, Minnesota. The USFWS manages the study area as part of the Refuge. The Refuge as a whole covers over 14,000 acres of the river valley, extending from River Mile 4 to River Mile 68 on the Minnesota River. Established in 1976, the Refuge is one of the few national wildlife refuges located within a major metropolitan area.

The proposed study area is mostly on Refuge land, with Cargill and the Minnesota Department of Transportation (MnDOT) parcels on the east end (Figure 1). Cargill is a corporation that trades, purchases, and distributes agricultural commodities among other business endeavors.

The study area is approximately 2,085 acres in size and the project features are located mostly within the Refuge, which USFWS manages. Cargill owns 1.8 acres of land where the access road improvements will be accomplished, along with the Cargill plug and rock overflow features.

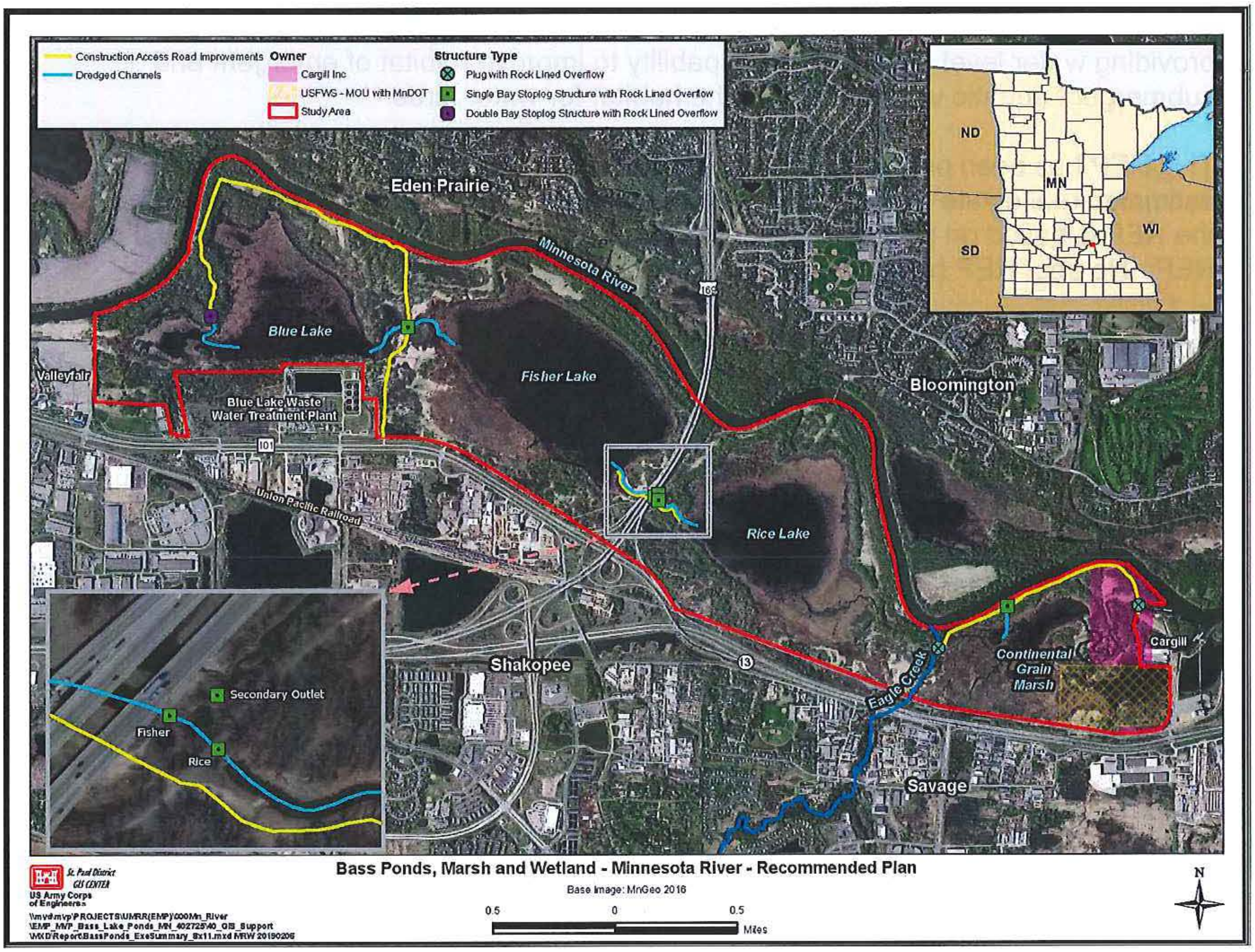


Figure 1 - Recommended Plan Overview

1.4 During the flow analysis, the team identified a water level management (WLM) structure on the east end of Continental Grain Marsh, located on Cargill property. Figure 2 below shows the location of the structure in relation to refuge land. The Cargill structure was constructed in 1985 by the USFWS which was before the loss of the beaver dam on the western end of the marsh and throughout the lifespan of the Continental Grain Marsh overflow structure that was installed as a part of the Rice Lake HREP. Throughout this time, this structure did not affect the marsh water levels and has been acting as a plug. Inspection of the structure indicated that it was silted in and functioning as a plug. There was also significant erosion observed around the failed structure. If this structure were to pass flow or fail completely, a new outlet would exist.

This new outlet would decrease the effectiveness of the proposed project plug and water level management structure significantly.

The proposed solution for this structure includes the construction of an earthen plug, rock-lined overflow structure at the current location of the Cargill culvert road crossing. Figure 2 below shows the proposed plug/rock overflow location. This new location is within and directly adjacent to the original real estate request for the road improvement. Enhancing the structure in the existing location was considered, but it was decided by the team that access to the structure and obtaining the required real estate would be significantly easier in the new location. This solution would require an increase in required real estate acreage. The original real estate plan included 1.44 acres of required land. The new plan includes 1.8 acres of required land which includes both the road improvement and proposed plug/rock overflow.

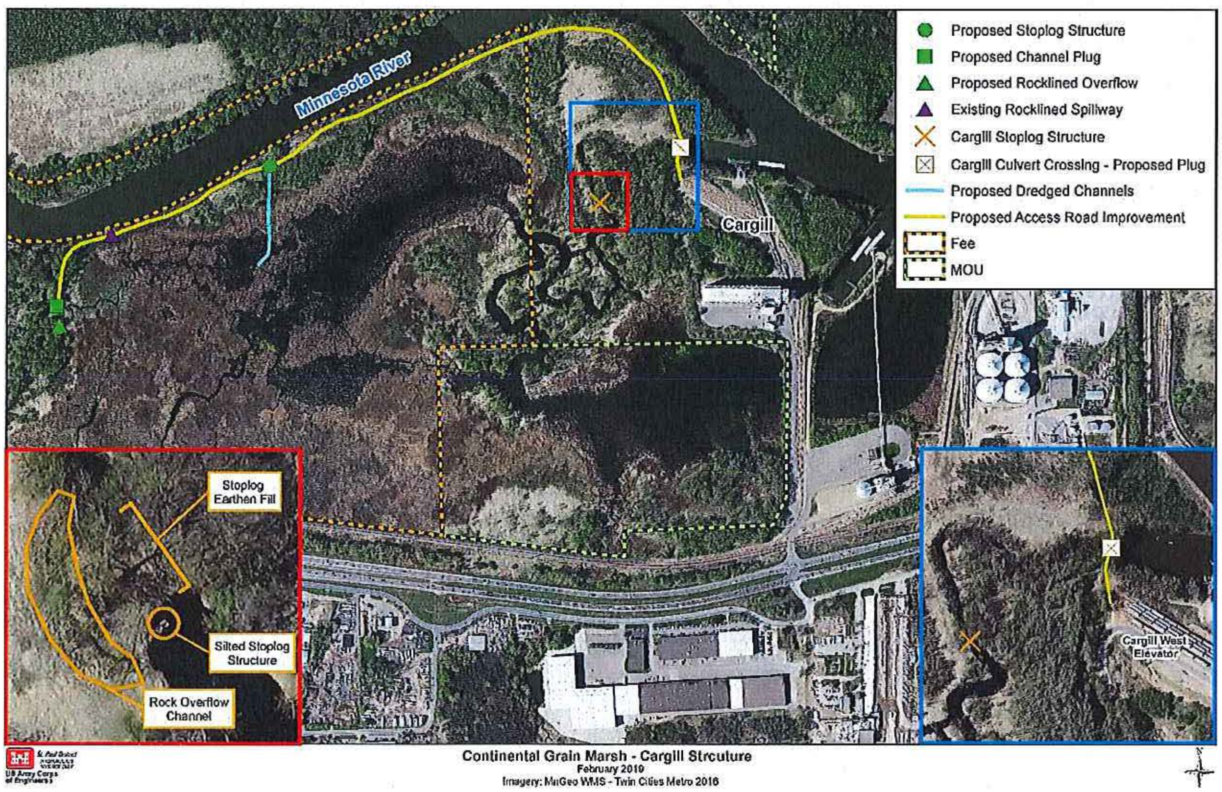


Figure 2 - Silted Stoplog Structure and Overflow Located on Cargill Private Property

The features of this HREP project include the construction of 6 water level management structures, associated rock-lined overflow channels, 1 earthen ditch plug, access dredging, and access road improvements to the structures. This plan would improve submergent and emergent aquatic vegetation on approximately 1,000 acres of aquatic and wetland habitat, and improve habitat for migratory waterbirds and waterfowl.

2.0 PROJECT LANDS, EASEMENTS, RIGHT-OF-WAYS, RELOCATIONS, AND DISPOSAL/BORROW AREAS (LERRD).

2.1 All project features will be constructed on refuge lands owned by the USFWS, except for a perpetual road easement that will be required from Cargill, Inc. in order to access the Continental Grain Marsh for construction and future maintenance. This road is also the location where the Cargill plug and rock overflow features will be constructed. It is anticipated that a temporary access permit from the Minnesota Department of Transportation (MNDOT) may be required during construction within the Highway 169 right-of-way; the underlying fee owner is the USFWS; the MNDOT has an exclusive easement for purposes of maintaining the road. The Contractor will be responsible for applying for the permit with MNDOT. Staging area(s) for construction will be determined during development of plans and specifications. If the Staging area is on private land, USFWS will acquire a Temporary Work Area Easement (TWAE) for it.

The Site covers a large area and is assumed to be accessible from County Highway 101 at three points. One point is near Blue Lake Wastewater Treatment Plant directly adjacent to the east property line, another is under Highway 169 bridge crossing off of CH 101 Trail, and the last is off of Cargill's property on the extreme east end of the project area. It has been assumed that the County and State will allow access to the site using a portion of the highway easements. No formal agreements have been reached with the State and/or County regarding these assumptions. A permanent road easement on the far east end of the project area will be required from Cargill. Cargill owns ~56 acres of land within the project footprint; however, other than the permanent road easement that is anticipated, there are no proposed project features that will be constructed within these lands.

It is assumed that a nearby commercial landfill will be used for disposal if necessary and that an easement would not be necessary.

Upon completion of construction, the USFWS would accept responsibility for the project in accordance with Section 107(b) of the Water Resources Development Act of 1992, 33 U.S.C. § 652(e)(7)(A). The operation and maintenance responsibilities of the USFWS will be addressed in a Memorandum of Agreement (MOA) between the

USFWS and USACE.

A small portion of land within the project footprint is owned by MNDOT, ~73 acres, however, those acres will not contain any physical project features. They are low-lying floodplain lands that would be used for inundation purposes only. This project will not cause any additional flooding to this area.

3.0 FEDERAL PARTNER LERRD.

3.1 Lands within the project construction area are owned by USFWS as part of the Minnesota Valley National Wildlife Refuge. The operation, maintenance, repair, rehabilitation, and replacement responsibilities of the USFWS are addressed in the proposed Memorandum of Agreement for the project (Appendix "C" of the Feasibility Report).

Because the project is located on national wildlife refuge lands, project costs would be 100-percent federal in accordance with Section 906(e) of Public Law 99-662, 33 U.S.C. § 2283(e).

4.0 ESTATES TO BE ACQUIRED.

4.1 The project will not require the use of any non-standard estates to accommodate the construction, or operation and maintenance of the project. All of the required estates for the project are "standard estates" as found in ER 405-1-11, Chapter 5, Exhibit 5-29.

4.2 The following are the estates that are deemed necessary for the USFWS to obtain for the construction, operations and maintenance of the proposed project (cross reference Table 1).

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ________________, beginning with date possession of the land is granted to the United States or the non-Federal sponsor, for use by the United States or the non-Federal sponsor, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

ROAD EASEMENT.

A (perpetual [exclusive] [non-exclusive] and assignable) (temporary) easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); [1] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.0 <u>EXISTING FEDERAL OR OVERLAPPING PROJECTS.</u>

5.1 The Corps completed the Rice Lake HREP in 1998 (USACE 2012a). It consisted of four main strategies: dredging, water level management, bank stabilization, and forest restoration. Rice Lake is included within the boundary of this project.

The Corps placed an earthen plug in the eastern outlet and installed a 42" culvert and stoplog structure at the western outlet. The purpose of the culvert and stoplog structure was to allow USFWS staff to manage the water levels in Rice Lake and promote optimal growth of aquatic vegetation. The Corps also installed a rock-lined spillway within the Minnesota River berm of Continental Grain Marsh to prevent interior drainage and wetland habitat loss due to riverbank erosion. An additional component was restoration of a 40-acre farm field to bottomland hardwood forest.

The project area is also a part of the Minnesota Valley National Wildlife Refuge as managed by the U.S. Fish and Wildlife Service.

[1] The parenthetical clause maybe deleted, where necessary; however, the use of this reservation may substantially reduce the liability of the Government through reduction of severance damages and consideration of special benefits; therefore, its deletion should be fully justified. Also, access may be restricted to designated points as in Estate No. 12.

6.0 FEDERALLY-OWNED LANDS OR OTHER INTEREST.

6.1 The project features to be constructed within the delineated project area are mostly within Refuge lands owned and managed by the USFWS, except for the 1.8 acres required for the Cargill plug and rock overflow feature that will be constructed on an existing road that Cargill owns. The USFWS owns 1955.37 acres of land within this area. The USFWS also possesses a Memorandum of Understanding (MOU) with the MNDOT for the property they own that lies within the southeast corner of the delineated project footprint. The USFWS will need to acquire a permanent road easement from Cargill for the improvements on the Cargill road.

7.0 NAVIGATION SERVITUDE.

7.1 The project area is considered to be within a backwater area of the Minnesota River, none of the lands fall within the rights of navigation servitude. All required environmental permits will be applied for with the State of Minnesota. See main report for detailed permit information.

8.0 PROJECT MAP.

8.1 Project Real Estate Map

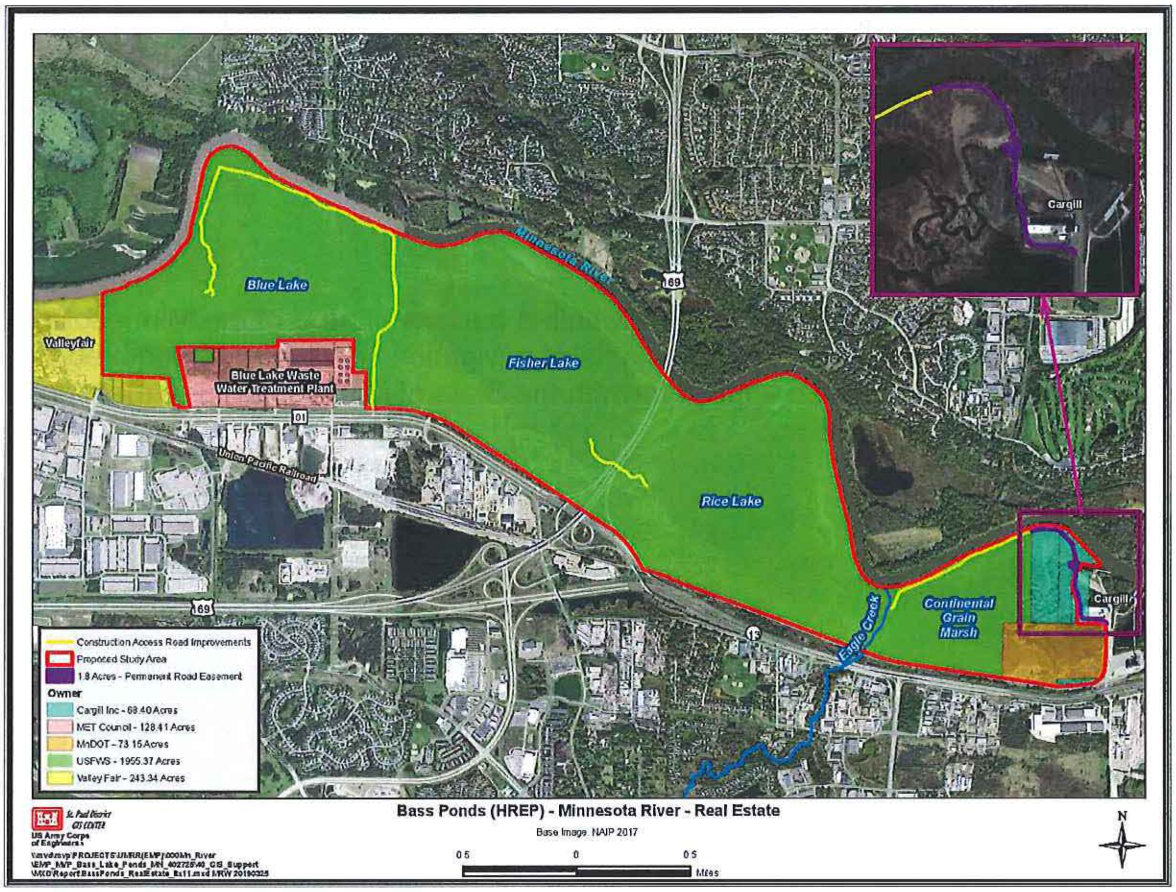


Figure 3 - Real Estate Map

9.0 INDUCED FLOODING.

9.1 The study area includes three backwater lakes (Blue, Fisher, and Rice) and Continental Grain Marsh. The Minnesota River banks overtop during high-water events, but the lakes are largely isolated from the river during normal flows.

Blue Lake is a backwater lake in the northwest portion of the study area. During normal flows, Blue Lake has two outlets: the northwest outlet flows into the Minnesota River,

and the southeast outlet flows into Fisher Lake. During flood conditions, the northwest outlet acts as an inlet, and the Minnesota River discharges into Blue Lake.
Fisher Lake is located downstream of Blue Lake. Water from Fisher Lake can discharge either into Rice Lake or through a secondary outlet into the Minnesota River.

Rice Lake is downstream from Fisher Lake. Rice Lake discharges through the secondary outlet into the Minnesota River.

Continental Grain Marsh is located downstream from Rice Lake but does not connect to the lake. Water currently flows from the marsh into Eagle Creek, a designated trout stream. There will not be flooding induced by the construction of the project. The proposed structure elevations are at or below the existing structure elevations and aren't directly in the banks of the river. This project will not cause any induced flooding on the Cargill property, therefore no takings analysis is needed.

This project will not cause any induced flooding on the ~73 acres that MNDOT owns within the delineated project footprint.

10.0 BASELINE COST ESTIMATE FOR REAL ESTATE (BCERE).

10.1 The total baseline cost estimate for real estate and relocations is shown in Exhibit A as $126,000.00. With the exception of the Cargill access road necessary to reach the Continental Grain Marsh, all project features are on lands owned and managed by the Refuge.

11.0 RELOCATION ASSISTANCE BENEFITS, PUBLIC LAW 91-646.

11.1. There will be no Public Law 91-646 relocations of businesses or residences, but there is a utility relocation discussed in paragraph 16.

12.0 MINERAL ACTIVITY.

12.1 There are no known mineral recovery activities currently ongoing or anticipated, or oil/gas wells present on the project LERRD and the immediate vicinity that will impact the construction, operation, or maintenance of the project. No acquisition of any mineral interest from the surface owner or rights outstanding in third parties will be required.

13.0 FEDERAL PARTNER REAL ESTATE AQUISITION CAPABILITIES ASSESSMENT.

13.1 An assessment of our Federal Partner's real estate acquisition capability is not necessary for this project. The USFWS is a Federal agency with a Real Estate office that performs acquisitions routinely as part of their mission; they possess the capability to perform any acquisitions necessary for this project.

14.0 ZONING ORDINANCE REQUIREMENTS.

14.1 No application or enactment of zoning ordinances is proposed in lieu of, or to facilitate, LERRD acquisition in connection with the project.

15.0 PROJECT SCHEDULE.

15.1 The project features to be constructed are on lands owned by the USFWS, with the exception of an access road that is located on privately owned land. The USFWS will acquire a permanent road easement for this access, estimated to be 1.8 acres. The estimated acquisition milestones and duration for this permanent road easement is in shown in table 3. Total acquisition duration is estimated to be 285 days (9.5 months). A more precise project construction schedule will be developed and coordinated with the USFWS prior to execution of an MOA.

Project construction would likely start in the winter of 2020 and be completed by 2021. Construction activities include dredging, construction of temporary bypass areas, construction of stoplog structures for water level management, and rock-lined overflow channels.

TABLE 1
REAL ESTATE MILESTONES

TASK	Duration
Mapping & Tract Descriptions	45 Days (1.5 Months)
Tract Appraisal	60 Days (2 Months)
Title	Concurrent With Appraisal
Negotiations	90 Days (3 Months)
Closing	60 Days (2 Months)
Condemnation	0 Days
NFS Authorization For Entry For Construction	30 Days (1 Month)

16.0. PUBLIC UTILITY OR FACILITY RELOCATIONS, ALTERATIONS, OR REPLACEMENT.

16.1 Two utilities have been identified within the overall project footprint: a fiber optic cable located near Highway 169 just north of 101, in the MN DOT Right-of-Way, owned and maintained by Consolidated Communications of Mattoon, Illinois, and a 12" petroleum pipeline owned and maintained by Magellan Pipeline Company (Figure 3). Magellan Pipeline Company has an easement from the refuge to operate and maintain the pipeline, which includes a 40' setback on either side of the pipeline, for an area equal to 80'. The Refuge is the underlying fee owner of the lands of both of these utilities.

More information can be found in Appendix C – Plan Formulation. To avoid the pipeline at the Interlake structure, dredging will occur only on the eastern side and stay outside the 80' Right-of-Way. In order to manage construction of the Fisher Lake outlet structure, the team included costs associated with relocating the cable within the LERRDs component of the cost estimate. More information is being gathered to determine if relocating the cable is a project cost or if the utility owner will bear the costs of the relocation of the fiber optic cable.

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE FEDERAL PARTNER AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

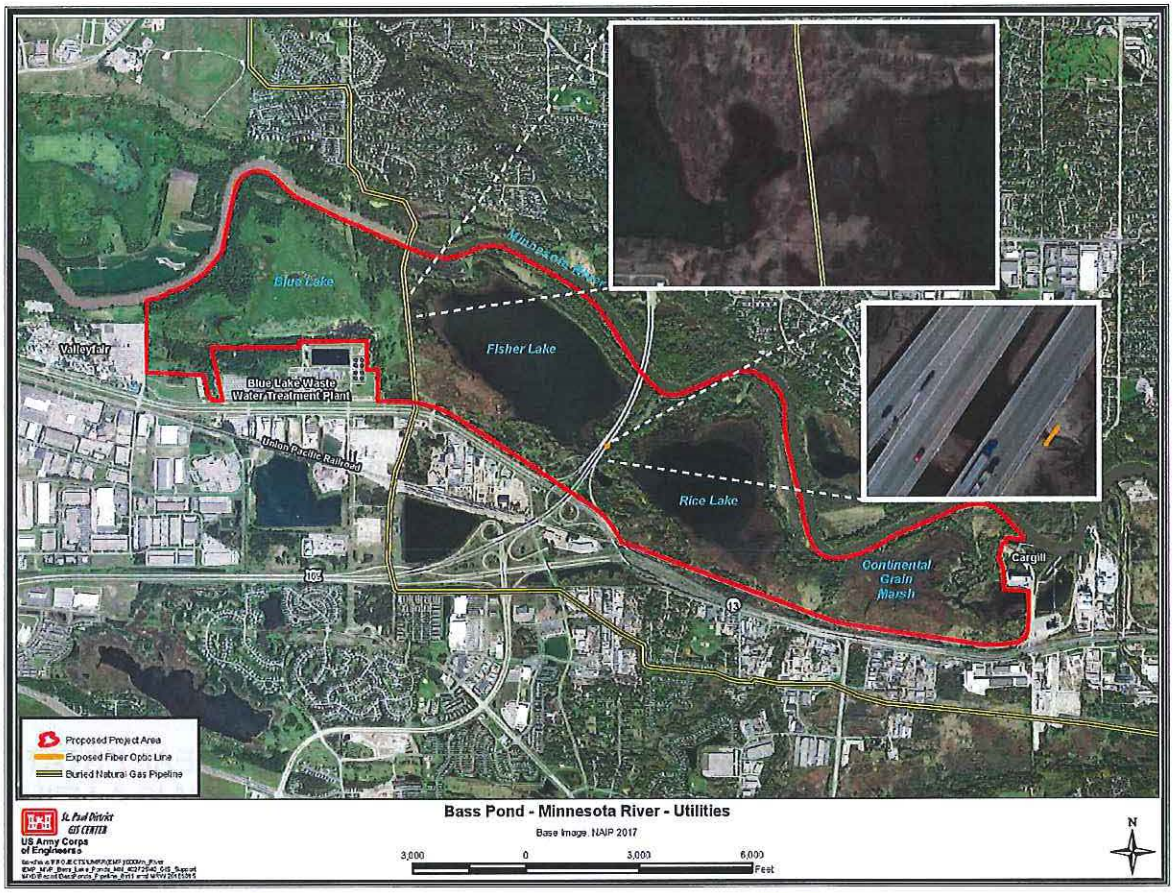


Figure 4 - Identified Utilities

17.0 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW).

17.1. A Phase I HTRW analysis was conducted in June 2018, in accordance with ER 165-2-132, Water Resource Policies and Authorities HTRW Guidance for Civil Works Projects (see Appendix L – HTRW, for the full report). Based on the desktop search and on-site inspection, this assessment revealed that there were no recognized environmental conditions. Therefore, USACE does not recommend a Phase II assessment.

There are no known HTRW sites at the study area; therefore, there are no HTRW concerns with either the No-Action Alternative or the Recommended Plan.

18.0 LANDOWNER OPPOSITION/PUBLIC CONCERNS.

18.1 USACE distributed a communication flyer to potentially interested stakeholders and agencies in the summer of 2018 regarding the beginning of a feasibility study in the area.

The U.S. Fish and Wildlife Service, the project sponsor, supports the Recommended Plan. Letters of support for the project can be found in Appendix A – Correspondence and Coordination.

USACE released the draft feasibility report and integrated environmental assessment for the project for public review in February 2019. Overall, no comments were received during the comment period that would impact plan selection; a summary is included in Appendix A – Correspondence & Coordination.

A public meeting was held in Bloomington, MN at the Minnesota Valley National Wildlife Refuge Visitor on February 12, 2019 to present the tentatively selected plan and field questions from the public. Three members of the public attended the meeting. Overall the general public is in favor of the project. Comments received can also be found in Appendix A - Correspondence & Coordination.

19.0 LERRD ACQUISITION PRIOR TO MEMORANDUM OF AGREEMENT (MOA) EXECUTION.

19.1 The FWS was advised, by letter dated 29 October 2018, of the risk associated with acquisition of the projects LERRD prior to execution of an MOA and written formal notice from the Federal Government to proceed with LERRD acquisition. See Exhibit D.

20.0 OTHER RELEVANT REAL ESTATE ISSUES.

N/A

Stephanie Dupey
Realty Specialist
Planning & Acquisition Branch
St. Paul District

Approved By:

Penny Caldwell
Acting Chief, Real Estate Division
St. Paul District

Exhibit A - Real Estate Base Cost Estimate			
01 LANDS AND DAMAGES			
Description	# Tracts	Cost per Tract	Total Cost
Appraisal	1	$3,500.00	$3,500.00
Survey - Surveys for easement legal descriptions.	1	$3,000.00	$3,000.00
Title Search - Ownership and encumbrance search for each property	1	$1,500.00	$1,500.00
Attorney Fees - Due to the lower value of the acquisition it is estimated that less time is required for acquisition. Time for this property(s) is estimated to be 20 hours at $140 per hour.	1	$2,800.00	$2,800.00
Federal Partner's Labor Costs - Forty hours per tract is estimated at $110 per hour for labor costs by the Federal Partner	1	$4,400.00	$4,400.00
USACE Labor Costs - Forty hours per tract is estimated at $110 per hour for labor costs.	1	$4,400.00	$4,400.00
Total Estimated Federal Administrative Costs			$19,600.00
25% Contingency			$4,900.00
TOTAL ESTIMATED FEDERAL ADMINISTRATIVE COSTS			$24,500.00
Permanent Road Easement (Rounded from $41,191.63)			$41,200.00
25% Contingency			$10,300.00
TOTAL ESTIMATED LANDS COSTS			$51,500.00
TOTAL 01 LANDS AND DAMAGES			$76,000.00
02 RELOCATIONS			
Fiber Optic Cable - Fisher Culvert Area (Consolidated Communications w/in the MN DOT ROW)	1	$ 40,000.00	$40,000.00
25% Contingency			$10,000.00
TOTAL 02 RELOCATIONS			$50,000.00
TOTAL ESTIMATED PROJECT LERRD COSTS			$126,000.00

Exhibit B

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ARMY CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

REPLY TO
ATTENTION OF

October 29, 2018

Real Estate Division

RE: Bass Ponds Habitat Rehabilitation Enhancement Program (HREP) Project – Acquisition Prior to Memorandum of Agreement (MOA) Signing

Sarena Selbo
Refuge Manager, Region 3
Minnesota Valley National Wildlife Refuge
3815 American Boulevard East
Bloomington, Minnesota 55425-1659

Dear Ms. Selbo:

The purpose of this letter is to address the potential risks associated with acquiring real estate interests, as identified in the feasibility study for the Bass Ponds HREP project, in advance of the MOA being fully executed and before the final design specifications have been prepared.

Although we do not encourage advance acquisition, it is entirely your decision. However, we are required by regulation to notify you of the risks associated with this decision. These risks include the following:

1. An MOA, mutually agreed upon by the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service, Minnesota Valley Wildlife Refuge (Refuge), may not be executed and implemented.

2. The Refuge may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, arising out of local, state or federal laws or regulations.

3. The Refuge may incur responsibility and expense by virtue of its ownership of lands, or interests therein, arising out of the National Historic Preservation Act of 1966, or other laws regulating historic and archeological resources.

4. The Refuge may acquire interests or estates that are not appropriate for, or approved as necessary to support the proposed project.

5. The Refuge may initially acquire insufficient or excess real property acreage which may result in additional negotiations, as well as the payment of additional fair market value to affected landowners, which could have been avoided by delaying acquisition until after MOA execution and the USACE's notice to commence acquisition.

6. The Refuge assumes full and sole responsibility for such risks and all costs and expenses related to this decision.

-2-

It is also important to note that acquisition of all project lands must comply with Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act, as amended.

If you have any questions regarding this letter, please contact Stephanie Dupey of my staff at (651) 290-5369 or myself at (651) 290-5253.

Sincerely,

Kevin J. Sommerland
Chief, Real Estate Division
Real Estate Contracting Officer

Copy furnished:
Mr. Ethan Mooar
Ms. Kelly Phillips
Mr. Tom Novak

US Army Corps of Engineers ®
St. Paul District

Appendix I: Civil Drawings

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2018

A1 SITE PLAN

OVERALL PROJECT AREA
SCALE: 1" =1000'

0 800' 1600'

N

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88 GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL): NAD 83 (2011) MN SPCS, SOUTH ZONE-U.S. SURVEY FT. COMBINED FACTOR (CF): 0.999966392

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: PJM | DATE:
DWN BY: PJM | CKD BY: | SOLICITATION NO.:
SUBMITTED BY: | CONTRACT NO.:
PLOT SCALE: | PLOT DATE: 3/22/2019 | FILE NUMBER:
SIZE: ANSI D | FILE NAME: BLPHR_C-001XXX.dgn

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN
OVERALL PROJECT AREA

Sheet ID
C-001

A1

SITE PLAN

BLUE LAKE PROJECT AREA
SCALE: 1" =400'

0 400' 800'

N

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINED FACTOR (CF): 0.999966392

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MARK	DESCRIPTION	DATE	APPR.

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ST. PAUL, MINNESOTA

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SIZE: ANSI D	FILE NAME: BLPHR_C-101XXX.dgn		

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

BLUE LAKE
SITE PLAN

Sheet ID
C-101

A1 **SITE PLAN**

FISHER LAKE PROJECT AREA
SCALE: 1" =100'

0 100' 200'

N

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINED FACTOR (CF): 0.999966392

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BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

FISHER LAKE
SITE PLAN

Sheet ID
C-102

A1 SITE PLAN

CONTINENTAL GRAIN PROJECT AREA
SCALE: 1" =300'

0 300' 600'

N

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINED FACTOR (CF): 0.999966392

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ST. PAUL, MINNESOTA

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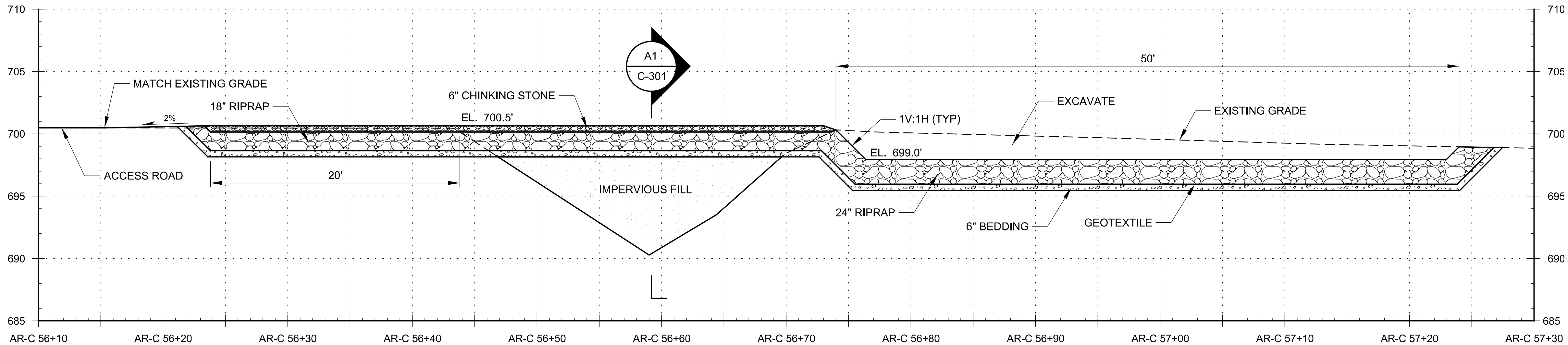
BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

CONTINENTAL GRAIN MARSH
SITE PLAN

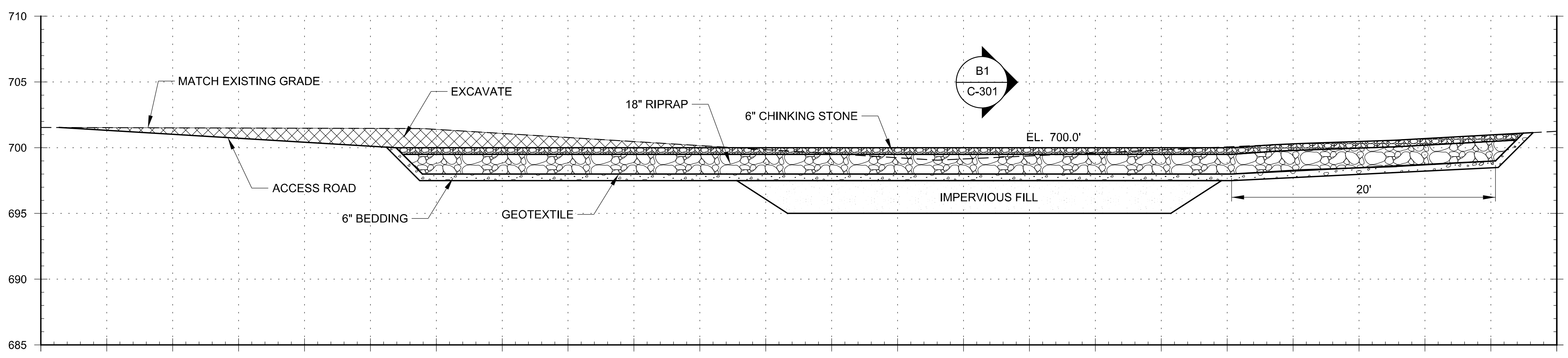
Sheet ID
C-103

US Army Corps of Engineers



C1 CONTINENTAL GRAIN DITCH PLUG B PROFILE ALONG ACCESS ROAD

BASS PONDS HREP
SCALE: 1" =5'



A1 CONTINENTAL GRAIN DITCH PLUG A PROFILE ALONG ACCESS ROAD

BASS PONDS HREP
SCALE: 1" =5'

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINED FACTOR (CF): 0.999966392

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ST. PAUL, MINNESOTA

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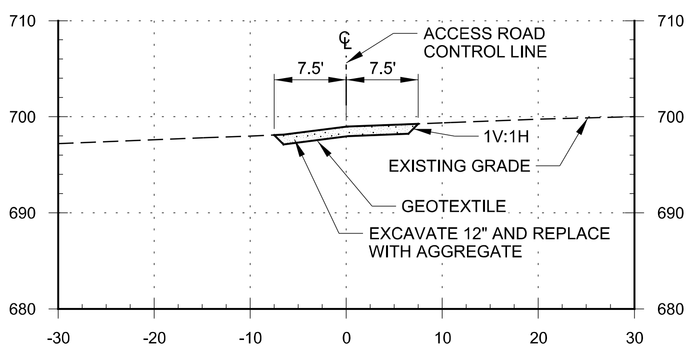
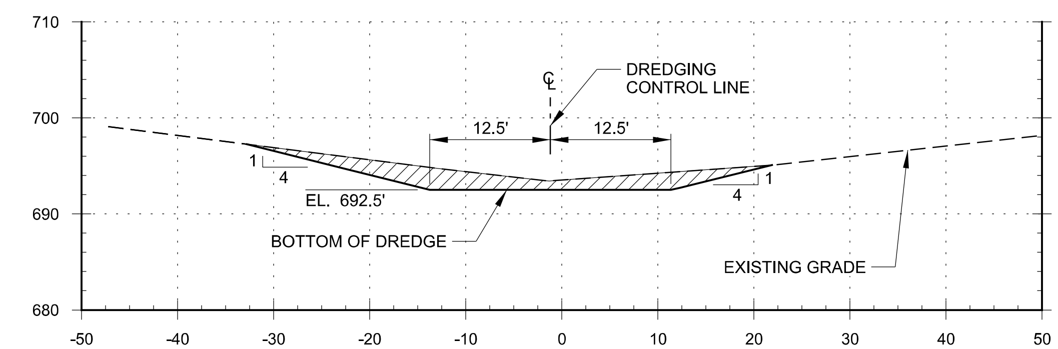
BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

PROFILES

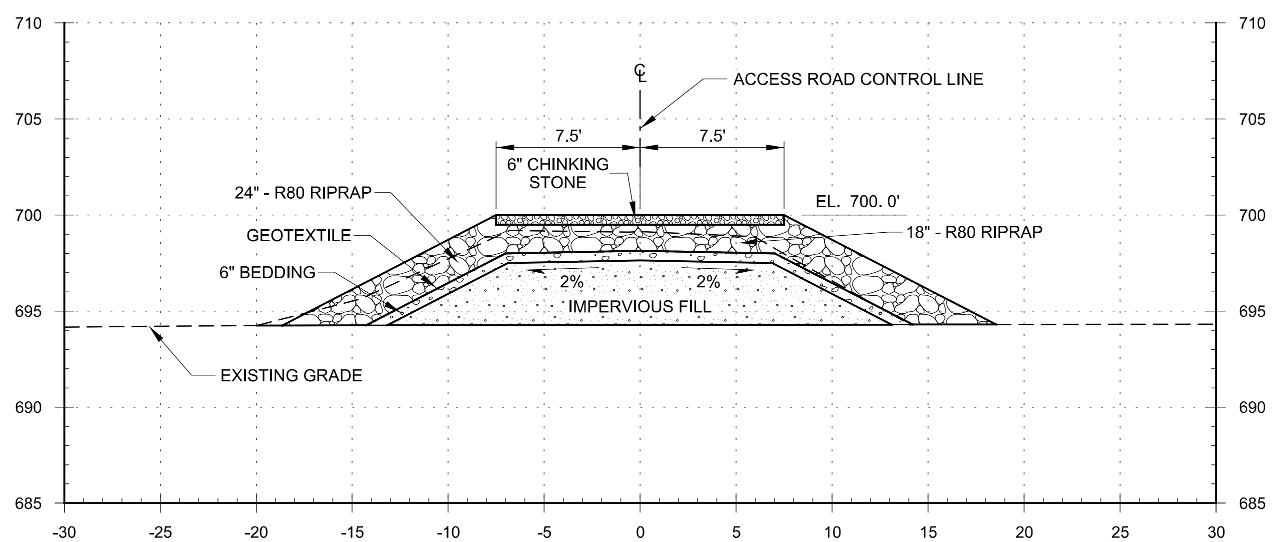
Sheet ID
C-201



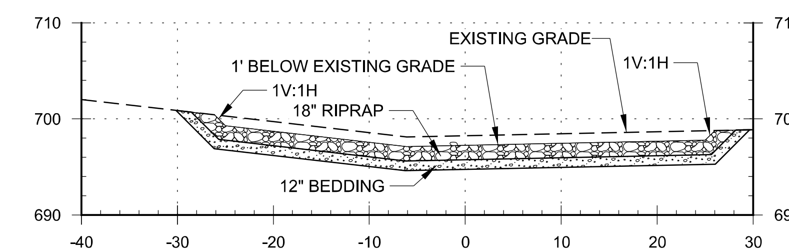
D1 **TYPICAL SECTION**
CONSTRUCTION ACCESS ROAD
SCALE: 1" =10'



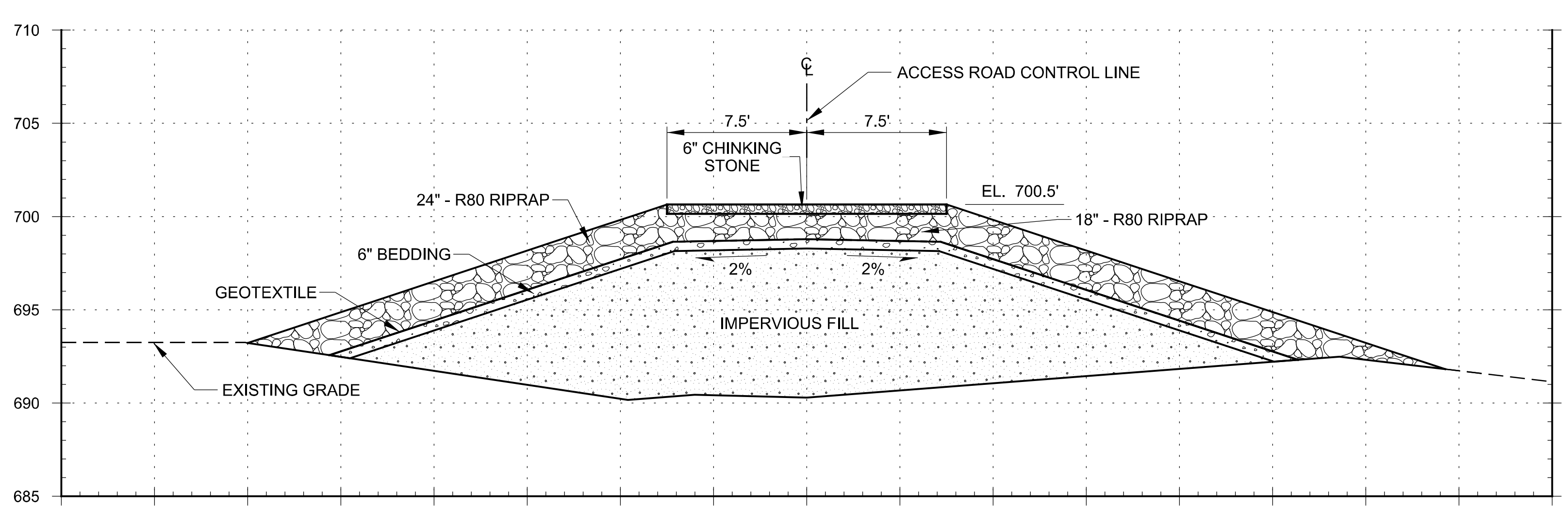
C3 **TYPICAL SECTION**
DREDGING
SCALE: 1" =10'



B1 **SECTION**
CONTINENTAL GRAIN MARSH DITCH PLUG A
SCALE: 1" =5



B4 **TYPICAL SECTION**
ROCK OVERFLOWS AT STRUCTURES
SCALE: 1" =10'



A1 **SECTION**
CONTINENTAL GRAIN MARSH DITCH PLUG B
SCALE: 1" =5

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88 GEOID12B
COORDINATE SYSTEM (HORIZONTAL CONTROL): NAD 83 (2011) MN SPCS, SOUTH ZONE-U.S. SURVEY FT. COMBINED FACTOR (CF): 0.999966392

US Army Corps of Engineers

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

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PLOT DATE: 3/19/2019
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FILE NAME: BLPHR_C-301XXX.dgn
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CONTRACT NO.:
FILE NUMBER:

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN
SECTIONS

Sheet ID
C-301

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St. Paul District

Appendix J: Structural Engineering

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix J: Structural Engineering

TABLE OF CONTENTS

1 Introduction 2

2 Technical Guidelines and Reference Standards 2
  2.1 General 2
  2.2 Closure Structures and Retaining and Flood Walls 3

3 Design Criteria 3
  3.1 Material 3
  3.2 Material Dead Load Unit Weights 4

4 Loads 4

5 Structural Design 7
  5.1 Stoplog Water Control Structures 7
  5.2 Miscellaneous Drainage Features 15
  5.3 Corrosion Control 15

6 Operations and Maintenance Considerations 15

LIST OF FIGURES

Figure 1: Plan view of a typical double bay water control structure 7
Figure 2: Plan view of a typical single bay water control structure 7
Figure 3: Two-Bay Control Structure Cross Section. 11
Figure 4: Single Bay Control Structure Cross Section. 11
Figure 5: Standard MNDOT Axle Weight Limit Sign 15

LIST OF TABLES

Table 1: Stoplogs Water Control Structures Location 2
Table 2: Structural Stability Criteria 9
Table 3: Concrete Strength Criteria 9
Table 4: Two-Bay Water Control Structure Stability 12
Table 5: Single Bay Water Control Structure Stability 13

1 Introduction

This appendix provides the structural engineering in support of the Recommended Plan for the feasibility study for the Minnesota River, Bass Ponds HREP, in Scott County, MN. The report was based on developing sufficient structural engineering and design to enable refinement of the project features, prepare the baseline cost estimate, develop a construction schedule, and allow detailed designed to begin immediately following receipt of Preconstruction Engineering and Design (PED) funds.

The Recommended Plan is BFR5-M2. The main features consists of the following: a double bay stoplog control structure at Blue Lake, a single bay stoplog control structure between Blue Lake and Fisher Lake, a single bay stoplog control structure at Fisher Lake outlet, a single bay stoplog control structure at Rice Lake outlet, a single bay stoplog control structure at outlet to the river and a single bay stoplog control structure at Continental Grain Marsh (Table 1). The structural components of the design and analysis consist of reinforced concrete U-frame control structure and retaining walls. Section 6 of the Main Report provides a detailed summary of the Recommended Plan and operation.

Table 1: Stoplogs Water Control Structures Location

Structure Location	From	To	Top Elevation	Bottom Elevation	Invert Elevation
Blue Lake	Blue Lake	Minnesota River	700.00	691.75	693.00
Interlake	Blue Lake	Fisher Lake	702.00	691.75	693.00
Fisher lake	Fisher lake	Channel	701.00	691.75	693.00
Rice Lake	Rice Lake	Channel	704.60	691.75	693.00
Secondary Outlet	Channel	Minnesota River	701.00	691.75	693.00
Con Grain Marsh	Con Grain Marsh	Minnesota River	701.50	691.75	693.00

2 Technical Guidelines and Reference Standards

2.1 General

1. 2012 International Building Code, International Code Council; June 2011.
2. ACI 318-11, Building Code Requirements for Structural Concrete, ACI Committee 318; 2011.
3. AISC 325-11, Steel Construction Manual, Fourteenth Edition, American Institute of Steel Construction; February 2013.
4. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers; 2013.
5. UFC 3-320-06A, 1 March 2005, Concrete Floor Slabs on Grade Subjected to Heavy Loads.
6. EM 385-1-1 Safety and Health Requirements, 2014.
7. Aluminum Design Manual, 2010 Edition.

2.2 Closure Structures and Retaining and Flood Walls

1. ECB 2017-2 Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502.
2. EM 1110-2-1612 Ice Engineering (October 2002)
3. EM 1110-2-2100, Stability Analysis of Concrete Structures, U.S. Army Corps of Engineers, Washington DC; 1 December 2005.
4. EM 1110-2-2102 Waterstops and Other Preformed Joint Materials for Civil Works Structures (September 1995)
5. EM 1110-2-2104, Strength Design for Reinforced-Concrete Hydraulic Structures, U.S. Army Corps of Engineers, Washington DC (November 2016).
6. EM 1110-2-2502, Retaining and Flood Walls, U.S. Army Corps of Engineers, Washington DC; 29 September 1989.
7. EM 1110-2-2504 Design of Sheet Pile Walls (March 1994)
8. ETL 1110-2-584, Design of Hydraulic Steel Structures, U.S. Army Corps of Engineers, Washington DC; 30 June 2014.

3 Design Criteria

3.1 Material

- Concrete: Compressive strength, fc' = 4000 psi at 28 days for structural concrete
- Minimum concrete cover:
  - Unformed concrete placed against earth: 4"
  - Surfaces to be in contact with earth or water less than or equal to 2 ft. thick : 3"
  - Surfaces to be in contact with earth or water greater than 2 ft. thick: 4"
  - All other places: 2"
- Reinforcing Steel ASTM A615 Grade 60, uncoated.
- Structural Steel
  - Wide-flange sections: ASTM A992 or A572 Grade 50
  - ASTM A992 – Wide Flange Shapes.
  - ASTM A500, Grade B – Hollow Structural Shapes.
  - ASTM A36 – Other Standard Shapes.
  - ASTM A36 – Plates, bars and sheets.
  - ASTM A325 – Structural Bolts
- Stainless Steel
  - Type 316/316L – Submerged or corrosive applications.
  - Type 304/304L – All other areas.

- Aluminum
  - 6061-T6 – All applications, except as noted.
  - 6063 – Railing.

- Soil

  The material properties of the soil and associated design recommendations are based on Long Meadow Lake, which is in the vicinity, soil parameters:
  - Lateral earth pressures (psf/ft) – Equivalent fluid pressure
    - Active 50
    - Active (Below groundwater) 89
    - At-Rest 72
    - At-Rest (Below groundwater) 101
    - Passive 360
    - Passive (Below groundwater) 254
    - Traffic surcharge 2-feet of soil
    - Foundation, drained, Ø=22° , C=0 psf
    - Embankment, drained Ø=28°, C=0 psf

- Net Allowable Bearing Pressure 2000 psf
- Soil density 120 pcf
- Frost depth 4'-0"
- Coefficient of friction – Concrete on soil 0.33

3.2 Material Dead Load Unit Weights

- Concrete : 150 pounds per cubic foot (pcf)
- Non-reinforced structural grout: 130 pounds per cubic foot (pcf)
- Steel : 490 pcf
- Water : 62.5 pcf
- Moist Soil: 112 pounds per cubic foot (pcf)
- Saturated Soil: 115 pounds per cubic foot (pcf)
- Buoyant Soil: 52.5 pounds per cubic foot (pcf)

4 Loads

Live Loads. Live loading for this project will be analyzed in accordance EM 1110-2-3104.

- Floors (Heavy Equipment rooms) – 300 psf uniform.
- Ladder and Rungs – one 300 pounds concentrated load plus additional 300 pound concentrated loads as determined from the anticipated usage.
- Traffic loads. Each control structure is primarily used for pedestrian traffic using the designated hiking trails within the refuge. It is also design for service and maintenance vehicles. Per AASHTO Pedestrian Bridge Manual a minimum maintenance traffic load for this bridge width (>10') is an H-10 truck load (10 ton). It also states impact factors are not required for these cases. The USFWS mentioned a dump truck of rock maybe required to cross the structures for future maintenance operations. Thus the truck load was increased to a loaded tandem loaded truck (55,000 lbs).

Dead Loads. Self-weight and dead loads include the total weight of the concrete structure and its appurtenant features (grating and railings etc).

Incidental Loads. Incidental loads from silt, debris pile up and atmospheric ice loading is consider minimal and was neglected.

Hydrostatic Loads. Hydrostatic loading is linear and increases with the fluid depth. Hydrostatic pressure is applied perpendicular to all surfaces regardless of orientation. For the structures in this system, hydrostatic pressures will occur laterally on vertical walls or vertically on base slabs. The design fluid depth is a function of the structure's location relative to the free water surfaces on each side of the line of protection and the load case considered. Hydrostatic loads will consist of hydrostatic water pressure causing a head differential across the structure. Hydrostatic lateral and vertical pressures will be applied to all structures based on the assumed water level for each load case at a magnitude of 62.5 psf per foot depth.

Construction/Maintenance Surcharge load. A surcharge load is applied to account for vehicle loading on the backfill behind abutments. The usual load case used 100 psf to account for service vehicles (pick-ups) and unusual load case used 250 psf to account for the H-20 truck loading.

Earth Loads. The assumed soil parameters used for stability and capacity can be found in section 3.2 above. The structures will be surrounded by soils exhibiting both cohesive and cohesionless properties. The soil acts more cohesively when undrained and less cohesively when drained. Both soil states were conservatively assessed, assuming θ equals 0 for the cohesive (undrained) condition and c equals 0 for the cohesionless (drained) condition.

Lateral and vertical soil loads will be computed and applied in accordance with EM 1110-2-2502 for shallow or pile founded concrete structures. Because minimal movement or rotation is anticipated, at-rest pressures will be applied to the structures per EM 1110-2-2100. In sliding analysis of the retaining wall footing, in accordance with EM 1110-2-2502 and further USACE guidance, resisting passive pressures can be ignored due to potential of scour. Compaction induced load will be applied in accordance with Appendix J of EM 1110-2-2502 which uses both active and passive pressures.

Wind Loads. Where applicable, wind loads are computed in accordance with ASCE 7-10.

- Velocity, v: 90 mph

- Importance factor, I: 1.0
- Exposure category: C

Snow Loads. Where applicable, snow loads are determined and distributed in accordance with ASCE 7-10. Snow loads are per square foot of horizontal projection.

- Ground snow load, pg:50 psf
- Importance factor, I: 1.2
- Snow exposure factor, Ce: 0.9

Earthquake Loads. Where applicable, seismic design will be in accordance with ASCE 7-10 and the design criteria provided in the geotechnical investigation. Building structures will comply with Chapter 12. Non-Structural components will comply with Chapter 13. Non-building structures will comply with Chapter 15.

1. Short period spectral response acceleration, Ss – 0.062g
2. 1-second period spectral response acceleration, S1 – 0.022g
3. Site Class – E
4. Seismic Importance Factor – 1.5 (Table 1.5-2 and 13.1.3, Risk Category IV)
5. Design Spectral Response Acceleration at Short Period (Sds) – 0.103
6. Design Spectral Response Acceleration at 1-second Period (Sd1) – 0.0513
7. Seismic Design Category - A

Ice, Debris, and Impact Loads. Impact loads include floating debris and ice. Given the size of this structure debris and ice will tend to bridge across approaches and these loads were neglected except for stoplog design. Any debris or ice loading into to retained fill of approach walls will not govern.

Uplift Pressure. Uplift. Uplift was determined using full head on upstream and downstream side of structure. It assumes no cut-off and a linear distribution from upstream head to downstream head.

Frost Protection. All foundations are placed a minimum depth of four feet below ground surface to avoid problems with frost.

Loading conditions and Assumptions.
All control structures are to manage various lake levels depending on time of year and inflow/out flow conditions. During high water events on the Minnesota River, some control structures regulate flows into the lake. During seasonal local run-off events some structure regulate the outflow to the Minnesota River. Given these possible flow conditions the structure can be loaded load in both directions. In coordination with Hydraulics, three general load cases were assumed and listed below:

1. Normal High River Stage with Low Lake Level (Flow into lake)
2. Normal High Lake with Low River Stage (Flow into river)
3. Construction/Maintenance Condition

5 Structural Design

The Recommended Plan would be designed, constructed, and operated in accordance with current USACE standards and in accordance with the methods and references cited in USACE engineering manuals, technical letters, regulations, and other documents.
The following documents major features associated with the RP:

- Double Bay stoplog water control structure (1 total)
- Single Bay stoplog water control structures (5 total)

5.1 Stoplog Water Control Structures

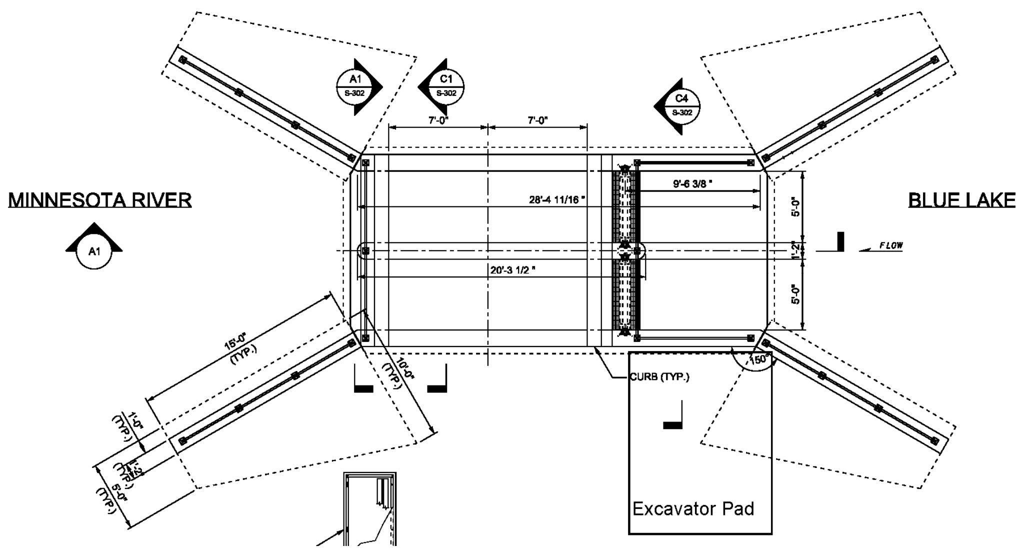


Figure 1: Plan view of a typical double bay water control structure

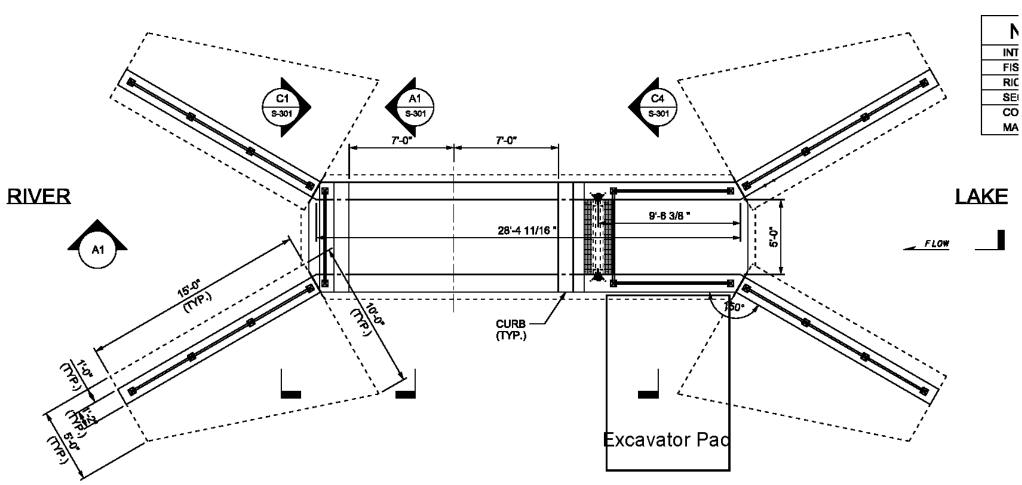


Figure 2: Plan view of a typical single bay water control structure

5.1.1 Structural Design Criteria

The control structure is designed in accordance with USACE guidance for design of hydraulic structures. Structural stability of the Control Structure is in accordance with EM 1110-2-2100, STABILITY ANALYSIS OF CONCRETE STRUCTURES, 2005. Structural stability of the Approach Walls are in accordance with EM 1110-2-2502, RETAINING AND FLOOD WALLS 1989. The bridge slab and associated bearing are design accordance with ASSHTO Bridge Design. Strength design of concrete U-structure and approach walls is in accordance with EM 1110-2-2104, STRENGTH DESIGN FOR REINFORCED CONCRETE HYDRAULIC STRUCTURES, 1992. Vehicle Guard Rail is accordance with MNDOT standard requirements. The excavator pad is designed in accordance with UFC 3-320-06A, EM 1110-2-2104 and ACI-318-11 requirements.

In accordance with EM 2100, structures are to be designated as Critical or Normal. Given that the Bass Ponds HREP is not a high hazard project whose failure would result in loss of life, it is designated as Normal. The required structural stability design criteria for Normal structures is listed below.

Table 2: Structural Stability Criteria

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria
					EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	1.3
	Normal High Lake	Usual	691.26	696.5	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	1.3
	Construction, Truck	Unusual	690.26	690.26	1.3
					Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	75
	Normal High Lake	Usual	691.26	696.5	100
	Normal High Lake, Truck	Unusual	691.26	696.5	75
	Construction, Truck	Unusual	690.26	690.26	100
					Assumed allowable Bearing Pressure, psf
Bearing	High River Stage	Unusual	698.26	694.3	2000
	Normal High Lake	Usual	691.26	696.5	
	Normal High Lake, Truck	Unusual	691.26	696.5	
	Construction, Truck	Unusual	690.26	690.26	
					EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	1.2
	Normal High Lake	Usual	691.26	696.5	1.3

Table 3: Concrete Strength Criteria

Load Case	**River Stage EL,ft**	**Lake Pool EL,ft**	**Load Condition Category**	**Load Factor**	**Hydraulic Factor**	**Load Condition Factor**	**Design Load Factor**
Normal High River	698.26	694.3	Usual	1.7	1.3	1	2.21
Normal High River, Truck	698.26	694.3	Unusual	1.7	1.3	0.75	1.66
Normal High Lake	691.26	696.5	Usual	1.7	1.3	1	2.21
Normal High Lake, Truck	691.26	696.5	Unusual	1.7	1.3	0.75	1.66
Construction, Truck	690.26	690.26	Unusual	1.7	1.3	0.75	1.66

5.1.2 Design and Analysis

This section outlines the design procedure and assumptions used to design the various features of the control structure. Procedures and assumptions follow applicable USACE guidelines and industry standards.

5.1.2.1 Bridge Slab and/or Grating

Concrete bridge slab is used on top of the control structure to allow pedestrian and maintenance traffic. It is designed for H-20 loading. An axle rating is used as the slab span of 72 inches only allows loading from a single axle. After discussion with USFWS on 12/19/18, bridge grating will be used instead of concrete slab to facilitate debris removal inside the structures.

5.1.2.2 Control Structure

The three load cases were used to analyze the structural stability of the control structure. Limit states that were evaluated included sliding, overturning, bearing and floatation. All applicable loads were input into an Excel spreadsheet, and vertical and horizontal resultants were determined. For overturning, moments were taken about the lake side base of footing. Location of resultants were determined and bearing pressures were calculated. The allowable bearing pressure is assumed of 2000 psf based on soil parameters from Long Meadow Lake which is in the vicinity. For all load cases the base is in 100% compression. Sliding resistance was calculated using foundation soil strengths. Any sliding resistance along the wall/embankment interface was ignored. Floatation factors of safety were also calculated. A summary of structural stability results is given in Tables 4 and 5 below.

Reinforced concrete strength design is based on determining the maximum shear and moment in the individual members. Members include the abutments, top slab and base slab. The members are part of a U-frame structure shown in Figures 3 and 4 below.

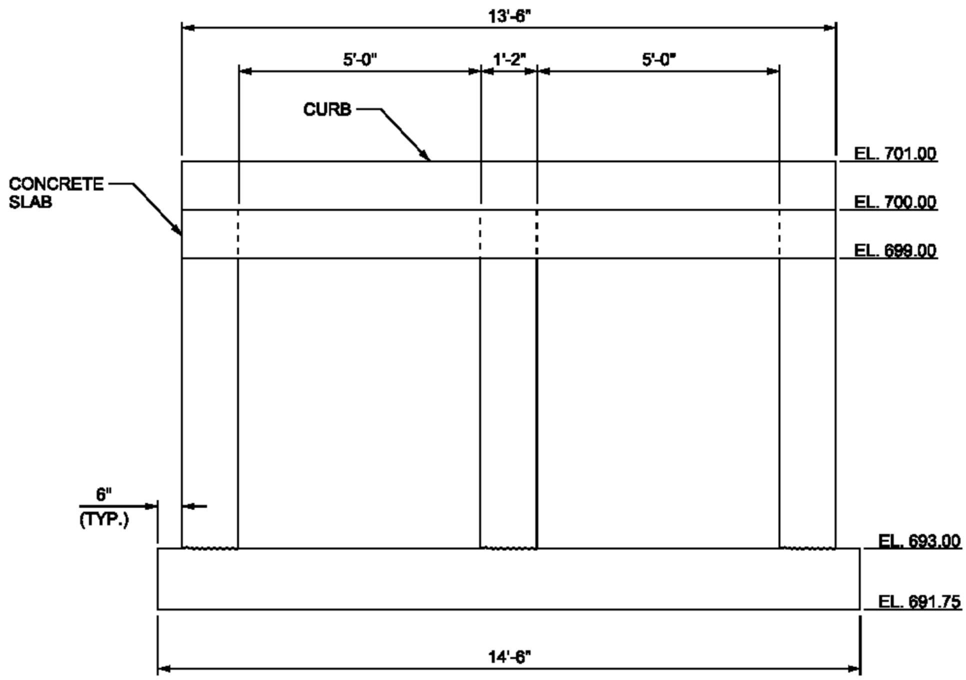


Figure 3: Two-Bay Control Structure Cross Section.

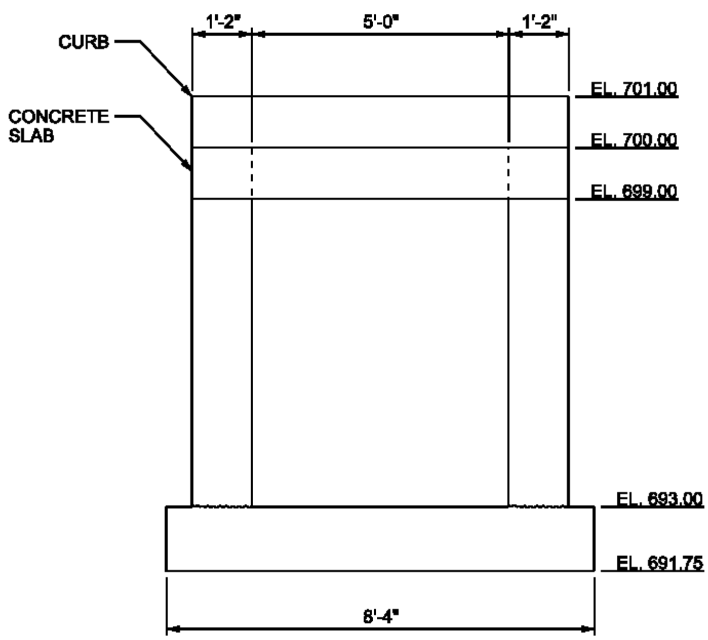


Figure 4: Single Bay Control Structure Cross Section.

Table 4: Two-Bay Water Control Structure Stability

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.05	1.3
	Normal High Lake	Usual	691.26	696.5	8.10	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	9.52	1.3
	Construction, Truck	Unusual	690.26	690.26	61.77	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	487.61	2000
	Normal High Lake	Usual	691.26	696.5	461.42	
	Normal High Lake, Truck	Unusual	691.26	696.5	548.62	
	Construction, Truck	Unusual	690.26	690.26	534.01	
					Calculated FOS	EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	2.80	1.2
	Normal High Lake	Usual	691.26	696.5	3.52	1.3

Table 5: Single Bay Water Control Structure Stability

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.72	1.3
	Normal High Lake	Usual	691.26	696.5	9.43	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	11.94	1.3
	Construction, Truck	Unusual	690.26	690.26	93.43	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	552.85	
	Normal High Lake	Usual	691.26	696.5	542.46	
	Normal High Lake, Truck	Unusual	691.26	696.5	702.43	2000
	Construction, Truck	Unusual	690.26	690.26	827.73	
					Calculated FOS	EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	3.12	1.2
	Normal High Lake	Usual	691.26	696.5	4.03	1.3

5.1.2.3 Concrete Abutment Walls

Abutment walls were designed as free cantilevers or simply supported on top. Analysis was performed using the Corps program CFRAME software. See calculations in Attachment 1.

5.1.2.4 Base Slab

The base slab was designed as a part of U-frame structure. It is using the Corps program CFRAME. The analysis calculated maximum moment and shear within the base slab. The summary of results for the frame analysis are shown in the attached calculation. The governing load cases for shear and moment are highlighted.

5.1.2.5 Top Slab

Concrete bridge slab is used on top of the control structure to allow pedestrian and maintenance traffic. It is designed for H-20 loading. An axle rating is used as the slab span of 72 inches only allows loading from a single axle. The slab was designed as simply supported structure. The Box-frame structure is analyzed using the Corps program CFRAME. The analysis calculated maximum moment and shear within the slab. The summary of results for the frame analysis are shown in the attached calculations. The governing load cases for shear and moment are highlighted.

5.1.2.6 Excavator Pad

After discussion with USFWS on 5/3/19, an excavator pad is added to each structure and to be placed on the side of the access road on U/S side of the stoplogs. The pad will facilitate the parking of the excavation and trash removal vehicles on concrete surfaces. The pad is about 12 feet wide and 25 feet long and 8” thick and placed on compacted gravel. The slab is designed in accordance to UFC 3-320-06A, EM 1110-2-2104 and ACI-318-11 requirements.

5.1.3 Stoplogs

Stoplogs are designed as aluminum HSS members for the full head loading of about 8.00 ft. Each stoplog is 5.5 feet lond, 4-inch by 6-inch rectangular tube with 1/4-inch thick walls are assumed for the closures. Stoplogs are supported at the ends by grooves formed by steel embedment anchored to the concrete walls. Allowable stresses are in conformance with EM 1110-1-2101 and the Aluminum Design Manual.

5.1.4 Miscellaneous Metals (grating, guard rail and handrail

Designs for guard rail and handrail were based on standardize MNDOT designs.

5.1.5 Bridge Load Rating

The structures are designed for H-20 truck. To load rate the bridge, the maximum legal axle load under Minnesota State law (20,000 lbs single axle or 34,000 lbs tandem axle) was checked.

Based on discussions with USFWS, fully loaded dumps (55,000 lbs) were using the long meadow lake structure in the same vicinity. Several loads of gravel were brought across bridge to repair the road. Other utility trucks (Xcel Energy) have also used the bridge. Given this heavy use, the control structure is designed to accommodate such loading.

5.1.6 Approach Retaining Walls

There are 4 similar retaining wingwalls, one at each corner of the control structure. The walls are 15 lineal feet long and have varied height. No concrete keys were utilized to aid in sliding resistance for the T-wall. Design procedure for the T-wall is according to EM1110-2-2502 for load and load combination determinations and stability analyses, and EM 1110-2-2104 for reinforced concrete design. See drawings for plan sections and details.

For T-wall load Cases R1 and R2 were the only load cases investigated and only long-term soil conditions (drained condition) were analyzed. Water elevations in the soil behind the wall were taken 2 feet below top of the wall for Load Case R1 and R2. The Water elevations in the channel were taken 5 feet below top of the wall for Load Case R1 and dry channel elevation is used for Load Case R2. The bottom of the base slab is embedded 4 feet below the ground surface for frost protection. Vertical loads consist of concrete weight, water, buoyant soil, and uplift pressures along the base. Driving loads consisted of water and soil loads. Uplift pressures were obtained by the Line-of-Creep method using a seepage path from the base of the slab on the driving side to the top of soil on the resisting side. Surcharge load of 250 psf were used where heavy vehicle will be used to clean up the channel.

T-Wall was analyzed for rotational, bearing, and sliding stability. Sliding stability was evaluated for the inclined and block wedge conditions. Sliding stability under the block wedge condition was the primary controlling factor in stability analyses. Partial passive soil pressures were used in the sliding stability analysis when active soil pressures were inadequate in satisfying sliding stability criteria. Wall thicknesses were obtained from factored water pressures from the top of the wall with no resisting loads. Slab thicknesses were obtained from factored bearing pressures.

5.2 Miscellaneous Drainage Features

RCP Pipes are designed according to EM 1110 2 2902 and ACPA Concrete Pipe Handbook guidelines.

5.3 Corrosion Control

To help resist corrosion, the metals will be hot dip galvanized after fabrication.

6 Operations and Maintenance Considerations

The Operations and Maintenance (O&M) Manual should contain the following information:

- Structure and Bridge should be inspected periodically and prior to any heavy truck loads
- Any vehicles crossing the structure should reduce speed to below 5mph
- Axle limit is 10 tons and should be signed accordingly. Below is standard MNDOT Axle Weight Limit sign.

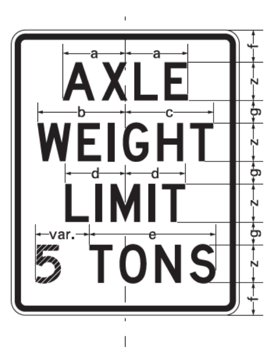


Figure 5: Standard MNDOT Axle Weight Limit Sign

Structural Calculations
The following information is included in Attachment 1 to this appendix:

- Double Bay Control Structure Stability and Design
- Single Bay Control Structure Stability and Design
- Approach Retaining Wall Design
- Stoplog Design
- Drawings

US Army Corps of Engineers®
St. Paul District

Appendix J: Structural Engineering

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

Attachment 1

April, 2019

Structural Calculations:

- Double Bay Control Structure Stability and Design
- Single Bay Control Structure Stability and Design
- Approach Retaining Wall Design
- Stoplog Design
- Drawings

Two-Bay Control Structure Stability

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Structural Stability	Chkd: By	Date:	PC File: Calc_Sht .xls

Structural Stability: Summarry of Results

EM 2100, Structure Designation.

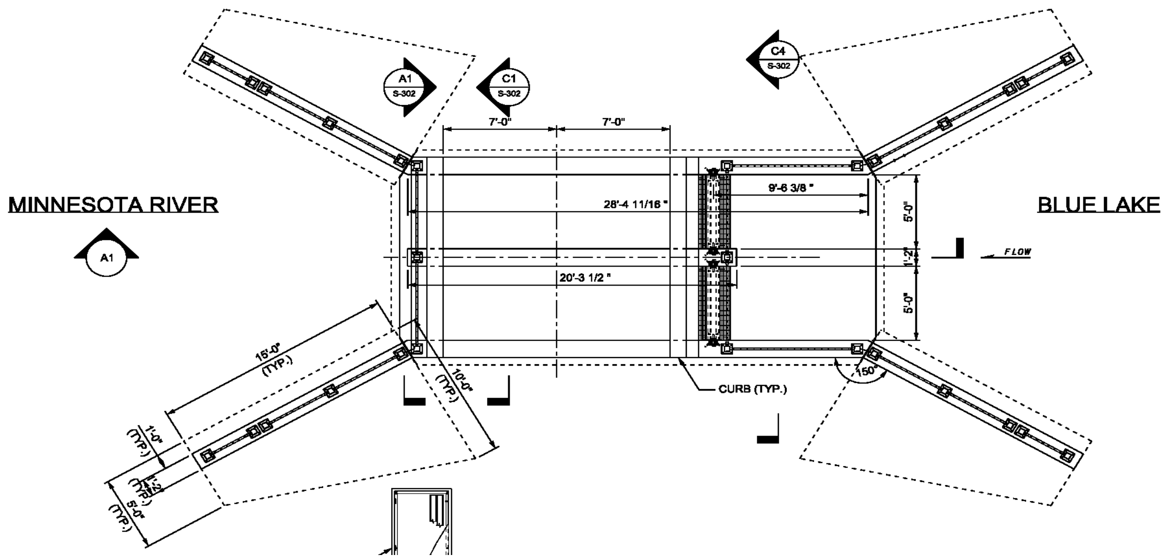
Structures are to be designated as Critical or Normal. Given Bass Pond Lakes are not a high hazard project whose failure would result in loss of life, it is desinated as:

Structure Designation: **Normal**

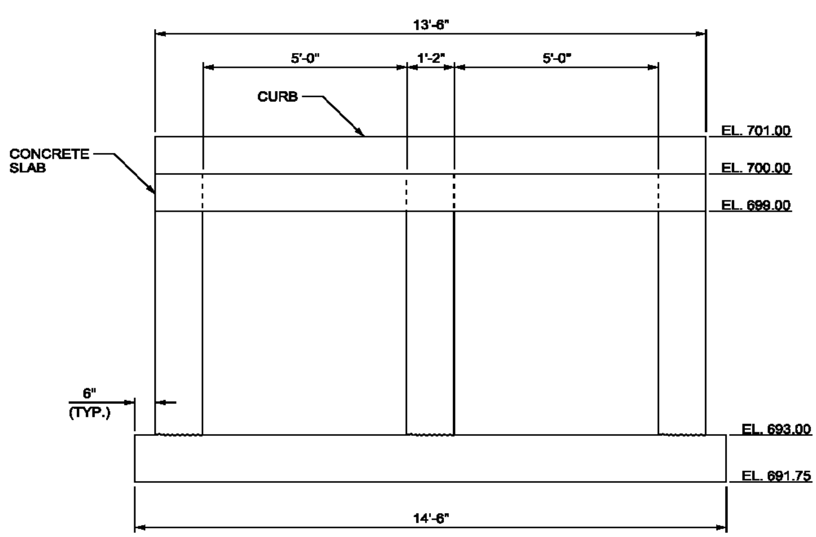
Limit State	Load Case	Load Condition Category	River Stage EL,ft	Lake Pool EL,ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.05	1.3
	Normal High Lake	Usual	691.26	696.5	8.10	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	9.54	1.3
	Construction, Truck	Unusual	690.26	690.26	61.77	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	487.61	698.25
	Normal High Lake	Usual	691.26	696.5	461.42	525
	Normal High Lake, Truck	Unusual	691.26	696.5	548.62	698.25
	Construction, Truck	Unusual	690.26	690.26	534.01	698.25
					Calculated FOS	EM2100 Required FOS
Floation	High River Stage	Unusual	698.26	694.3	2.80	1.2
	Normal High Lake	Usual	691.26	696.5	3.52	1.3

See Geotech Appendix for allowbale bearing pressure, 525 psf

Design sketches



2 Bays WCS Plan



2 Bays WCS Section

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Water to Top of Structure with Normal Lake Level	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Water to Top of Structure with Normal Lake Level

Prevent MN river water from backing into Lake.

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall and pier	699.00	ft	Wall and pier length	29.00	ft
Base slab thick	1.25	ft	Base width	14.50	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall and pier thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	13.50	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	698.26	ft	Heel width	0.50	
LAKE POOL ELEV	694.30	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	6.51	ft
Pressure Head at C (D/S Edge)	2.55	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	6.51	

Forces: Horizontal, Vertical and Moment about Downstream Edge **NOTE Driving Direction is toward lake**

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Right Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Pier	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Base slab	1.25	29.00	14.50	0.15	78.84		14.50	1143.23
Bridge slab	1.00	18.00	13.50	0.15	36.45		9.00	328.05
U/S Grating	1.00	2.00	10.00	0.01	0.28		19.25	5.39
	2.60	11.00		5.59	0.16		19.25	3.08
	1.30	9.75	5.00	0.06	7.92		24.13	191.12
		19.25	5.00	0.06	63.28		9.63	609.11
		29.00	1.00	0.06	5.94		14.50	86.20
		28.48	1.00	0.11	11.87		14.50	172.06
Avg SatSoilHeel(both)	3.28	28.48	1.00	0.12	10.74		14.50	155.77
Truck					0.00		9.00	0.00
Driving Water	6.51		14.50	0.06		19.20	2.17	41.67
Resiting Water	2.55		14.50	0.06		-2.95	0.85	-2.50
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	2.55	29.00	14.50	0.06	-67.02		14.50	-971.75
Uplift D/S Tri	3.96	29.00	14.50	0.06	-52.04		9.67	-503.02
Resultant loads					203.04	16.26		2804.18

Floatation ANALYSIS

Ws =	316.15	SFf = Ws+Wc+S/U-Wg	2.80
Wc =	0		
S =	0		
U =	119.05		
Wg	5.94		

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith	Chkd: By	Date:	PC File: Calc_Sht .xls

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical =	13.81 FT	
e, eccentricity = B/2 - Xbar =	0.69 FT	
Kern, Base Length/6 =	4.83 FT	OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake side) (PSF)
482.86	4.75	-4.75	478.12	487.61

Percent Base in Compression 100 percent

SLIDING ANALYSIS

Neglect side friction along abutments

c, cohesion	0	
ø, foundation =	22	degrees
N' = NET VERTICAL LOAD	14.00	kips/foot of width
Lslide = EFFECTIVE BASE WIDTH =	29	FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase = 5.66 kips
NET HORIZONTAL LOAD = 1.12 kips

FS AGAINST SLIDING = 5.05

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Normal Lake Level no water in Channel	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Normal Lake Level no water in Channel

Normal high pool with no water MN river water from backing into channel

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall and pier	699.00	ft	Wall and pier length	29.00	ft
Base slab thick	1.25	ft	Base width	14.50	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall and pier thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	13.50	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	693.00	ft	Heel width	0.50	
LAKE POOL ELEV	696.50	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	1.25	ft
Pressure Head at C (D/S Edge)	4.75	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	4.75	

Forces: Horizontal, Vertical and Moment about Downstream Edge

NOTE Driving Direction is toward lake

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Right Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Pier	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Base slab	1.25	29.00	14.50	0.15	78.84		14.50	1143.23
Bridge slab	1.00	18.00	13.50	0.15	36.45		9.00	328.05
U/S Grating	1.00			0.01	0.28		19.25	5.39
				5.59	0.43		19.25	8.28
		19.25						
		29.00						
		28.48						
Avg SatSoilHeel(both)	1.75	28.48	1.00	0.12	5.73		14.50	83.11
Truck					0.00		9.00	0.00
Resisting Water	1.25		14.5	0.063		0.71	0.42	0.30
Driving Water	4.75		14.5	0.063		-10.22	1.58	-16.19
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	1.25	29.00	14.5	0.063	-32.85		14.50	-476.35
Uplift D/S Tri	3.50	29.00	14.5	0.063	-45.99		19.33	-889.18
Resultant loads					190.74	-9.52		2535.77

Floatation ANALYSIS

Ws =	266.42	SFf = Ws+Wc+S/U-Wg	3.52
Wc =	0		
S =	0		
U =	78.84		
Wg	3.17		

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical =	13.29	FT	
e, eccentricity = B/2 - Xbar =	1.21	FT	
Kern, Base Length/6 =	4.83	FT	OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake Side) (PSF)
453.61	7.80	-7.80	461.42	445.81

Percent Base in Compression 100 percent

SLIDING ANALYSIS

Neglect side friction along abutments

c, cohesion	0	
ø, foundation =	22	degrees
N' = NET VERTICAL LOAD	13.15	kips/foot of width
Lslide = EFFECTIVE BASE WIDTH :	29	FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase =	5.31	kips
NET HORIZONTAL LOAD =	0.66	kips

FS AGAINST SLIDING = 8.10

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Construction	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Construction/Maintenance

Prevent MN river water from backing into Long Meadow Lake.

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall and pier	699.00	ft	Wall and pier length	29.00	ft
Base slab thick	1.25	ft	Base width	14.50	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall and pier thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	13.50	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	691.75	ft	Heel width	0.50	
LAKE POOL ELEV	691.75	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	0.00	ft
Pressure Head at C (D/S Edge)	0.00	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	0.00	

Forces: Horizontal, Vertical and Moment about Downstream Edge **NOTE Driving Direction is toward lake**

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Right Abut	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Pier	7.00	29.00	1.17	0.15	35.54		14.50	515.26
Base slab	1.25	29.00	14.50	0.15	78.84		14.50	1143.23
Bridge slab	1.00	18.00	13.50	0.15	36.45		9.00	328.05
U/S Grating	1.00	2.00	10.00	0.01	0.28		19.25	5.39
Stoplogs	-2.50	11.00		5.59	-0.15		19.25	-2.96
Bay Water U/S stoplog	-1.25	9.75	5.00	0.06	-7.62		24.13	-183.76
Bay Water D/S	-1.25	19.25	5.00	0.06	-15.04		9.63	-144.75
Weight of water on Heel	0.00	29.00	1.00	0.06	0.00		14.50	0.00
Avg MoistSoil Heel (both)	7.00	28.48	1.00	0.11	22.33		14.50	323.76
Avg SatSoilHeel(both)	0.00	28.48	1.00	0.12	0.00		14.50	0.00
Truck					0.00		9.00	0.00
Resisting Water	0.00		14.5	0.063		0.00	0.00	0.00
Driving Water	0.00		14.5	0.063		0.00	0.00	0.00
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	0.00	29.00	14.5	0.063	0.00		14.50	0.00
Uplift D/S Tri	0.00	29.00	14.5	0.063	0.00		19.33	0.00
Resultant loads					221.70	0.00		3014.74

Floatation ANALYSIS

Ws =	221.70	SFf = Ws+Wc+S/U-Wg	2216.98
Wc =	0		
S =	0		
U =	0.10		
Wg	0.00		

US Army Corps of Engineers St. Paul District	Project: Bass Ponds Blue Lake WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Normal Lake Level no water in Channel	Chkd: By	Date:	PC File: Calc_Sht .xls

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical =	13.60	FT	
e, eccentricity = B/2 - Xbar =	0.90	FT	
Kern, Base Length/6 =	4.83	FT	OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake Side) (PSF)
527.22	6.78	-6.78	534.01	520.44

Percent Base in Compression 100 percent

SLIDING ANALYSIS

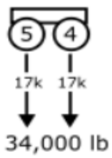
Neglect side friction along abutments

c, cohesion	0	
ø, foundation =	22	degrees
N' = NET VERTICAL LOAD	15.29	kips/foot of width
Lslide = EFFECTIVE BASE WIDTH =	29	FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase =	6.18	kips
NET HORIZONTAL LOAD =	0.10	kips
FS AGAINST SLIDING =	61.77	

US Army Corps of Engineers St. Paul District	Project: Bass Ponds WCS	Comp. By TSF	Date: 10/12/2018	Sheet:	
	Subject: Bridge Grating	Chkd: By	Date:	PC File: Calc_Sht .xls	

Bridge Grating



The contructure bridge is being designed to allow for maintenance type vehicles. This would include a tandem dump truck (3 axle,GVW~40,000lbs). Minnesota follows the Federal Bridge Formula which has Vehicle Weight Limits. The maximum weight allowed on a single axle is 20,000 lbs. The maximum total weight allowed on any two consecutive axles spaced eight or fewer feet apart (like dump tandem axles) is 34,000 lbs. The maximum Gross Vehicle Weight (GVW) on Interstate highways is 80,000 lbs, even if formula results in a higher value.
Because of the control structures has short spans(60 inches) a typical AASHTO design truck would only be have one axle on the bridge at any time. For example a typical tandem-axle set-up are only spaced 55" apart and would have a max combined axle load of 34,000 lbs. Therefore the single axle, 20,000 lbs maximum will govern.
Minnesota Vehicle Size Limits
Width: The maximum width of a vehicle is 102 inches. Length: The maximum length of a straight truck is 45 feet (ie dump truck, semis can be longer). Height: The maximum height of a vehicle is 13 feet 6 inches

Loading

Per AASHTO Pedestrian Bridge Manual, Minimum maintenance vehicle is an H-10, given

Table 3.2-1—Design Vehicle

Clear Deck Width	Design Vehicle
7 to 10 ft	H5
Over 10 ft	H10

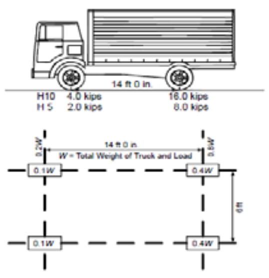
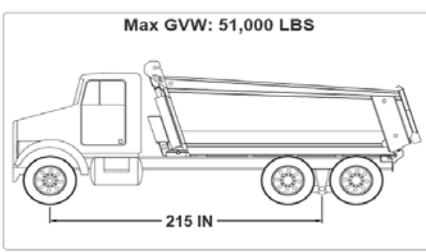


Figure 3.2-1—Maintenance Vehicle Configurations

During design is was discussed a load of rock may be required to cross the bridge, so a H-20 truck is considered.

	GVW Ton	Front Axle	Rear Axle
H-5	5	2000	8000
H-10	10	4000	16000
H-15	15	6000	24000
H-20	20	8000	32000

As stated above top concrete slab will be checked for the MN max axle load of 20,000 lbs. The 20,000 lbs single axle load would represent the front axle of an off-road tandem dump truck. An over the road tandem dump truck would have a front axle(single tire) load of about 17,000 lbs



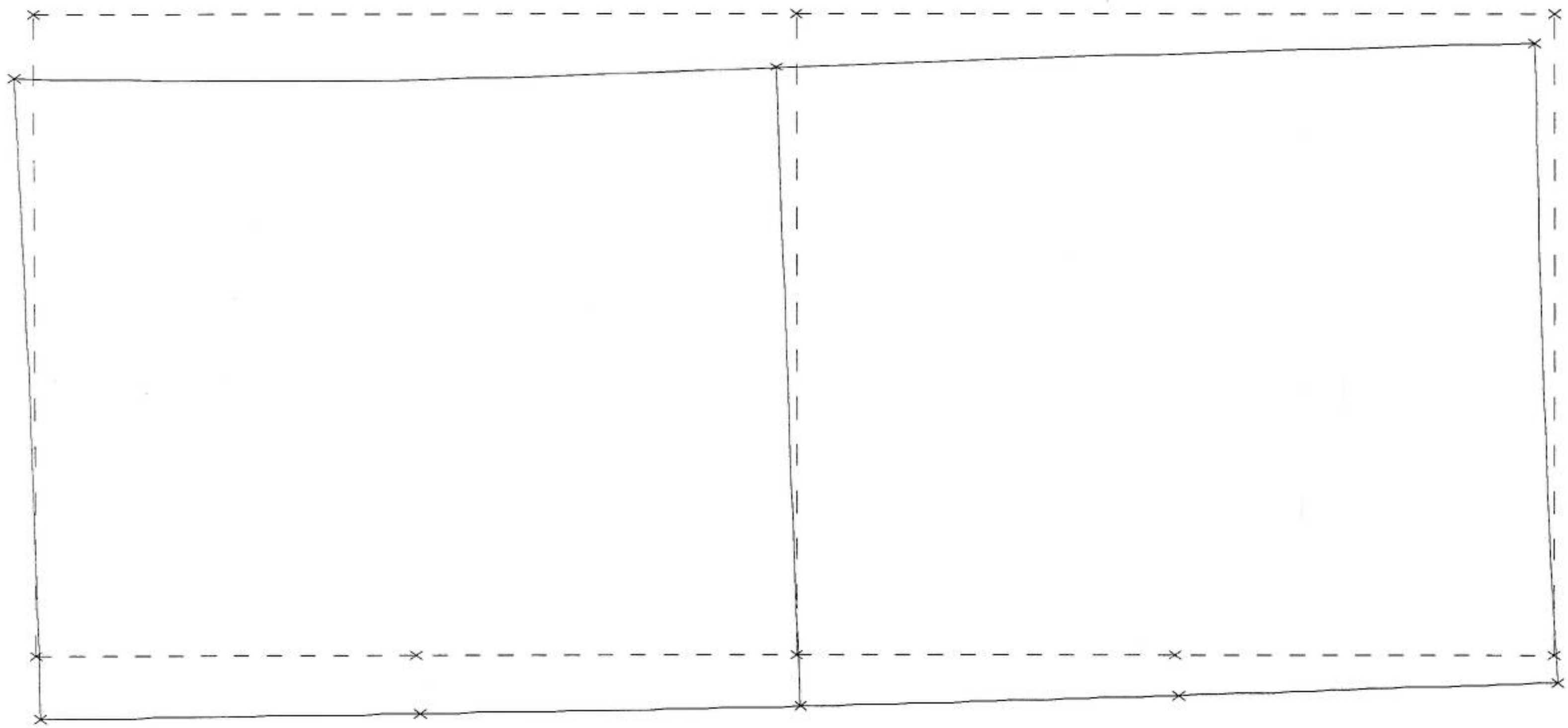
Front ≈0.33 W

Rear ≈0.67 W

https://www.superdumps.com/bridge_laws/

Load will be used in CFRAME analysis

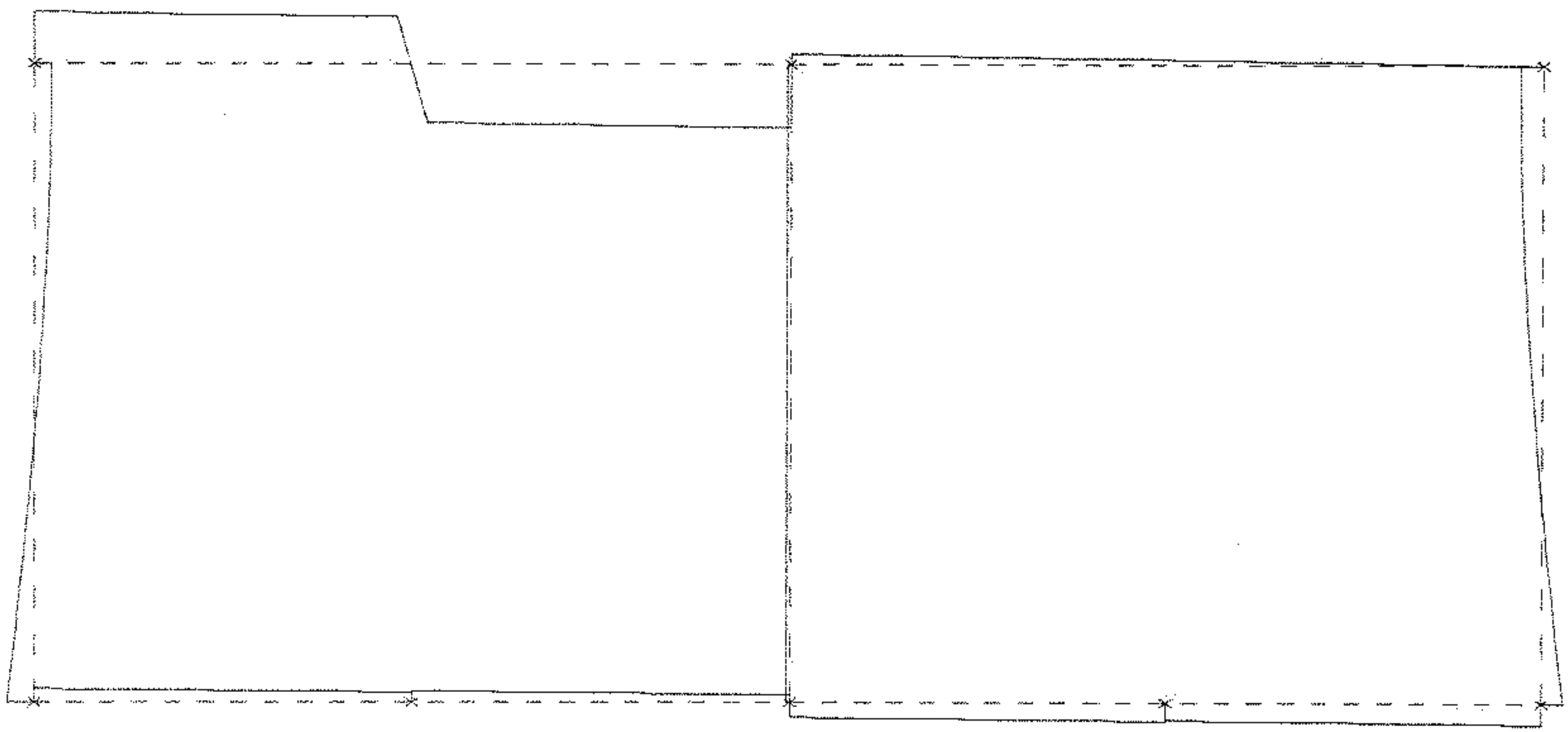
CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE , 2-Bays, slab on Top



= 0.15 IN DEFLECTION 10/12/2018 10:41:18

LOAD CASE 2 NORMAL WATER PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE



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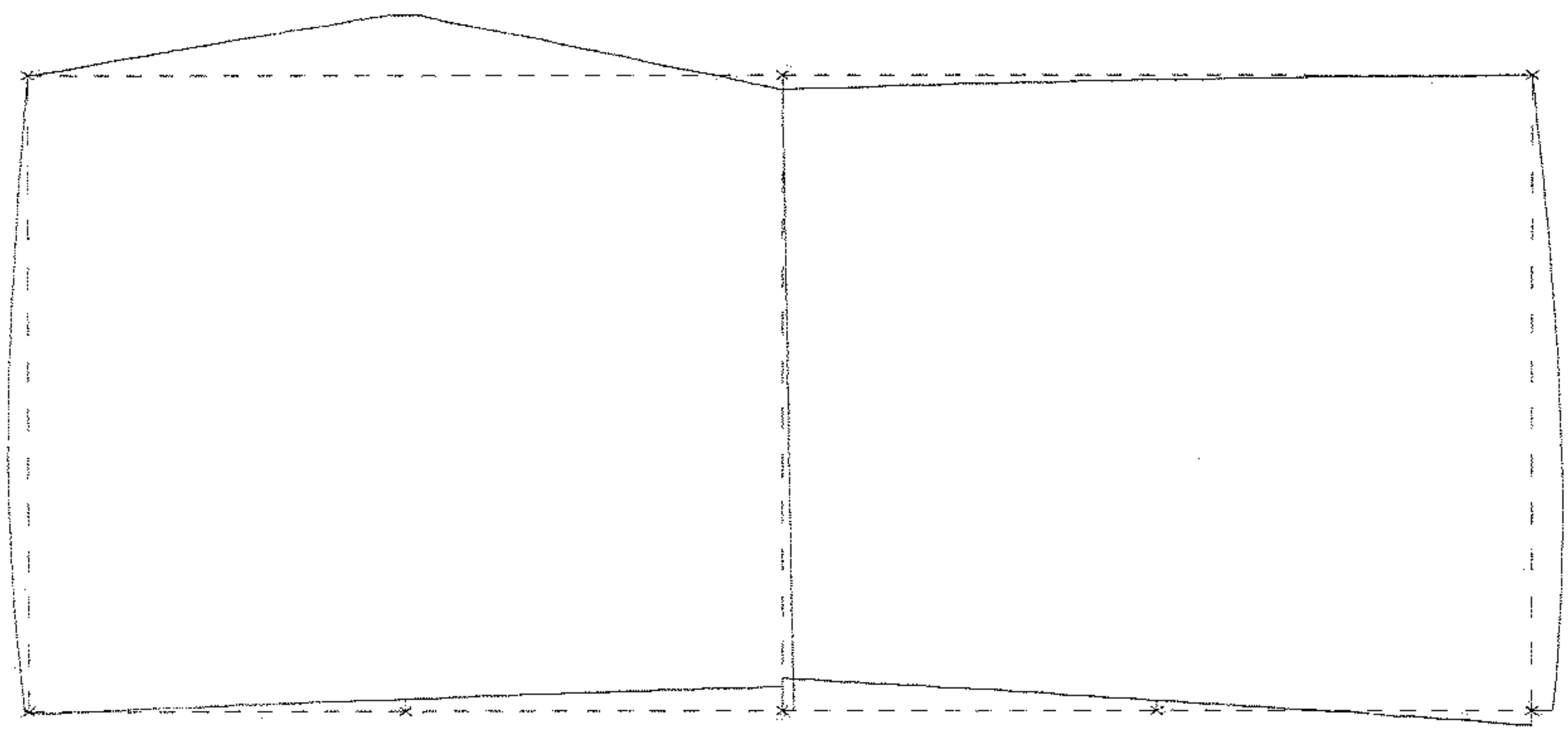
LOAD CASE 2 NORMAL WATER PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE



[scale bar] =	181.02	IN-KIP	MOMENT	10/12/2018	10:41:18
LOAD CASE		2	NORMAL WATER PLUS TRUCK		

PROGRAM CFRAME V02.05 24JUL84
--*-*-*-*-*-*-*-*-*-*-*-*-*-*

RUN DATE = 10/10/2018
RUN TIME = 11:58:41

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE

*** JOINT DATA ***

			------------------FIXITY-------------------					
JOINT	X	Y	X	Y	R	KX	KY	KR
	---FT	---				---KIP /IN	---	IN -KIP/RAD
1	0.00	0.00				0.500E+02	0.500E+02	
2	3.20	0.00					0.100E+01	
3	6.40	0.00					0.500E+02	
4	9.60	0.00					0.100E+01	
5	12.80	0.00				0.500E+02	0.500E+02	
6	0.00	7.50				0.100E+02		
7	6.40	7.50						
8	12.80	7.50				0.100E+02		

*** MEMBER DATA ***

MEMBER	END A	END B	LENGTH	I	A	AS	E	G
			FT	IN **4	IN **2	IN **2	KSI	KSI
1	1	2	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
2	2	3	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
3	3	4	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
4	4	5	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
5	6	7	6.40	0.1728E+04	0.1440E+03	0.1440E+03	0.3000E+04	0.1250E+04
6	7	8	6.40	0.1728E+04	0.1440E+03	0.1440E+03	0.3000E+04	0.1250E+04
7	1	-6	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04
8	3	-7	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04
9	5	-8	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04

*** LOAD CASE 1 NORMAL WATER

MEMBER	LA	PA	LB	PB	ANGLE
	FT	KIP /FT	FT	KIP /FT	DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.2200E+00	3.20	0.2200E+00	0.00

4	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.2200E+00	3.20	0.2200E+00	0.00
5	0.00	0.1500E+00	6.40	0.1500E+00	0.00
6	0.00	0.1500E+00	6.40	0.1500E+00	0.00
7	0.00	0.9000E+00	7.50	0.0000E+00	0.00
7	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
9	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
9	0.00	0.2200E+00	3.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00
5	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 2 NORMAL WATER PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.2200E+00	3.20	0.2200E+00	0.00
4	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.2200E+00	3.20	0.2200E+00	0.00
5	0.00	0.1500E+00	6.40	0.1500E+00	0.00
6	0.00	0.1500E+00	6.40	0.1500E+00	0.00
7	0.00	0.9000E+00	7.50	0.0000E+00	0.00
7	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
9	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
9	0.00	0.2200E+00	3.50	0.0000E+00	0.00

MEMBER	L FT	P KIP	ANGLE DEG
5	3.20	0.1000E+02	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00
5	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
5	0.00	0.1500E+00	6.40	0.1500E+00	0.00
6	0.00	0.1500E+00	6.40	0.1500E+00	0.00
7	0.00	0.9000E+00	7.50	0.0000E+00	0.00
9	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

MEMBER	L FT	P KIP	ANGLE DEG
5	3.20	0.1000E+02	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00
5	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 4 CONSTRUCTION PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
5	0.00	0.1500E+00	6.40	0.1500E+00	0.00
6	0.00	0.1500E+00	6.40	0.1500E+00	0.00
7	0.00	0.9000E+00	7.50	0.0000E+00	0.00
9	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

MEMBER	L FT	P KIP	ANGLE DEG
5	3.20	0.1000E+02	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

5 0.0000E+00 -0.1310E+01 0.0000E+00

1 LOAD CASE 1 NORMAL WATER

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.2806E-03	-0.4609E-01	-0.1129E-03
2	0.1403E-03	-0.4972E-01	-0.6650E-04
3	0.0000E+00	-0.5099E-01	0.0000E+00
4	-0.1403E-03	-0.4972E-01	0.6650E-04
5	-0.2806E-03	-0.4609E-01	0.1129E-03
6	0.1781E-03	-0.4619E-01	-0.1191E-03
7	0.0000E+00	-0.5114E-01	0.0000E+00
8	-0.1781E-03	-0.4619E-01	0.1191E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.1973E+01	0.4651E+00	0.5558E+01	0.1666E+02	38.40
	2	-0.1973E+01	-0.1131E+00	0.1666E+02	0.5558E+01	0.00
2	2	-0.1973E+01	0.1628E+00	0.1666E+02	0.1811E+02	17.66
	3	-0.1973E+01	0.1892E+00	0.1616E+02	0.1616E+02	38.40
3	3	-0.1973E+01	0.1892E+00	0.1616E+02	0.1811E+02	20.74
	4	-0.1973E+01	0.1628E+00	0.1666E+02	0.1616E+02	0.00
4	4	-0.1973E+01	-0.1131E+00	0.1666E+02	0.1666E+02	0.00
	5	-0.1973E+01	0.4651E+00	0.5558E+01	0.5558E+01	38.40
5	6	-0.1002E+01	0.5294E+00	0.0000E+00	0.1121E+02	43.01
	7	-0.1002E+01	0.4306E+00	0.3797E+01	0.0000E+00	0.00
6	7	-0.1002E+01	0.4306E+00	0.3797E+01	0.1121E+02	33.79
	8	-0.1002E+01	0.5294E+00	0.0000E+00	0.0000E+00	76.80
7	1	-0.5294E+00	0.1987E+01	-0.5558E+01	0.3282E+02	41.40
	6	-0.5294E+00	0.1003E+01	0.0000E+00	-0.5558E+01	0.00
8	3	-0.8611E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00
	7	-0.8611E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00
9	5	-0.5294E+00	-0.1987E+01	0.5558E+01	0.5558E+01	0.00
	8	-0.5294E+00	-0.1003E+01	0.0000E+00	-0.3282E+02	41.40

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1403E-01	0.2305E+01	0.0000E+00
2	0.0000E+00	0.4972E-01	0.0000E+00
3	0.0000E+00	0.2549E+01	0.0000E+00
4	0.0000E+00	0.4972E-01	0.0000E+00
5	0.1403E-01	0.2305E+01	0.0000E+00
6	-0.1781E-02	0.0000E+00	0.0000E+00
8	0.1781E-02	0.0000E+00	0.0000E+00

TOTAL 0.0000E+00 0.7258E+01

1 LOAD CASE 2 NORMAL WATER PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.6936E-02	-0.1506E+00	0.2839E-03
2	0.6830E-02	-0.1393E+00	0.3384E-03
3	0.6724E-02	-0.1231E+00	0.5361E-03
4	0.6599E-02	-0.9700E-01	0.7691E-03
5	0.6473E-02	-0.6673E-01	0.7445E-03
6	-0.3328E-01	-0.1515E+00	-0.3067E-03
7	-0.3355E-01	-0.1244E+00	0.9073E-03
8	-0.3376E-01	-0.6672E-01	0.6992E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.1493E+01	0.1266E+01	-0.7677E+01	0.3417E+02	38.40
	2	-0.1493E+01	-0.9137E+00	0.3417E+02	-0.7677E+01	0.00
2	2	-0.1493E+01	0.1053E+01	0.3417E+02	0.6784E+02	38.40
	3	-0.1493E+01	-0.7010E+00	0.6784E+02	0.3417E+02	0.00
3	3	-0.1759E+01	-0.1466E+01	0.9183E+02	0.9183E+02	0.00
	4	-0.1759E+01	0.1818E+01	0.2879E+02	0.2879E+02	38.40
4	4	-0.1759E+01	-0.1721E+01	0.2879E+02	0.2879E+02	0.00
	5	-0.1759E+01	0.2073E+01	-0.4404E+02	-0.4404E+02	38.40
5	6	-0.1483E+01	0.4954E+01	0.0000E+00	0.1810E+03	38.40
	7	-0.1483E+01	0.6006E+01	-0.4039E+02	-0.4039E+02	76.80
6	7	-0.1217E+01	0.1006E+01	-0.4039E+02	0.0000E+00	76.80
	8	-0.1217E+01	-0.4596E-01	0.0000E+00	-0.4039E+02	0.00
7	1	-0.4954E+01	0.1840E+01	0.7677E+01	0.4030E+02	37.80
	6	-0.4954E+01	0.1150E+01	0.0000E+00	0.0000E+00	90.00
8	3	-0.7012E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
	7	-0.7012E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
9	5	0.4596E-01	-0.1436E+01	-0.4404E+02	0.0000E+00	90.00
	8	0.4596E-01	-0.1554E+01	0.0000E+00	-0.6346E+02	28.80

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.3468E+00	0.7530E+01	0.0000E+00
2	0.0000E+00	0.1393E+00	0.0000E+00
3	0.0000E+00	0.6155E+01	0.0000E+00
4	0.0000E+00	0.9700E-01	0.0000E+00
5	-0.3237E+00	0.3337E+01	0.0000E+00
6	0.3328E+00	0.0000E+00	0.0000E+00
8	0.3376E+00	0.0000E+00	0.0000E+00

TOTAL   0.0000E+00   0.1726E+02

1   LOAD CASE   3 NO WATER INSIDE PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.6984E-02	-0.1505E+00	0.2763E-03
2	0.6854E-02	-0.1395E+00	0.3355E-03
3	0.6724E-02	-0.1233E+00	0.5361E-03
4	0.6574E-02	-0.9711E-01	0.7721E-03
5	0.6425E-02	-0.6665E-01	0.7521E-03
6	-0.3328E-01	-0.1514E+00	-0.3113E-03
7	-0.3355E-01	-0.1245E+00	0.9073E-03
8	-0.3377E-01	-0.6664E-01	0.7038E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.1832E+01	0.1253E+01	-0.6202E+01	0.3517E+02	38.40
	2	-0.1832E+01	-0.9015E+00	0.3517E+02	-0.6202E+01	0.00
2	2	-0.1832E+01	0.1041E+01	0.3517E+02	0.6838E+02	38.40
	3	-0.1832E+01	-0.6889E+00	0.6838E+02	0.3517E+02	0.00
3	3	-0.2098E+01	-0.1453E+01	0.9237E+02	0.9237E+02	0.00
	4	-0.2098E+01	0.1805E+01	0.2980E+02	0.2980E+02	38.40
4	4	-0.2098E+01	-0.1708E+01	0.2980E+02	0.2980E+02	0.00
	5	-0.2098E+01	0.2060E+01	-0.4256E+02	-0.4256E+02	38.40
5	6	-0.1527E+01	0.4962E+01	0.0000E+00	0.1813E+03	38.40
	7	-0.1527E+01	0.5998E+01	-0.3977E+02	-0.3977E+02	76.80
6	7	-0.1260E+01	0.9979E+00	-0.3977E+02	0.0000E+00	76.80
	8	-0.1260E+01	-0.3787E-01	0.0000E+00	-0.3977E+02	0.00
7	1	-0.4962E+01	0.2181E+01	0.6202E+01	0.4260E+02	36.00
	6	-0.4962E+01	0.1194E+01	0.0000E+00	0.0000E+00	90.00
8	3	-0.6996E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
	7	-0.6996E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
9	5	0.3787E-01	-0.1777E+01	-0.4256E+02	0.0000E+00	90.00
	8	0.3787E-01	-0.1598E+01	0.0000E+00	-0.6596E+02	28.80

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.3492E+00	0.7526E+01	0.0000E+00
2	0.0000E+00	0.1395E+00	0.0000E+00
3	0.0000E+00	0.6163E+01	0.0000E+00
4	0.0000E+00	0.9711E-01	0.0000E+00
5	-0.3213E+00	0.3332E+01	0.0000E+00
6	0.3328E+00	0.0000E+00	0.0000E+00
8	0.3377E+00	0.0000E+00	0.0000E+00

TOTAL 0.0000E+00 0.1726E+02

1 LOAD CASE 4 CONSTRUCTION PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.6979E-02	-0.1570E+00	0.2635E-03
2	0.6851E-02	-0.1465E+00	0.3255E-03
3	0.6724E-02	-0.1305E+00	0.5361E-03
4	0.6577E-02	-0.1042E+00	0.7821E-03
5	0.6431E-02	-0.7315E-01	0.7649E-03
6	-0.3327E-01	-0.1579E+00	-0.3244E-03
7	-0.3355E-01	-0.1317E+00	0.9073E-03
8	-0.3378E-01	-0.7315E-01	0.7169E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.1794E+01	0.1555E+01	-0.9627E+01	0.3843E+02	38.40
	2	-0.1794E+01	-0.9475E+00	0.3843E+02	-0.9627E+01	0.00
2	2	-0.1794E+01	0.1094E+01	0.3843E+02	0.6877E+02	38.40
	3	-0.1794E+01	-0.4860E+00	0.6877E+02	0.3843E+02	0.00
3	3	-0.2061E+01	-0.1251E+01	0.9275E+02	0.9275E+02	0.00
	4	-0.2061E+01	0.1859E+01	0.3305E+02	0.3305E+02	38.40
4	4	-0.2061E+01	-0.1754E+01	0.3305E+02	0.3305E+02	0.00
	5	-0.2061E+01	0.2362E+01	-0.4599E+02	-0.4599E+02	38.40
5	6	-0.1565E+01	0.4985E+01	0.0000E+00	0.1822E+03	38.40
	7	-0.1565E+01	0.5975E+01	-0.3800E+02	-0.3800E+02	76.80
6	7	-0.1298E+01	0.9748E+00	-0.3800E+02	0.0000E+00	76.80
	8	-0.1298E+01	-0.1483E-01	0.0000E+00	-0.3800E+02	0.00
7	1	-0.4985E+01	0.2143E+01	0.9627E+01	0.4466E+02	36.00
	6	-0.4985E+01	0.1232E+01	0.0000E+00	0.0000E+00	90.00
8	3	-0.6950E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
	7	-0.6950E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
9	5	0.1483E-01	-0.1739E+01	-0.4599E+02	0.0000E+00	90.00
	8	0.1483E-01	-0.1636E+01	0.0000E+00	-0.6834E+02	27.00

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.3489E+00	0.7851E+01	0.0000E+00
2	0.0000E+00	0.1465E+00	0.0000E+00
3	0.0000E+00	0.6523E+01	0.0000E+00
4	0.0000E+00	0.1042E+00	0.0000E+00
5	-0.3215E+00	0.3658E+01	0.0000E+00
6	0.3327E+00	0.0000E+00	0.0000E+00
8	0.3378E+00	0.0000E+00	0.0000E+00

TOTAL 0.0000E+00 0.1828E+02

1 MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	1	-0.1973E+01	0.4651E+00	0.5558E+01	0.1666E+02	38.40
		2	-0.1973E+01	-0.1131E+00	0.1666E+02	0.5558E+01	0.00
	2	1	-0.1493E+01	0.1266E+01	-0.7677E+01	0.3417E+02	38.40
		2	-0.1493E+01	-0.9137E+00	0.3417E+02	-0.7677E+01	0.00
	3	1	-0.1832E+01	0.1253E+01	-0.6202E+01	0.3517E+02	38.40
		2	-0.1832E+01	-0.9015E+00	0.3517E+02	-0.6202E+01	0.00
	4	1	-0.1794E+01	0.1555E+01	-0.9627E+01	0.3843E+02	38.40
		2	-0.1794E+01	-0.9475E+00	0.3843E+02	-0.9627E+01	0.00
2	1	2	-0.1973E+01	0.1628E+00	0.1666E+02	0.1811E+02	17.66
		3	-0.1973E+01	0.1892E+00	0.1616E+02	0.1616E+02	38.40
	2	2	-0.1493E+01	0.1053E+01	0.3417E+02	0.6784E+02	38.40
		3	-0.1493E+01	-0.7010E+00	0.6784E+02	0.3417E+02	0.00
	3	2	-0.1832E+01	0.1041E+01	0.3517E+02	0.6838E+02	38.40
		3	-0.1832E+01	-0.6889E+00	0.6838E+02	0.3517E+02	0.00
	4	2	-0.1794E+01	0.1094E+01	0.3843E+02	0.6877E+02	38.40
		3	-0.1794E+01	-0.4860E+00	0.6877E+02	0.3843E+02	0.00
3	1	3	-0.1973E+01	0.1892E+00	0.1616E+02	0.1811E+02	20.74
		4	-0.1973E+01	0.1628E+00	0.1666E+02	0.1616E+02	0.00
	2	3	-0.1759E+01	-0.1466E+01	0.9183E+02	0.9183E+02	0.00
		4	-0.1759E+01	0.1818E+01	0.2879E+02	0.2879E+02	38.40
	3	3	-0.2098E+01	-0.1453E+01	0.9237E+02	0.9237E+02	0.00
		4	-0.2098E+01	0.1805E+01	0.2980E+02	0.2980E+02	38.40
	4	3	-0.2061E+01	-0.1251E+01	0.9275E+02	0.9275E+02	0.00
		4	-0.2061E+01	0.1859E+01	0.3305E+02	0.3305E+02	38.40
4	1	4	-0.1973E+01	-0.1131E+00	0.1666E+02	0.1666E+02	0.00
		5	-0.1973E+01	0.4651E+00	0.5558E+01	0.5558E+01	38.40
	2	4	-0.1759E+01	-0.1721E+01	0.2879E+02	0.2879E+02	0.00
		5	-0.1759E+01	0.2073E+01	-0.4404E+02	-0.4404E+02	38.40
	3	4	-0.2098E+01	-0.1708E+01	0.2980E+02	0.2980E+02	0.00
		5	-0.2098E+01	0.2060E+01	-0.4256E+02	-0.4256E+02	38.40
	4	4	-0.2061E+01	-0.1754E+01	0.3305E+02	0.3305E+02	0.00
		5	-0.2061E+01	0.2362E+01	-0.4599E+02	-0.4599E+02	38.40
5	1	6	-0.1002E+01	0.5294E+00	0.0000E+00	0.1121E+02	43.01
		7	-0.1002E+01	0.4306E+00	0.3797E+01	0.0000E+00	0.00
	2	6	-0.1483E+01	0.4954E+01	0.0000E+00	0.1810E+03	38.40
		7	-0.1483E+01	0.6006E+01	-0.4039E+02	-0.4039E+02	76.80
	3	6	-0.1527E+01	0.4962E+01	0.0000E+00	0.1813E+03	38.40
		7	-0.1527E+01	0.5998E+01	-0.3977E+02	-0.3977E+02	76.80
	4	6	-0.1565E+01	0.4985E+01	0.0000E+00	0.1822E+03	38.40
		7	-0.1565E+01	0.5975E+01	-0.3800E+02	-0.3800E+02	76.80
6	1	7	-0.1002E+01	0.4306E+00	0.3797E+01	0.1121E+02	33.79
		8	-0.1002E+01	0.5294E+00	0.0000E+00	0.0000E+00	76.80
	2	7	-0.1217E+01	0.1006E+01	-0.4039E+02	0.0000E+00	76.80
		8	-0.1217E+01	-0.4596E-01	0.0000E+00	-0.4039E+02	0.00
	3	7	-0.1260E+01	0.9979E+00	-0.3977E+02	0.0000E+00	76.80
		8	-0.1260E+01	-0.3787E-01	0.0000E+00	-0.3977E+02	0.00
	4	7	-0.1298E+01	0.9748E+00	-0.3800E+02	0.0000E+00	76.80
		8	-0.1298E+01	-0.1483E-01	0.0000E+00	-0.3800E+02	0.00

7	1	1	-0.5294E+00	0.1987E+01	-0.5558E+01	0.3282E+02	41.40
		6	-0.5294E+00	0.1003E+01	0.0000E+00	-0.5558E+01	0.00
	2	1	-0.4954E+01	0.1840E+01	0.7677E+01	0.4030E+02	37.80
		6	-0.4954E+01	0.1150E+01	0.0000E+00	0.0000E+00	90.00
	3	1	-0.4962E+01	0.2181E+01	0.6202E+01	0.4260E+02	36.00
		6	-0.4962E+01	0.1194E+01	0.0000E+00	0.0000E+00	90.00
	4	1	-0.4985E+01	0.2143E+01	0.9627E+01	0.4466E+02	36.00
		6	-0.4985E+01	0.1232E+01	0.0000E+00	0.0000E+00	90.00
8	1	3	-0.8611E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00
		7	-0.8611E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00
	2	3	-0.7012E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
		7	-0.7012E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
	3	3	-0.6996E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
		7	-0.6996E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
	4	3	-0.6950E+01	0.2665E+00	-0.2398E+02	0.0000E+00	90.00
		7	-0.6950E+01	-0.2665E+00	0.0000E+00	-0.2398E+02	0.00
9	1	5	-0.5294E+00	-0.1987E+01	0.5558E+01	0.5558E+01	0.00
		8	-0.5294E+00	-0.1003E+01	0.0000E+00	-0.3282E+02	41.40
	2	5	0.4596E-01	-0.1436E+01	-0.4404E+02	0.0000E+00	90.00
		8	0.4596E-01	-0.1554E+01	0.0000E+00	-0.6346E+02	28.80
	3	5	0.3787E-01	-0.1777E+01	-0.4256E+02	0.0000E+00	90.00
		8	0.3787E-01	-0.1598E+01	0.0000E+00	-0.6596E+02	28.80
	4	5	0.1483E-01	-0.1739E+01	-0.4599E+02	0.0000E+00	90.00
		8	0.1483E-01	-0.1636E+01	0.0000E+00	-0.6834E+02	27.00

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Design Information:

Data below are from analysis performed by CFRAME

Design Service Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Edge	*1.00*	0.53	3.80	1.48	6.01	40.39	1.53	6.00	39.77	1.57	5.98	38.00
Top Slab @ Middle	*1.00*	0.00	11.21	1.48	0.04	181.30	1.53	5.40	181.30	1.57	5.70	182.20
Side Wall At Top	0.53	1.00	0.00	4.99	1.55	0.00	4.99	1.59	0.00	4.99	1.63	0.00
Side Wall @ Middle	*0.53*	1.98	32.82	4.99	1.55	63.40	4.99	1.59	65.96	4.99	1.63	68.34
Side Wall @Bottom	*0.53*	1.98	5.55	4.99	1.84	44.04	4.99	2.18	42.56	4.99	2.14	45.99
Pier @ Top	0.86	0.00	0.00	7.01	0.27	0.00	6.99	0.27	0.00	6.99	0.27	0.00
Pier @ Middle	0.86	0.00	0.00	7.01	0.27	23.98	6.99	0.27	23.98	6.99	0.27	23.98
Pier @Bottom	0.86	0.00	0.00	7.01	0.27	23.98	6.99	0.27	23.98	6.99	0.27	23.98
Bottom Slab @ Side wall	*1.97*	0.47	5.55	1.75	1.26	44.04	2.10	2.06	42.56	2.06	2.36	45.99
Bottom Slab @ Middle	*1.97*	0.47	18.11	1.75	1.26	34.17	2.10	2.06	92.37	2.06	1.75	38.44
Bottom Slab @ Pier	*1.97*	0.12	16.16	1.75	1.81	91.82	2.10	1.82	68.38	2.06	1.25	92.75

Design Load Factor

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Edge	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Top Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Side Wall At Top	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Side Wall @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Side Wall @Bottom	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Pier @ Top	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Pier @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Pier @Bottom	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Side wall	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Pier	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Design Factored Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Pier	*2.21*	*1.17*	*8.40*	*2.46*	*9.98*	*67.05*	*2.54*	*9.96*	*66.02*	*2.61*	*9.93*	*63.08*
Top Slab @ Middle	*2.21*	*0.00*	*24.77*	*2.46*	*0.07*	*300.96*	*2.54*	*8.96*	*300.96*	*2.61*	*9.46*	*302.45*
Side Wall At Top	*1.17*	*2.21*	*0.00*	*8.28*	*2.57*	*0.00*	*8.28*	*2.64*	*0.00*	*8.28*	*2.71*	*0.00*
Side Wall @ Middle	*1.17*	*4.38*	*72.53*	*8.28*	*2.57*	*105.24*	*8.28*	*2.64*	*109.49*	*8.28*	*2.71*	*113.44*
Side Wall @Bottom	*1.17*	*4.38*	*12.27*	*8.28*	*3.05*	*73.11*	*8.28*	*3.62*	*70.65*	*8.28*	*3.55*	*76.34*
Pier @ Top	*1.90*	*0.00*	*0.00*	*11.64*	*0.45*	*0.00*	*11.60*	*0.45*	*0.00*	*11.60*	*0.45*	*0.00*
Pier @ Middle	*1.90*	*0.00*	*0.00*	*11.64*	*0.45*	*39.81*	*11.60*	*0.45*	*39.81*	*11.60*	*0.45*	*39.81*
Pier @Bottom	*1.90*	*0.00*	*0.00*	*11.64*	*0.45*	*39.81*	*11.60*	*0.45*	*39.81*	*11.60*	*0.45*	*39.81*
Bottom Slab @ Side wall	*4.35*	*1.04*	*12.27*	*2.91*	*2.09*	*73.11*	*3.49*	*3.42*	*70.65*	*3.42*	*3.92*	*76.34*
Bottom Slab @ Middle	*4.35*	*1.04*	*40.02*	*2.91*	*2.09*	*56.72*	*3.49*	*3.42*	*153.33*	*3.42*	*2.91*	*63.81*
Bottom Slab @ Pier	*4.35*	*0.27*	*35.71*	*2.91*	*3.00*	*152.42*	*3.49*	*3.02*	*113.51*	*3.42*	*2.08*	*153.97*

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Top Slab @ Pier

Thickness	1.00	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	0.750	inches	φ shear =	0.75
T & S Steel Dia. =	0.75	inches	φ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	9.977	kips
Moment (M) =	5.587	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	9.98	kips		
d min =	8.76	in	=Vu/(phi shear)(2)(l)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	8.63			
φ Vc =	9.82	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.74	in^2	[(ρ max)(bw)(d)]	

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**5.59**	**kip-ft**	[(M)(DLF)]
As =	0.15	in^2	[solved for based on above formula]

As Minimum

As, min =	0.35	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.19	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.13	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.20	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

		fs = 1.69	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Top Slab @ Middle

Thickness	1.00	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	0.750	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	0.066	kips
Moment (M) =	25.080	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	0.07	kips		
d min =	0.06	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	8.63			
ϕ Vc =	9.82	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.74	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**25.08**	**kip-ft**	[(M)(DLF)]
As =	0.69	in^2	[solved for based on above formula]

As Minimum

As, min =	0.35	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.92	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.13	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.20	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	6.00	in	**Use # 6 @ 6"**
Total Steel =	0.88	in^2	

Spacing Maximum

			fs = 4.44 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Side Wall @ Top

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	φ shear =	0.75
T & S Steel Dia. =	0.75	inches	φ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	2.573	kips
Moment (M) =	0.000	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	2.57	kips		
d min =	2.26	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	9.50			
φ Vc =	10.82	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.81	in^2	[(ρ max)(bw)(d)]	

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**0.00**	**kip-ft**	[(M)(DLF)]
As =	0.00	in^2	[solved for based on above formula]

As Minimum

As, min =	0.38	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.00	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 0.00 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**#####**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Side Wall @ Maximum Positive Momment Near Middle

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	2.573	kips
Moment (M) =	8.770	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	2.57	kips		
d min =	2.26	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	#####		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	#####		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**8.77**	**kip-ft**	[(M)(DLF)]
As =	0.19	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.25	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

		fs =	2.12	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]			ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Side Wall @Bottom

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	3.054	kips
Moment (M) =	6.092	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	3.05	kips		
d min =	2.68	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**6.09**	**kip-ft**	[(M)(DLF)]
As =	0.13	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.17	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 1.47 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Pier @ Top

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) = 0.448 kips

Moment (M) = 0.000 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 0.45 kips

d min =	0.39	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	9.50			
ϕ Vc =	10.82	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.81	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**0.00**	**kip-ft**	[(M)(DLF)]
As =	0.00	in^2	[solved for based on above formula]

As Minimum

As, min =	0.38	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.00	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum — fs = 0.00 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = ##### in [(15*(40/fs)-2.5Cc] ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Pier @ Maximum Positive Momment Near Middle

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	0.448	kips
Moment (M) =	3.317	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 0.45 kips

d min =	0.39	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	#####		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	#####		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**3.32**	**kip-ft**	[(M)(DLF)]
As =	0.07	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.09	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

		fs = 0.80	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Pier @ Bottom

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	0.448	kips
Moment (M) =	3.317	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	0.45	kips		
d min =	0.39	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**3.32**	**kip-ft**	[(M)(DLF)]
As =	0.07	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.09	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

		fs = 0.80	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Bottom Slan @ Side Wall

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear =	0.75
T & S Steel Dia. =	1.000	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	2.092	kips
Moment (M) =	6.092	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 2.09 kips

d min =	1.84	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**6.09**	**kip-ft**	[(M)(DLF)]
As =	0.13	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.17	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum — fs = 1.48 — =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in — [(15*(40/fs)-2.5Cc] — ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Bottom Slab @ Middle

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear =	0.75
T & S Steel Dia. =	1.000	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	2.092	kips
Moment (M) =	4.727	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	2.09	kips		
d min =	1.84	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**4.73**	**kip-ft**	[(M)(DLF)]
As =	0.10	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.14	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 1.15	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, Slab on Top	CHK BY:		

Bottom Slab @ Pier

Thickness	1.25	feet	λ = , ACI 8.6.1 = 1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear = 0.75
T & S Steel Dia. =	1.000	inches	ϕ moment = 0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) = 0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) = 1.30
f'c =	4.00	ksi	Load Factor (LF) = 1.70
			Design Load Factor (DLF) = 1.66

Moment and Shear

Shear (V) = 3.005 kips

Moment (M) = 12.702 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 3.00 kips

d min =	2.64	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**12.70**	**kip-ft**	[(M)(DLF)]
As =	0.28	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.37	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

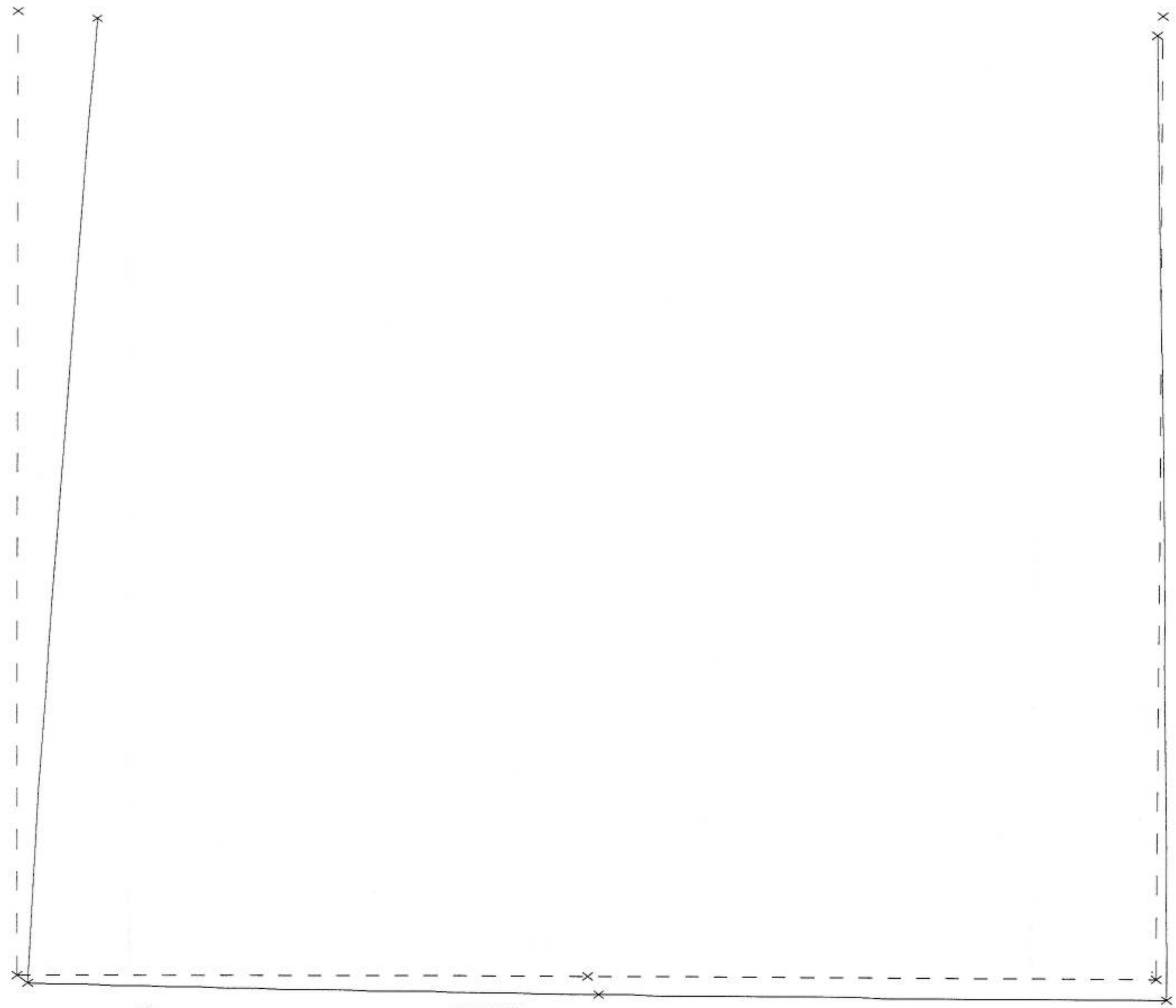
As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 3.09	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

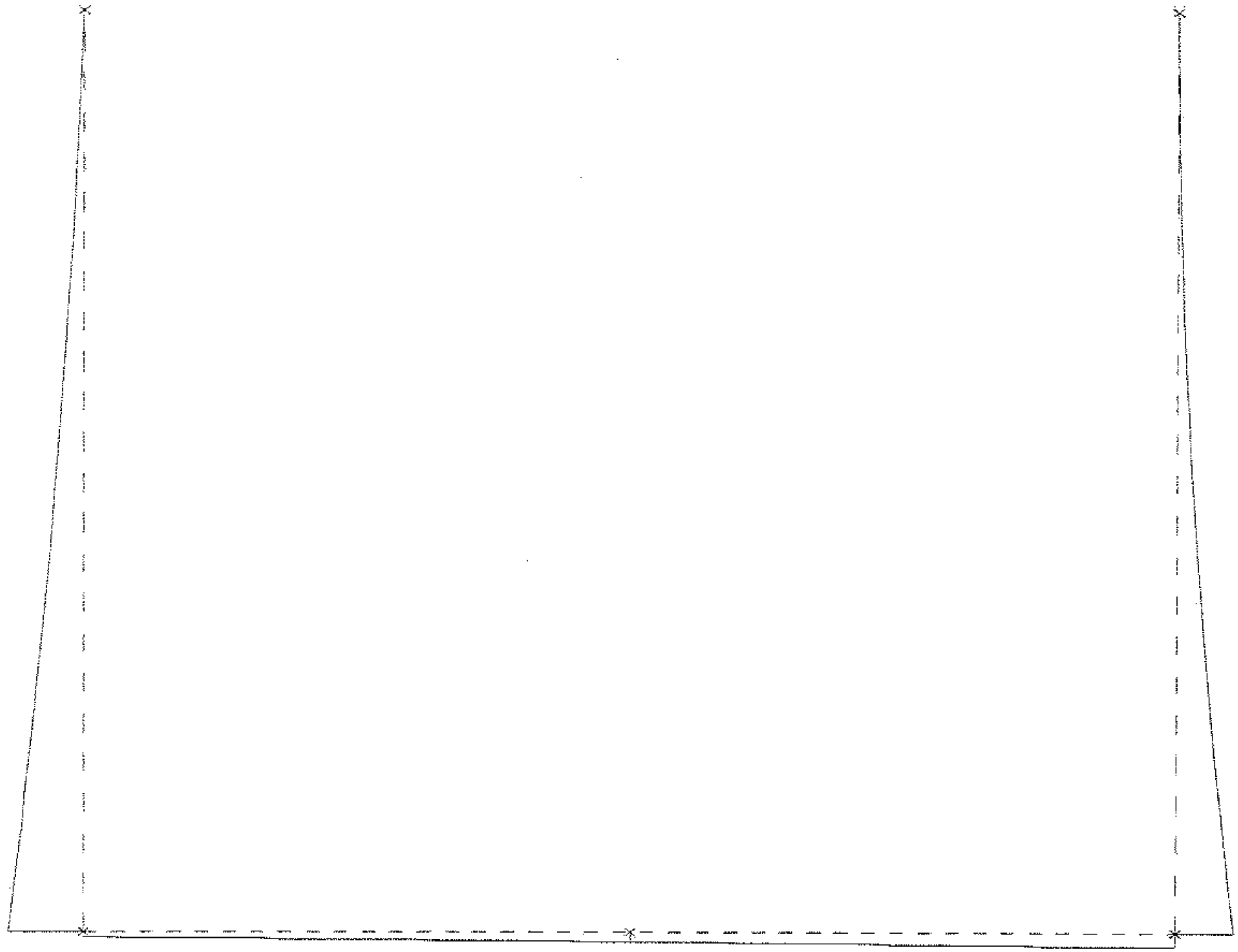
CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE ~~1 BAY U~~ 2-Bays, U @ End



= 0.14 IN DEFLECTION 10/12/2018 10:42: 8

LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

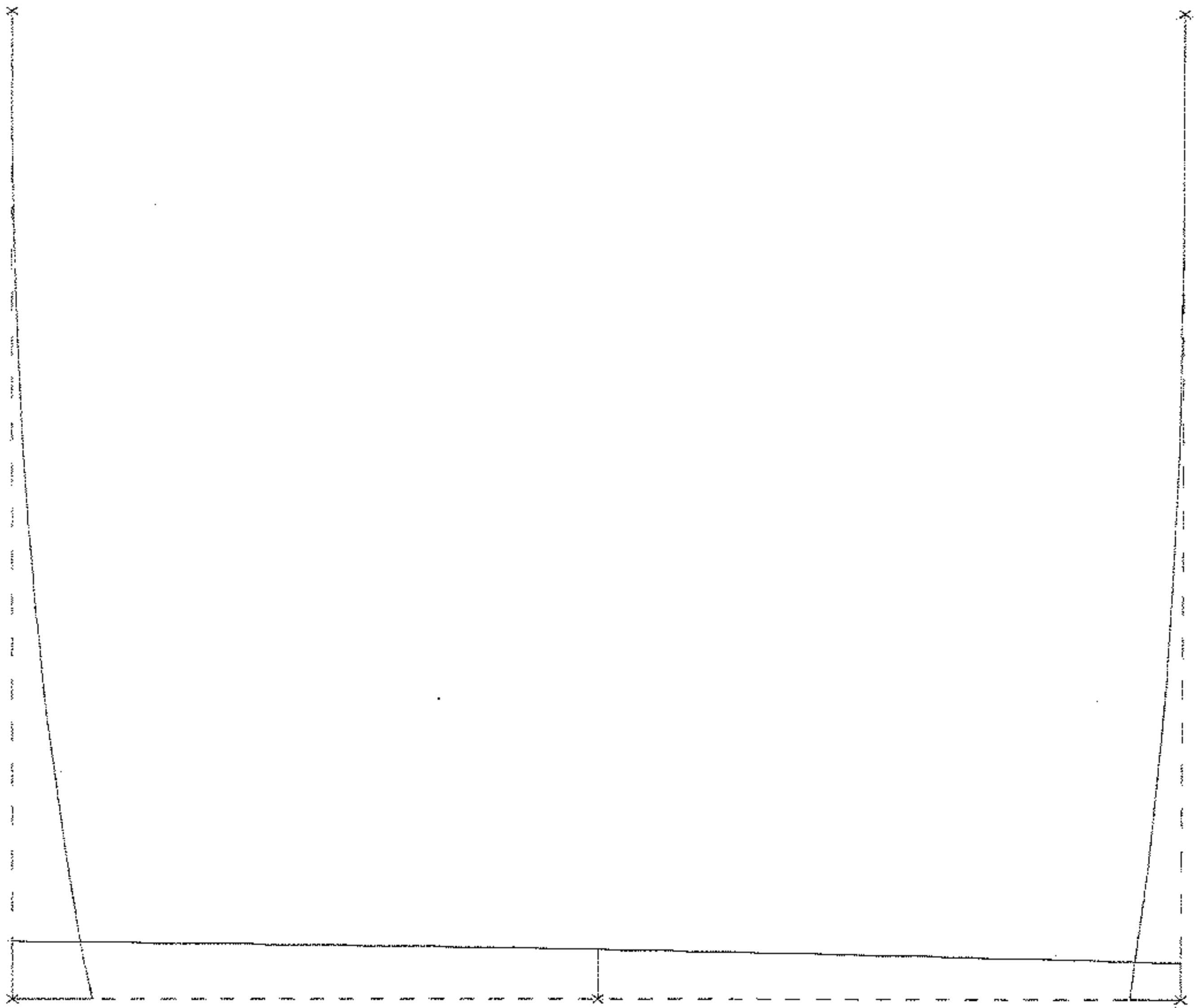
CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY U



= 4.31 KIP SHEAR 10/12/2018 10:42: 8

LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE WATCONTROL STRUCTURE 1 BAY U



= 157.38 IN-KIP MOMENT 10/12/2018 10:42: 8

LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

PROGRAM CFRAME V02.05 24JUL84
--*-*-*-*-*-*-*-*-*-*-*-*-*-*-*

RUN DATE = 10/11/2018
RUN TIME = 11:49:45

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE

*** JOINT DATA ***

JOINT	X	Y	X	Y	R	KX	KY	KR
	---FT	---				---KIP /IN	---	IN -KIP/RAD
1	0.00	0.00				0.100E-01	0.500E+02	
2	3.20	0.00					0.100E-01	
3	6.40	0.00					0.100E-01	
4	9.60	0.00					0.100E-01	
5	12.80	0.00				0.500E+02	0.500E+02	
6	0.00	7.50				0.100E-01		
7	12.80	7.50				0.100E-01		

(FIXITY spans X, Y, R, KX, KY, KR)

*** MEMBER DATA ***

MEMBER	END A	END B	LENGTH FT	I IN **4	A IN **2	AS IN **2	E KSI	G KSI
1	1	2	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
2	2	3	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
3	3	4	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
4	4	5	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
5	1	6	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04
6	5	7	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04

*** LOAD CASE 1 NORMAL WATER

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.2200E+00	3.20	0.2200E+00	0.00
4	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.2200E+00	3.20	0.2200E+00	0.00
5	0.00	0.9000E+00	7.50	0.0000E+00	0.00

5	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
6	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
6	0.00	0.2200E+00	3.50	0.0000E+00	0.00

*** LOAD CASE 2 NORMAL WATER PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.2200E+00	3.20	0.2200E+00	0.00
4	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.2200E+00	3.20	0.2200E+00	0.00
5	0.00	0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
5	0.00	0.0000E+00	7.50	0.2500E+00	0.00
6	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
6	0.00	0.2200E+00	3.50	0.0000E+00	0.00

*** LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
5	0.00	0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	0.0000E+00	7.50	0.2500E+00	0.00
6	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

*** LOAD CASE 4 CONSTRUCTION PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00

3	0.00	0.1900E+00	3.20	0.1900E+00	0.00
4	0.00	0.1900E+00	3.20	0.1900E+00	0.00
5	0.00	0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	0.0000E+00	7.50	0.2500E+00	0.00
6	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

1 LOAD CASE 1 NORMAL WATER

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.8499E-03	-0.1407E-01	-0.8630E-03
2	0.6373E-03	-0.3975E-01	-0.4571E-03
3	0.4248E-03	-0.4864E-01	0.0000E+00
4	0.2122E-03	-0.3975E-01	0.4571E-03
5	0.0000E+00	-0.1407E-01	0.8630E-03
6	0.9827E-01	-0.1407E-01	-0.1132E-02
7	-0.9742E-01	-0.1407E-01	0.1132E-02

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2989E+01	0.7034E+00	0.9577E+02	0.1160E+03	38.40
	2	-0.2989E+01	-0.3514E+00	0.1160E+03	0.9577E+02	0.00
2	2	-0.2989E+01	0.3518E+00	0.1160E+03	0.1228E+03	38.40
	3	-0.2989E+01	0.2382E-03	0.1228E+03	0.1160E+03	0.00
3	3	-0.2989E+01	0.2481E-03	0.1228E+03	0.1228E+03	0.00
	4	-0.2989E+01	0.3518E+00	0.1160E+03	0.1160E+03	38.40
4	4	-0.2989E+01	-0.3514E+00	0.1160E+03	0.1160E+03	0.00
	5	-0.2989E+01	0.7034E+00	0.9577E+02	0.9577E+02	38.40
5	1	0.0000E+00	0.2989E+01	-0.9577E+02	0.9763E-03	88.20
	6	0.0000E+00	0.9827E-03	0.0000E+00	-0.9577E+02	0.00
6	5	0.0000E+00	-0.2989E+01	0.9577E+02	0.9577E+02	0.00
	7	0.0000E+00	-0.9742E-03	0.0000E+00	-0.9610E-03	88.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	0.0000E+00	0.7034E+00	0.0000E+00
2	0.0000E+00	0.3975E-03	0.0000E+00
3	0.0000E+00	0.4864E-03	0.0000E+00
4	0.0000E+00	0.3975E-03	0.0000E+00
5	0.1699E-04	0.7034E+00	0.0000E+00
6	-0.9827E-03	0.0000E+00	0.0000E+00
7	0.9742E-03	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.1408E+01	

1 LOAD CASE 2 NORMAL WATER PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1985E-01	-0.6751E-02	-0.1244E-02
2	0.1957E-01	-0.4325E-01	-0.6516E-03
3	0.1929E-01	-0.5682E-01	-0.6135E-04
4	0.1901E-01	-0.4852E-01	0.4757E-03
5	0.1873E-01	-0.2138E-01	0.9082E-03
6	0.1670E+00	-0.6751E-02	-0.1744E-02
7	-0.8277E-01	-0.2138E-01	0.1178E-02

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.3926E+01	0.3376E+00	0.1520E+03	0.1582E+03	36.86
	2	-0.3926E+01	0.1445E-01	0.1582E+03	0.1520E+03	0.00
2	2	-0.3926E+01	-0.1401E-01	0.1582E+03	0.1582E+03	0.00
	3	-0.3926E+01	0.3660E+00	0.1509E+03	0.1509E+03	38.40
3	3	-0.3926E+01	-0.3654E+00	0.1509E+03	0.1509E+03	0.00
	4	-0.3926E+01	0.7174E+00	0.1301E+03	0.1301E+03	38.40
4	4	-0.3926E+01	-0.7170E+00	0.1301E+03	0.1301E+03	0.00
	5	-0.3926E+01	0.1069E+01	0.9579E+02	0.9579E+02	38.40
5	1	0.0000E+00	0.3926E+01	-0.1520E+03	0.0000E+00	90.00
	6	0.0000E+00	0.1670E-02	0.0000E+00	-0.1520E+03	0.00
6	5	0.0000E+00	-0.2989E+01	0.9579E+02	0.9579E+02	0.00
	7	0.0000E+00	-0.8277E-03	0.0000E+00	-0.6973E-03	88.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1985E-03	0.3376E+00	0.0000E+00
2	0.0000E+00	0.4325E-03	0.0000E+00
3	0.0000E+00	0.5682E-03	0.0000E+00
4	0.0000E+00	0.4852E-03	0.0000E+00
5	-0.9365E+00	0.1069E+01	0.0000E+00
6	-0.1670E-02	0.0000E+00	0.0000E+00
7	0.8277E-03	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.1408E+01	

1 LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1996E-01	-0.6751E-02	-0.1285E-02
2	0.1965E-01	-0.4443E-01	-0.6721E-03
3	0.1934E-01	-0.5839E-01	-0.6135E-04
4	0.1904E-01	-0.4969E-01	0.4961E-03
5	0.1873E-01	-0.2138E-01	0.9491E-03
6	0.1714E+00	-0.6751E-02	-0.1791E-02
7	-0.8702E-01	-0.2138E-01	0.1225E-02

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.4311E+01	0.3375E+00	0.1573E+03	0.1636E+03	36.86
	2	-0.4311E+01	0.1447E-01	0.1635E+03	0.1573E+03	0.00
2	2	-0.4311E+01	-0.1402E-01	0.1635E+03	0.1635E+03	0.00
	3	-0.4311E+01	0.3660E+00	0.1563E+03	0.1563E+03	38.40
3	3	-0.4311E+01	-0.3654E+00	0.1563E+03	0.1563E+03	0.00
	4	-0.4311E+01	0.7174E+00	0.1355E+03	0.1355E+03	38.40
4	4	-0.4311E+01	-0.7169E+00	0.1355E+03	0.1355E+03	0.00
	5	-0.4311E+01	0.1069E+01	0.1012E+03	0.1012E+03	38.40
5	1	0.0000E+00	0.4311E+01	-0.1573E+03	0.0000E+00	90.00
	6	0.0000E+00	0.1714E-02	0.0000E+00	-0.1573E+03	0.00
6	5	0.0000E+00	-0.3374E+01	0.1012E+03	0.1012E+03	0.00
	7	0.0000E+00	-0.8702E-03	0.0000E+00	-0.7710E-03	88.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1996E-03	0.3375E+00	0.0000E+00
2	0.0000E+00	0.4443E-03	0.0000E+00
3	0.0000E+00	0.5839E-03	0.0000E+00
4	0.0000E+00	0.4969E-03	0.0000E+00
5	-0.9365E+00	0.1069E+01	0.0000E+00
6	-0.1714E-02	0.0000E+00	0.0000E+00
7	0.8702E-03	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.1408E+01	

1 LOAD CASE 4 CONSTRUCTION PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1996E-01	-0.1699E-01	-0.1384E-02
2	0.1965E-01	-0.5812E-01	-0.7403E-03
3	0.1934E-01	-0.7348E-01	-0.6135E-04
4	0.1904E-01	-0.6339E-01	0.5644E-03

5	0.1873E-01	-0.3161E-01	0.1048E-02
6	0.1803E+00	-0.1699E-01	-0.1891E-02
7	-0.9596E-01	-0.3161E-01	0.1325E-02

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.4310E+01	0.8493E+00	0.1573E+03	0.1783E+03	38.40
	2	-0.4310E+01	-0.2413E+00	0.1783E+03	0.1573E+03	0.00
2	2	-0.4310E+01	0.2419E+00	0.1783E+03	0.1801E+03	15.36
	3	-0.4310E+01	0.3661E+00	0.1759E+03	0.1759E+03	38.40
3	3	-0.4310E+01	-0.3654E+00	0.1759E+03	0.1759E+03	0.00
	4	-0.4310E+01	0.9734E+00	0.1502E+03	0.1502E+03	38.40
4	4	-0.4310E+01	-0.9727E+00	0.1502E+03	0.1502E+03	0.00
	5	-0.4310E+01	0.1581E+01	0.1012E+03	0.1012E+03	38.40
5	1	0.0000E+00	0.4311E+01	-0.1573E+03	0.0000E+00	90.00
	6	0.0000E+00	0.1803E-02	0.0000E+00	-0.1573E+03	0.00
6	5	0.0000E+00	-0.3374E+01	0.1012E+03	0.1012E+03	0.00
	7	0.0000E+00	-0.9596E-03	0.0000E+00	-0.9319E-03	88.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1996E-03	0.8493E+00	0.0000E+00
2	0.0000E+00	0.5812E-03	0.0000E+00
3	0.0000E+00	0.7348E-03	0.0000E+00
4	0.0000E+00	0.6339E-03	0.0000E+00
5	-0.9365E+00	0.1581E+01	0.0000E+00
6	-0.1803E-02	0.0000E+00	0.0000E+00
7	0.9596E-03	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.2432E+01	

1 MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	1	-0.2989E+01	0.7034E+00	0.9577E+02	0.1160E+03	38.40
		2	-0.2989E+01	-0.3514E+00	0.1160E+03	0.9577E+02	0.00
	2	1	-0.3926E+01	0.3376E+00	0.1520E+03	0.1582E+03	36.86
		2	-0.3926E+01	0.1445E-01	0.1582E+03	0.1520E+03	0.00
	3	1	-0.4311E+01	0.3375E+00	0.1573E+03	0.1636E+03	36.86
		2	-0.4311E+01	0.1447E-01	0.1635E+03	0.1573E+03	0.00
	4	1	-0.4310E+01	0.8493E+00	0.1573E+03	0.1783E+03	38.40
		2	-0.4310E+01	-0.2413E+00	0.1783E+03	0.1573E+03	0.00
2	1	2	-0.2989E+01	0.3518E+00	0.1160E+03	0.1228E+03	38.40
		3	-0.2989E+01	0.2382E-03	0.1228E+03	0.1160E+03	0.00
	2	2	-0.3926E+01	-0.1401E-01	0.1582E+03	0.1582E+03	0.00
		3	-0.3926E+01	0.3660E+00	0.1509E+03	0.1509E+03	38.40
	3	2	-0.4311E+01	-0.1402E-01	0.1635E+03	0.1635E+03	0.00

		3	-0.4311E+01	0.3660E+00	0.1563E+03	0.1563E+03	38.40
	4	2	-0.4310E+01	0.2419E+00	0.1783E+03	0.1801E+03	15.36
		3	-0.4310E+01	0.3661E+00	0.1759E+03	0.1759E+03	38.40
3	1	3	-0.2989E+01	0.2481E-03	0.1228E+03	0.1228E+03	0.00
		4	-0.2989E+01	0.3518E+00	0.1160E+03	0.1160E+03	38.40
	2	3	-0.3926E+01	-0.3654E+00	0.1509E+03	0.1509E+03	0.00
		4	-0.3926E+01	0.7174E+00	0.1301E+03	0.1301E+03	38.40
	3	3	-0.4311E+01	-0.3654E+00	0.1563E+03	0.1563E+03	0.00
		4	-0.4311E+01	0.7174E+00	0.1355E+03	0.1355E+03	38.40
	4	3	-0.4310E+01	-0.3654E+00	0.1759E+03	0.1759E+03	0.00
		4	-0.4310E+01	0.9734E+00	0.1502E+03	0.1502E+03	38.40
4	1	4	-0.2989E+01	-0.3514E+00	0.1160E+03	0.1160E+03	0.00
		5	-0.2989E+01	0.7034E+00	0.9577E+02	0.9577E+02	38.40
	2	4	-0.3926E+01	-0.7170E+00	0.1301E+03	0.1301E+03	0.00
		5	-0.3926E+01	0.1069E+01	0.9579E+02	0.9579E+02	38.40
	3	4	-0.4311E+01	-0.7169E+00	0.1355E+03	0.1355E+03	0.00
		5	-0.4311E+01	0.1069E+01	0.1012E+03	0.1012E+03	38.40
	4	4	-0.4310E+01	-0.9727E+00	0.1502E+03	0.1502E+03	0.00
		5	-0.4310E+01	0.1581E+01	0.1012E+03	0.1012E+03	38.40
5	1	1	0.0000E+00	0.2989E+01	-0.9577E+02	0.9763E-03	88.20
		6	0.0000E+00	0.9827E-03	0.0000E+00	-0.9577E+02	0.00
	2	1	0.0000E+00	0.3926E+01	-0.1520E+03	0.0000E+00	90.00
		6	0.0000E+00	0.1670E-02	0.0000E+00	-0.1520E+03	0.00
	3	1	0.0000E+00	0.4311E+01	-0.1573E+03	0.0000E+00	90.00
		6	0.0000E+00	0.1714E-02	0.0000E+00	-0.1573E+03	0.00
	4	1	0.0000E+00	0.4311E+01	-0.1573E+03	0.0000E+00	90.00
		6	0.0000E+00	0.1803E-02	0.0000E+00	-0.1573E+03	0.00
6	1	5	0.0000E+00	-0.2989E+01	0.9577E+02	0.9577E+02	0.00
		7	0.0000E+00	-0.9742E-03	0.0000E+00	-0.9610E-03	88.20
	2	5	0.0000E+00	-0.2989E+01	0.9579E+02	0.9579E+02	0.00
		7	0.0000E+00	-0.8277E-03	0.0000E+00	-0.6973E-03	88.20
	3	5	0.0000E+00	-0.3374E+01	0.1012E+03	0.1012E+03	0.00
		7	0.0000E+00	-0.8702E-03	0.0000E+00	-0.7710E-03	88.20
	4	5	0.0000E+00	-0.3374E+01	0.1012E+03	0.1012E+03	0.00
		7	0.0000E+00	-0.9596E-03	0.0000E+00	-0.9319E-03	88.20

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, U at Upper	CHK BY:		

Design Information:

Data below are from analysis performed by CFRAME

Design Service Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	*0.00*	3.00	95.80	0.00	3.90	152.00	0.00	4.30	157.40	0.00	4.30	157.40
Bottom Slab @ Side wall	*2.99*	0.71	95.80	3.93	0.34	152.00	4.31	0.34	157.40	4.31	0.85	157.40
Bottom Slab @ Middle	*2.99*	0.00	122.80	3.93	0.37	150.90	4.31	0.37	163.50	4.31	0.37	180.10

Design Load Factor

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Side wall	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66

Design Factored Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	*0.00*	*6.63*	*211.72*	*0.00*	*6.47*	*252.32*	*0.00*	*7.14*	*261.28*	*0.00*	*7.14*	*261.28*
Bottom Slab @ Side wall	*6.61*	*1.57*	*211.72*	*6.52*	*0.56*	*252.32*	*7.15*	*0.56*	*261.28*	*7.15*	*1.41*	*261.28*
Bottom Slab @ Middle	*6.61*	*0.00*	*271.39*	*6.52*	*0.61*	*250.49*	*7.15*	*0.61*	*271.41*	*7.15*	*0.61*	*298.97*

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, U at Upper	CHK BY:		

Side Wall @Bottom

Thickness	1.17 feet		λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000 inches		φ shear =	0.75
T & S Steel Dia. =	0.75 inches		φ moment =	0.90
Required Concrete Cover =	3.00 inches		Load Condition Factor (LCF) =	0.75
fy =	60.00 ksi		Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00 ksi		Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) = 7.138 kips

Moment (M) = 21.774 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 7.14 kips

d min =	6.27 in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)		ACI 11.2.1.1
Actual depth d =	10.50			
φ Vc =	11.96 kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]		ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85	[1.05-.05(f'c)]	.65 <= β1 <= .85	
ρ balanced =	######	[((.85 β1 f'c)/fy)(87000/(87000+fy))]		
ρ max =	######	[.25(ρ balanced)]		
As Maximum =	0.90 in^2	[(ρ max)(bw)(d)]		

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**21.77 kip-ft**	[(M)(DLF)]
As =	0.48 in^2	[solved for based on above formula]

As Minimum

As, min =	0.42 in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.64 in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15 in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24 in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44 in^2	As Based on As, min
Steel Spacing =	12.00 in	**Use # 6 @ 12"**
Total Steel =	0.44 in^2	

Spacing Maximum

		fs = 5.26	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

Bottom Slan @ Side Wall

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	φ shear =	0.75
T & S Steel Dia. =	1.000	inches	φ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	1.411	kips
Moment (M) =	21.774	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 1.41 kips

d min =	1.24	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
φ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]
ρ max =	######		[.25(ρ balanced)]
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**21.77**	**kip-ft**	[(M)(DLF)]
As =	0.48	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.64	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum — fs = 5.30 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*(40/fs)-2.5Cc] ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 2-Bays, U at Upper	CHK BY:		

Bottom Slab @ Middle

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear =	0.75
T & S Steel Dia. =	1.000	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	0.614	kips
Moment (M) =	24.914	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	0.61	kips		
d min =	0.54	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**24.91**	**kip-ft**	[(M)(DLF)]
As =	0.55	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.74	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 6.06 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

One-Bay Control Structure Stability

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Structural Stability	Chkd: By	Date:	PC File: Calc_Sht .xls

Structural Stability: Summarry of Results

EM 2100, Structure Designation.

Structures are to be designated as Critical or Normal. Given Bass Pond Lakes are not a high hazard project whose failure would result in loss of life, it is desinated as:

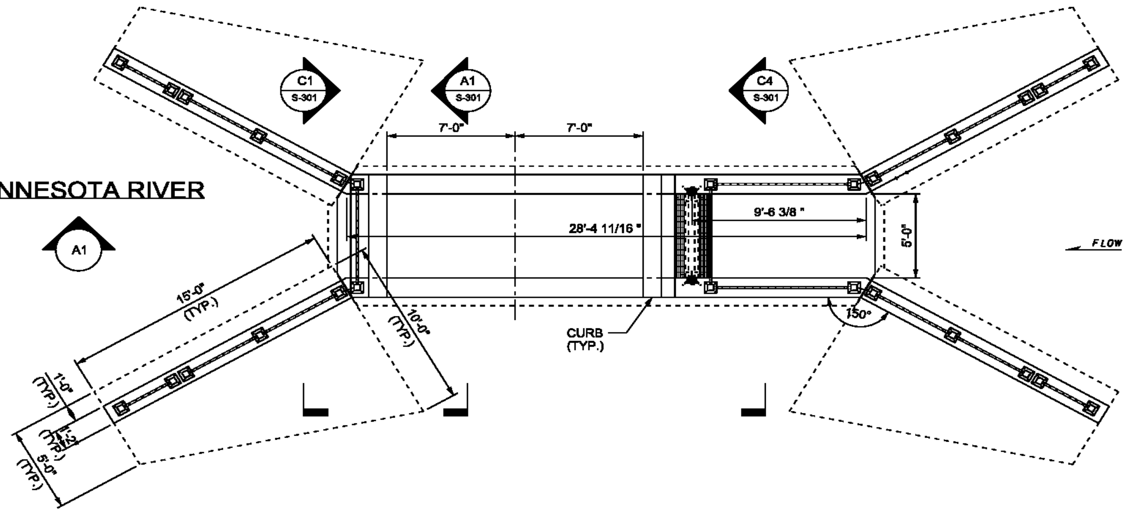
Structure Designation: **Normal**

Limit State	Load Case	Load Condition Category	River Stage EL,ft	Lake Pool EL,ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.72	1.3
	Normal High Lake	Usual	691.26	696.5	9.43	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	11.94	1.3
	Construction, Truck	Unusual	690.26	690.26	93.43	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	552.85	698.25
	Normal High Lake	Usual	691.26	696.5	542.46	525
	Normal High Lake, Truck	Unusual	691.26	696.5	702.43	698.25
	Construction, Truck	Unusual	690.26	690.26	827.73	698.25
					Calculated FOS	EM2100 Required FOS
Floation	High River Stage	Unusual	698.26	694.3	3.12	1.2
	Normal High Lake	Usual	691.26	696.5	4.03	1.3

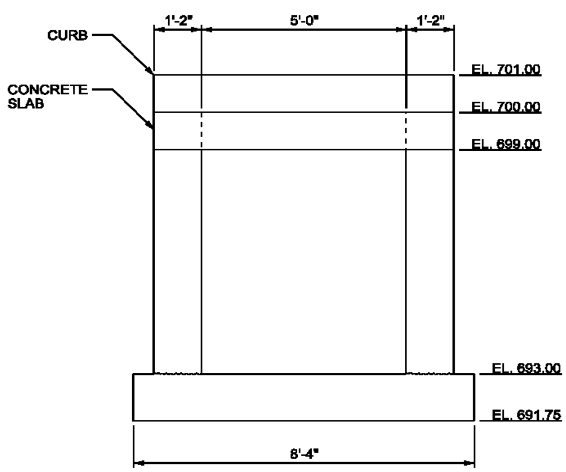
See Geotech Appendix for allowbale bearing pressure, 525 psf

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:	
	Subject: Control Structure -Stoplog Monolith	Chkd: By	Date:	PC File: Calc_Sht .xls	

Design sketches



1 bay WCS Plan



1 Bay WCS Section

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Water to Top of Structure with Normal Lake Level	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Water to Top of Structure with Normal Lake Level

Prevent MN river water from backing into Lake.

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall	699.00	ft	Wall length =	29.00	ft
Base slab thick	1.25	ft	Base width	8.33	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	7.33	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	698.26	ft	Heel width	0.50	
LAKE POOL ELEV	694.30	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	6.51	ft
Pressure Head at C (D/S Edge)	2.55	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	6.51	

Forces: Horizontal, Vertical and Moment about Downstream Edge **NOTE Driving Direction is toward lake**

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7	29	1.167	0.150	35.54		14.50	515.26
Right Abut	7	29	1.167	0.150	35.54		14.50	515.26
Base slab	1.25	29.00	8.33	0.150	45.29		14.50	656.77
Bridge slab	1	18	7.33	0.150	19.79		9.00	178.12
U/S Grating	1	2	5					
Stoplogs	2.6							
		19.25						
		29.00						
Avg MoistSoil Heel (both)	3.72	28.48						
Avg SatSoilHeel(both)	3.28	28.48	1	0.115	10.74		14.50	155.77
Truck					0.00		9.00	0.00
Driving Water	6.51		8.33	0.063		11.03	2.17	23.94
Resiting Water	2.55		8.33	0.063		-1.69	0.85	-1.44
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	2.55	29.00	8.33	0.063	-38.50		14.50	-558.25
Uplift D/S Tri	3.96	29.00	8.33	0.063	-29.89		9.67	-288.98
Resultant loads					132.14	9.34		1859.05

Floatation ANALYSIS

Ws =	194.59	SFf = Ws+Wc+S/U-Wg	3.12
Wc =	0		
S =	0		
U =	68.39		
Wg	5.94		

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith	Chkd: By	Date:	PC File: Calc_Sht .xls

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical =	14.07	FT	
e, eccentricity = B/2 - Xbar =	0.43	FT	
Kern, Base Length/6 =	4.83	FT	OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake side) (PSF)
547.00	5.86	-5.86	541.14	552.85

Percent Base in Compression 100 percent

SLIDING ANALYSIS

Neglect side friction along abutments

c, cohesion	0	
ø, foundation =	22	degrees
N' = NET VERTICAL LOAD	15.86	kips/foot of width
Lslide = EFFECTIVE BASE WIDTH =	29	FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase =	6.41	kips
NET HORIZONTAL LOAD =	1.12	kips

FS AGAINST SLIDING = 5.72

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Normal Lake Level no water in Channel	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Normal Lake Level no water in Channel

Normal high pool with no water MN river water from backing into channel

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall	699.00	ft	Wall length =	29.00	ft
Base slab thick	1.25	ft	Base width	8.33	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	7.33	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	693.00	ft	Heel width	0.50	
LAKE POOL ELEV	696.50	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	1.25	ft
Pressure Head at C (D/S Edge)	4.75	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	4.75	

Forces: Horizontal, Vertical and Moment about Downstream Edge **NOTE Driving Direction is toward lake**

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7	29	1.167	0.150	35.54		14.50	515.26
Right Abut	7	29	1.167	0.150	35.54		14.50	515.26
Base slab	1.25	29.00	8.33	0.150	45.29		14.50	656.77
Bridge slab	1	18	7.33	0.150	19.79		9.00	178.12
U/S Grating	1	2	5					
Stoplogs	7							
		19.25						
		29.00						
Avg MoistSoil Heel (both)	5.25	28.48						
Avg SatSoilHeel(both)	1.75	28.48	1	0.115	5.73		14.50	83.11
Truck					0.00		9.00	0.00
Resisting Water	1.25		8.33	0.063		0.41	0.42	0.17
Driving Water	4.75		8.33	0.063		-5.87	1.58	-9.30
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	1.25	29.00	8.33	0.063	-18.87		14.50	-273.65
Uplift D/S Tri	3.50	29.00	8.33	0.063	-26.42		19.33	-510.82
Resultant loads					127.53	-5.47		1707.83

Floatation ANALYSIS

Ws =	169.65	SFf = Ws+Wc+S/U-Wg	4.03
Wc =	0		
S =	0		
U =	45.29		
Wg	3.17		

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Normal Lake Level no water in Channel	Chkd: By	Date:	PC File: Calc_Sht .xls

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical =	13.39	FT	
e, eccentricity = B/2 - Xbar =	1.11	FT	
Kern, Base Length/6 =	4.83	FT	OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake Side) (PSF)
527.92	14.53	-14.53	542.46	513.39

Percent Base in Compression 100 percent

SLIDING ANALYSIS

Neglect side friction along abutments

c, cohesion	0	
ø, foundation =	22	degrees
N' = NET VERTICAL LOAD	15.31	kips/foot of width
Lslide = EFFECTIVE BASE WIDTH =	29	FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase =	6.19	kips
NET HORIZONTAL LOAD =	0.66	kips
FS AGAINST SLIDING =	9.43	

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Construction	Chkd: By	Date:	PC File: Calc_Sht .xls

Control Structure, Construction/Maintenance

Prevent MN river water from backing into Long Meadow Lake.

Stability Calculations

Top of structure	700.00	ft	Base Length	29.00	ft
Top of wall	699.00	ft	Wall length =	29.00	ft
Base slab thick	1.25	ft	Base width	8.33	ft
Base skab elev	691.75	ft	Top slab thic	1.00	ft
Wall thick	1.17	ft	Top slab length	18.00	ft
Bay width	5.00	ft	Top slab width	7.33	ft
Bottom of wall	693.00	ft	Length to SP	1.00	
RIVER ELEV	691.75	ft	Heel width	0.50	
LAKE POOL ELEV	691.75	ft	Moist Soil Unit Weight	0.11	
				0.12	

Uplift/Seepage Analysis:

Pressure Head at B (U/S Sheet Pile)	0.00	ft
Pressure Head at C (D/S Edge)	0.00	
Sheet pile effeciency	0	percent
Pressure Head at B' (D/S Sheet Pile)	0.00	

Forces: Horizontal, Vertical and Moment about Downstream Edge **NOTE Driving Direction is toward lake**

Item	Height ft	Length ft	Width ft	Unit Weight kcf	Fv kip	Fh kip	Arm ft	Moment k-ft
Left Abut	7	29	1.167	0.150	35.54		14.50	515.26
Right Abut	7	29	1.167	0.150	35.54		14.50	515.26
Base slab	1.25	29.00	8.33	0.150	45.29		14.50	656.77
Bridge slab	1	18	7.33	0.150	19.79		9.00	178.12
U/S Grating	1	2	5	0.014	0.14		19.25	2.70
Stoplogs	0	5.5		5.59	0.00		19.25	0.00
Bay Water U/S stoplog	0.00	9.75	5.00	0.063	0.00		24.13	0.00
Bay Water D/S	0.00	19.25	5.00	0.063	0.00		9.63	0.00
Weight of water on Heel	0.00	29.00	1	0.063	0.00		14.50	0.00
Avg MoistSoil Heel (both)	7	28.48	1	0.112	22.33		14.50	323.76
Avg SatSoilHeel(both)	0	28.48	1	0.115	0.00		14.50	0.00
Truck					34.00		9.00	306.00
Resisting Water	0.00		8.33	0.063		0.00	0.00	0.00
Driving Water	0.00		8.33	0.063		0.00	0.00	0.00
Resisting Soil(neglect due to scour)								
Uplift D/S Rec	0.00	29.00	8.33	0.063	0.00		14.50	0.00
Uplift D/S Tri	0.00	29.00	8.33	0.063	0.00		19.33	0.00
Resultant loads					192.62	0.00		2497.86

Floatation ANALYSIS

Ws =	158.62	SFf = Ws+Wc+S/U-Wg	1586.24
Wc =	0		
S =	0		
U =	0.10		
Wg	0.00		

US Army Corps of Engineers St. Paul District	Project: Bass Ponds 1 bay WCS	Comp. By TSF	Date: 10/12/2018	Sheet:
	Subject: Control Structure -Stoplog Monolith Normal Lake Level no water in Channel	Chkd: By	Date:	PC File: Calc_Sht .xls

OVERTURNING ANALYSIS

Xbar = SUMmoment/SUMvertical = 12.97 FT
e, eccentricity = B/2 - Xbar = 1.53 FT
Kern, Base Length/6 = 4.83 FT OK

EFFECTIVE BASE PRESSURES:

P/A (PSF)	6*Pe/B*H^2 (PSF)	-6*Pe/B*H^2 (PSF)	U/S (PSF)	D/S (Lake Side) (PSF)
797.38	30.35	-30.35	827.73	767.03

Percent Base in Compression 100 percent

SLIDING ANALYSIS

Neglect side friction along abutments

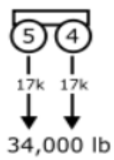
c, cohesion 0
ø, foundation = 22 degrees
N' = NET VERTICAL LOAD 23.12 kips/foot of width
Lslide = EFFECTIVE BASE WIDTH = 29 FT

SLIDING RESISTENCE = N'*TAN(PHIbase) + Cbase = 9.34 kips
NET HORIZONTAL LOAD = 0.10 kips

FS AGAINST SLIDING = 93.43

US Army Corps of Engineers St. Paul District	Project: Bass Ponds WCS	Comp. By TSF	Date: 10/12/2018	Sheet:	
	Subject: Bridge Grating	Chkd: By	Date:	PC File: Calc_Sht .xls	

Bridge Grating



The contructure bridge is being designed to allow for maintenance type vehicles. This would include a tandem dump truck (3 axle,GVW~40,000lbs). Minnesota follows the Federal Bridge Formula which has Vehicle Weight Limits. The maximum weight allowed on a single axle is 20,000 lbs. The maximum total weight allowed on any two consecutive axles spaced eight or fewer feet apart (like dump tandem axles) is 34,000 lbs. The maximum Gross Vehicle Weight (GVW) on Interstate highways is 80,000 lbs, even if formula results in a higher value. Because of the control structures has short spans(60 inches) a typical AASHTO design truck would only be have one axle on the bridge at any time. For example a typical tandem-axle set-up are only spaced 55" apart and would have a max combined axle load of 34,000 lbs. Therefore the single axle, 20,000 lbs maximum will govern.
Minnesota Vehicle Size Limits
Width: The maximum width of a vehicle is 102 inches. Length: The maximum length of a straight truck is 45 feet (ie dump truck, semis can be longer). Height: The maximum height of a vehicle is 13 feet 6 inches

Loading

Per AASHTO Pedestrian Bridge Manual, Minimum maintenance vehicle is an H-10, given

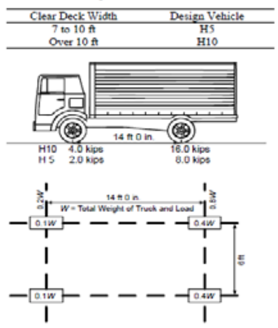


Table 3.2-1—Design Vehicle

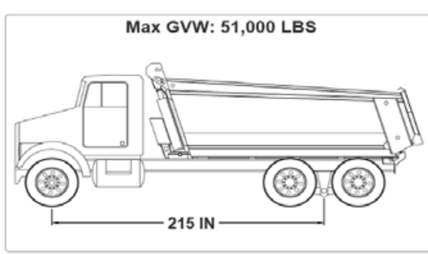
Clear Deck Width	Design Vehicle
7 to 10 ft	H5
Over 10 ft	H10

Figure 3.2-1—Maintenance Vehicle Configurations

During design is was discussed a load of rock may be required to cross the bridge, so a H-20 truck is considered.

	GVW Ton	Front Axle	Rear Axle
H-5	5	2000	8000
H-10	10	4000	16000
H-15	15	6000	24000
H-20	20	8000	32000

As stated above top concrete slab will be checked for the MN max axle load of 20,000 lbs. The 20,000 lbs single axle load would represent the front axle of an off-road tandem dump truck. An over the road tandem dump truck would have a front axle(single tire) load of about 17,000 lbs

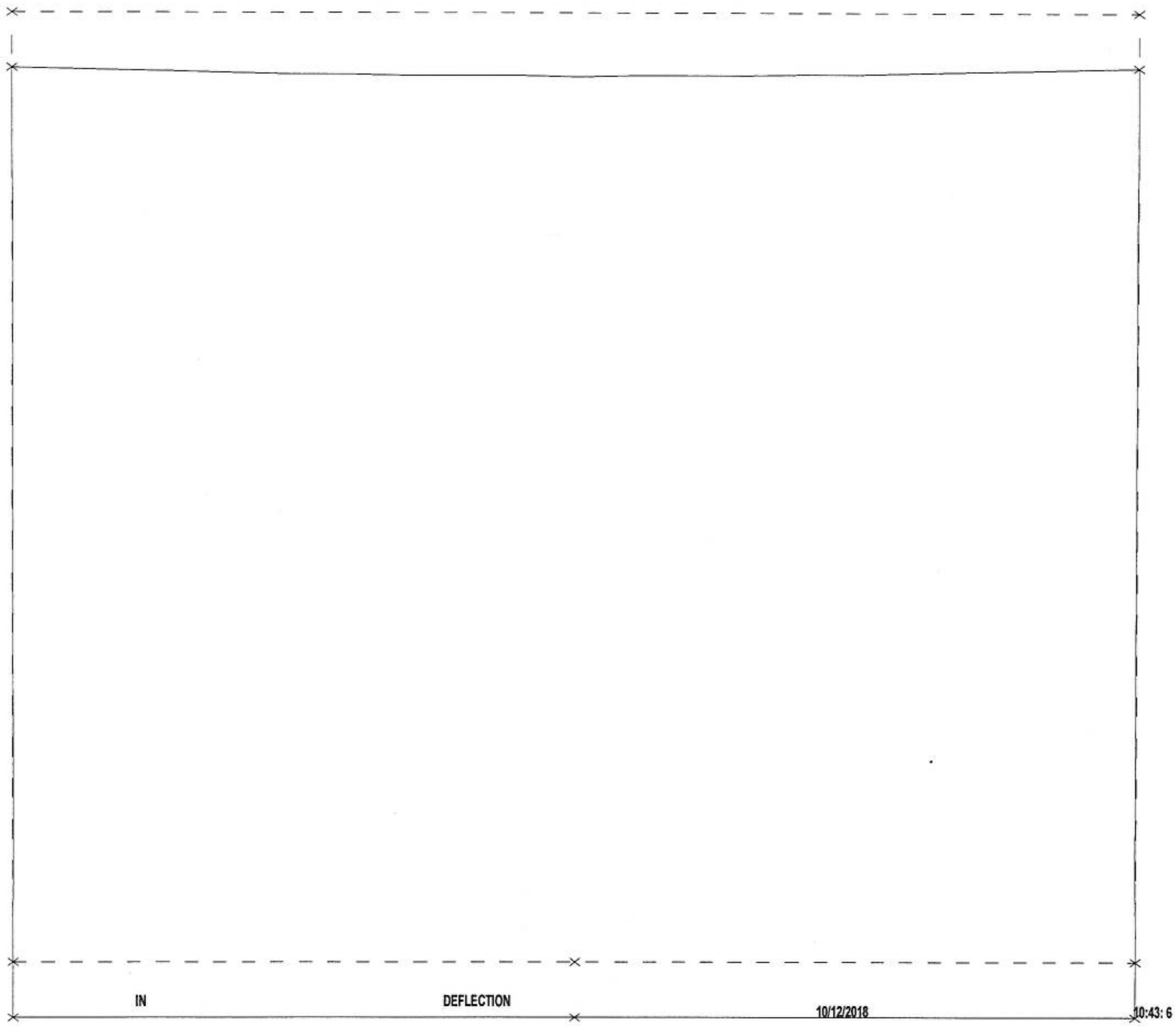


Front	Rear
≈0.33 W	≈0.67 W

https://www.superdumps.com/bridge_laws/

Load will be used in CFRAME analysis

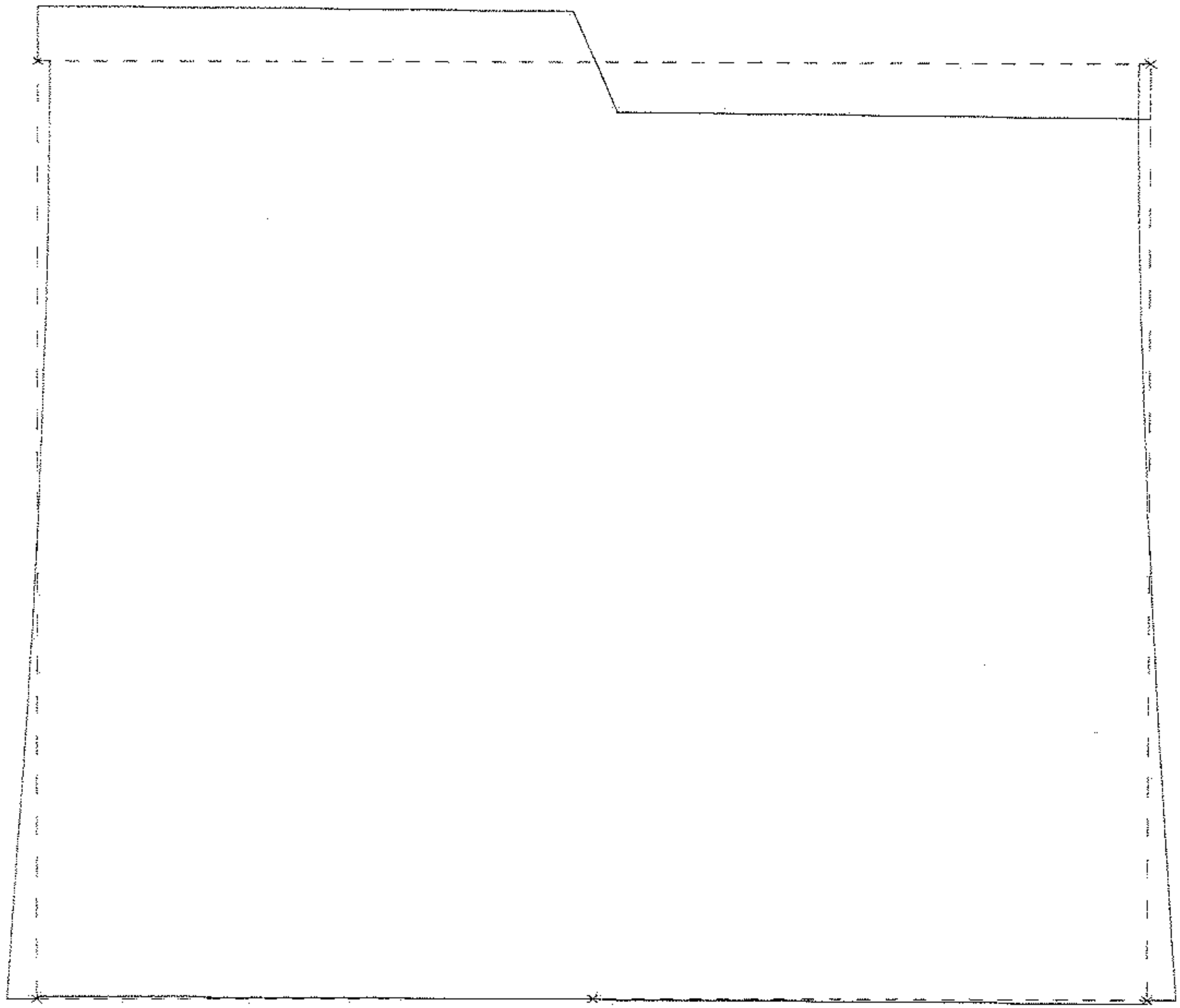
CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY , slab on Top



= 0.14 IN DEFLECTION 10/12/2018 10:43: 6

LOAD CASE 2 NORMAL WATER PLUS TRUCK

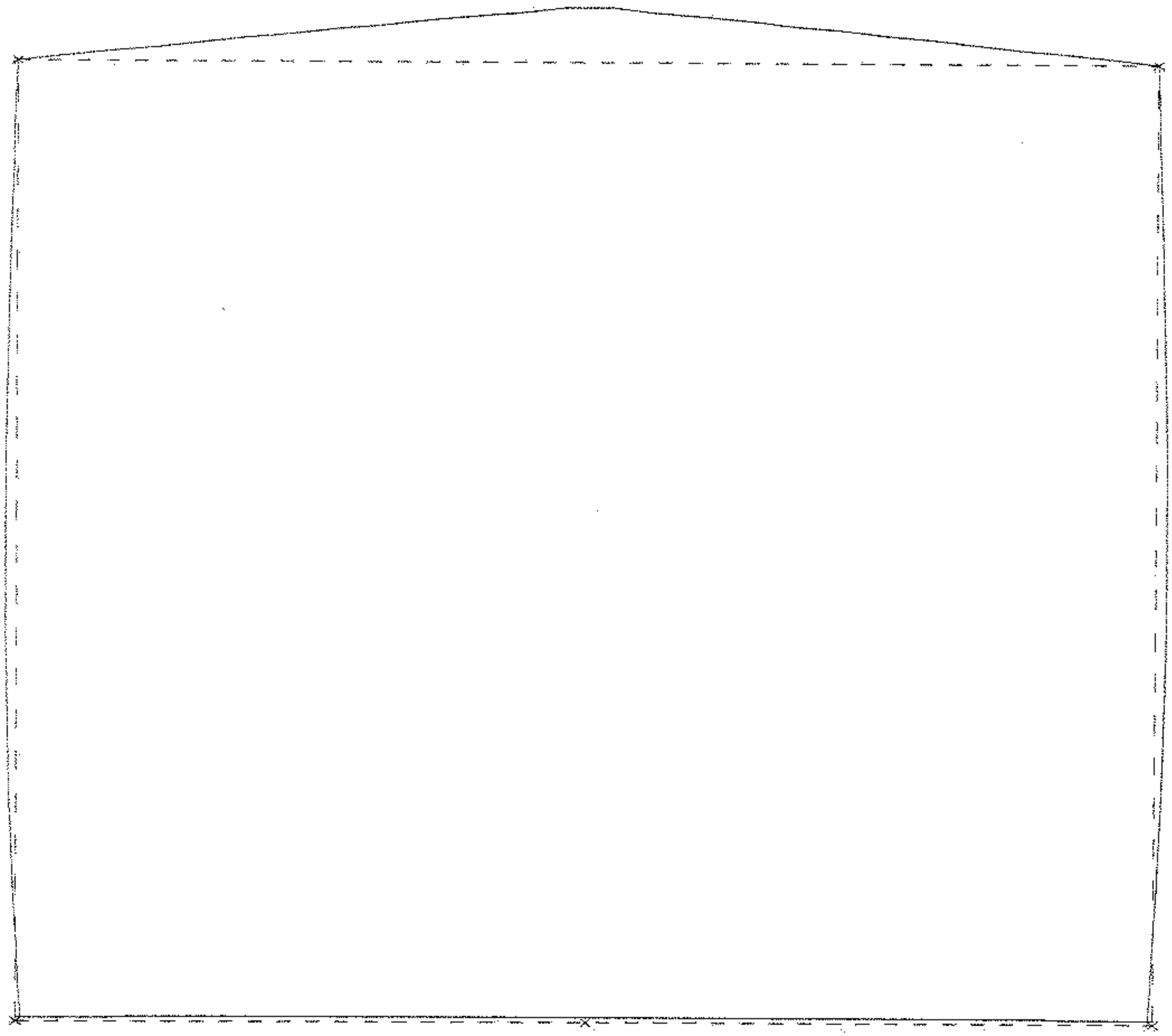
CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY



= 5.48 KIP SHEAR 10/12/2018 10:43: 6

LOAD CASE 2 NORMAL WATER PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY



= 201.22 IN-KIP MOMENT 10/12/2018 10:43: 6

LOAD CASE 2 NORMAL WATER PLUS TRUCK

PROGRAM CFRAME V02.05 24JUL84
--*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*

RUN DATE = 10/11/2018
RUN TIME = 14:10:59

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY

*** JOINT DATA ***

			------------------FIXITY-------------------					
JOINT	X	Y	X	Y	R	KX	KY	KR
	---FT	---				---KIP /IN	---	IN -KIP/RAD
1	0.00	0.00				0.500E+02	0.500E+02	
2	3.20	0.00					0.100E-01	
3	6.40	0.00				0.500E+02	0.500E+02	
4	0.00	7.50				0.100E-01		
5	6.40	7.50				0.100E-01		

*** MEMBER DATA ***

MEMBER	END A	END B	LENGTH FT	I IN **4	A IN **2	AS IN **2	E KSI	G KSI
1	1	2	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
2	2	3	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
3	4	5	6.40	0.1728E+04	0.1440E+03	0.1440E+03	0.3000E+04	0.1250E+04
4	1	-4	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04
5	3	-5	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04

*** LOAD CASE 1 NORMAL WATER

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	0.1500E+00	6.40	0.1500E+00	0.00
4	0.00	0.9000E+00	7.50	0.0000E+00	0.00
4	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
5	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	0.2200E+00	3.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP

1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 2 NORMAL WATER PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	0.1500E+00	6.40	0.1500E+00	0.00
4	0.00	0.9000E+00	7.50	0.0000E+00	0.00
4	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
5	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	0.2200E+00	3.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.1500E+00	6.40	0.1500E+00	0.00
4	0.00	0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

MEMBER	L FT	P KIP	ANGLE DEG
3	3.20	0.1000E+02	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 4 CONSTRUCTION PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.1500E+00	6.40	0.1500E+00	0.00
4	0.00	0.9000E+00	7.50	0.0000E+00	0.00
5	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

MEMBER	L FT	P KIP	ANGLE DEG
3	3.20	0.1000E+02	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

1 LOAD CASE 1 NORMAL WATER

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1487E-03	-0.4284E-01	-0.7619E-04
2	0.0000E+00	-0.4441E-01	0.0000E+00
3	-0.1487E-03	-0.4284E-01	0.7619E-04
4	0.7928E-04	-0.4292E-01	-0.4551E-04
5	-0.7928E-04	-0.4292E-01	0.4551E-04

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2091E+01	0.3518E+00	0.1559E+02	0.2234E+02	38.40
	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.1559E+02	0.00
2	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.2234E+02	0.00
	3	-0.2091E+01	0.3518E+00	0.1559E+02	0.1559E+02	38.40
3	4	-0.8919E+00	0.4800E+00	0.0000E+00	0.9216E+01	38.40
	5	-0.8919E+00	0.4800E+00	0.0000E+00	0.0000E+00	0.00
4	1	-0.4800E+00	0.2098E+01	-0.1559E+02	0.2750E+02	43.20
	4	-0.4800E+00	0.8919E+00	0.0000E+00	-0.1559E+02	0.00
5	3	-0.4800E+00	-0.2098E+01	0.1559E+02	0.1559E+02	0.00
	5	-0.4800E+00	-0.8919E+00	0.0000E+00	-0.2750E+02	43.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.7433E-02	0.2142E+01	0.0000E+00
2	0.0000E+00	0.4441E-03	0.0000E+00
3	0.7433E-02	0.2142E+01	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00
5	0.0000E+00	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.4284E+01	

1 LOAD CASE 2 NORMAL WATER PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1487E-03	-0.4284E-01	-0.7619E-04
2	0.0000E+00	-0.4441E-01	0.0000E+00
3	-0.1487E-03	-0.4284E-01	0.7619E-04
4	0.7928E-04	-0.4292E-01	-0.4551E-04
5	-0.7928E-04	-0.4292E-01	0.4551E-04

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2091E+01	0.3518E+00	0.1559E+02	0.2234E+02	38.40
	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.1559E+02	0.00
2	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.2234E+02	0.00
	3	-0.2091E+01	0.3518E+00	0.1559E+02	0.1559E+02	38.40
3	4	-0.8919E+00	0.4800E+00	0.0000E+00	0.9216E+01	38.40
	5	-0.8919E+00	0.4800E+00	0.0000E+00	0.0000E+00	0.00
4	1	-0.4800E+00	0.2098E+01	-0.1559E+02	0.2750E+02	43.20
	4	-0.4800E+00	0.8919E+00	0.0000E+00	-0.1559E+02	0.00
5	3	-0.4800E+00	-0.2098E+01	0.1559E+02	0.1559E+02	0.00
	5	-0.4800E+00	-0.8919E+00	0.0000E+00	-0.2750E+02	43.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.7433E-02	0.2142E+01	0.0000E+00
2	0.0000E+00	0.4441E-03	0.0000E+00
3	0.7433E-02	0.2142E+01	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00
5	0.0000E+00	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.4284E+01	

1 LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1731E-03	-0.1428E+00	-0.8291E-04
2	0.0000E+00	-0.1445E+00	0.0000E+00
3	-0.1731E-03	-0.1428E+00	0.8291E-04
4	0.8284E-04	-0.1438E+00	-0.7566E-03
5	-0.8285E-04	-0.1438E+00	0.7566E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2434E+01	0.3513E+00	0.1737E+02	0.2410E+02	38.40
	2	-0.2434E+01	0.7226E-03	0.2410E+02	0.1737E+02	0.00
2	2	-0.2434E+01	0.7226E-03	0.2410E+02	0.2410E+02	0.00
	3	-0.2434E+01	0.3513E+00	0.1737E+02	0.1737E+02	38.40
3	4	-0.9320E+00	0.5480E+01	0.0000E+00	0.2012E+03	38.40
	5	-0.9320E+00	0.5480E+01	0.0000E+00	0.0000E+00	0.00
4	1	-0.5480E+01	0.2443E+01	-0.1737E+02	0.2938E+02	43.20
	4	-0.5480E+01	0.9320E+00	0.0000E+00	-0.1737E+02	0.00
5	3	-0.5480E+01	-0.2443E+01	0.1737E+02	0.1737E+02	0.00
	5	-0.5480E+01	-0.9320E+00	0.0000E+00	-0.2938E+02	43.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.8655E-02	0.7141E+01	0.0000E+00
2	0.0000E+00	0.1445E-02	0.0000E+00
3	0.8655E-02	0.7141E+01	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00
5	0.0000E+00	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.1428E+02	

1 LOAD CASE 4 CONSTRUCTION PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1718E-03	-0.1479E+00	-0.8906E-04
2	0.0000E+00	-0.1498E+00	0.0000E+00

3	-0.1718E-03	-0.1479E+00	0.8906E-04
4	0.8448E-04	-0.1489E+00	-0.7566E-03
5	-0.8448E-04	-0.1489E+00	0.7566E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2416E+01	0.6073E+00	0.1571E+02	0.2736E+02	38.40
	2	-0.2416E+01	0.7492E-03	0.2736E+02	0.1571E+02	0.00
2	2	-0.2416E+01	0.7492E-03	0.2736E+02	0.2736E+02	0.00
	3	-0.2416E+01	0.6073E+00	0.1571E+02	0.1571E+02	38.40
3	4	-0.9504E+00	0.5480E+01	0.0000E+00	0.2012E+03	38.40
	5	-0.9504E+00	0.5480E+01	0.0000E+00	0.0000E+00	0.00
4	1	-0.5480E+01	0.2425E+01	-0.1571E+02	0.3025E+02	41.40
	4	-0.5480E+01	0.9504E+00	0.0000E+00	-0.1571E+02	0.00
5	3	-0.5480E+01	-0.2425E+01	0.1571E+02	0.1571E+02	0.00
	5	-0.5480E+01	-0.9504E+00	0.0000E+00	-0.3025E+02	41.40

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.8590E-02	0.7397E+01	0.0000E+00
2	0.0000E+00	0.1498E-02	0.0000E+00
3	0.8590E-02	0.7397E+01	0.0000E+00
4	0.0000E+00	0.0000E+00	0.0000E+00
5	0.0000E+00	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.1480E+02	

1 MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	1	-0.2091E+01	0.3518E+00	0.1559E+02	0.2234E+02	38.40
		2	-0.2091E+01	0.2221E-03	0.2234E+02	0.1559E+02	0.00
	2	1	-0.2091E+01	0.3518E+00	0.1559E+02	0.2234E+02	38.40
		2	-0.2091E+01	0.2221E-03	0.2234E+02	0.1559E+02	0.00
	3	1	-0.2434E+01	0.3513E+00	0.1737E+02	0.2410E+02	38.40
		2	-0.2434E+01	0.7226E-03	0.2410E+02	0.1737E+02	0.00
	4	1	-0.2416E+01	0.6073E+00	0.1571E+02	0.2736E+02	38.40
		2	-0.2416E+01	0.7492E-03	0.2736E+02	0.1571E+02	0.00
2	1	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.2234E+02	0.00
		3	-0.2091E+01	0.3518E+00	0.1559E+02	0.1559E+02	38.40
	2	2	-0.2091E+01	0.2221E-03	0.2234E+02	0.2234E+02	0.00
		3	-0.2091E+01	0.3518E+00	0.1559E+02	0.1559E+02	38.40
	3	2	-0.2434E+01	0.7226E-03	0.2410E+02	0.2410E+02	0.00
		3	-0.2434E+01	0.3513E+00	0.1737E+02	0.1737E+02	38.40
	4	2	-0.2416E+01	0.7492E-03	0.2736E+02	0.2736E+02	0.00
		3	-0.2416E+01	0.6073E+00	0.1571E+02	0.1571E+02	38.40

3	1	4	-0.8919E+00	0.4800E+00	0.0000E+00	0.9216E+01	38.40
		5	-0.8919E+00	0.4800E+00	0.0000E+00	0.0000E+00	0.00
	2	4	-0.8919E+00	0.4800E+00	0.0000E+00	0.9216E+01	38.40
		5	-0.8919E+00	0.4800E+00	0.0000E+00	0.0000E+00	0.00
	3	4	-0.9320E+00	0.5480E+01	0.0000E+00	0.2012E+03	38.40
		5	-0.9320E+00	0.5480E+01	0.0000E+00	0.0000E+00	0.00
	4	4	-0.9504E+00	0.5480E+01	0.0000E+00	0.2012E+03	38.40
		5	-0.9504E+00	0.5480E+01	0.0000E+00	0.0000E+00	0.00
4	1	1	-0.4800E+00	0.2098E+01	-0.1559E+02	0.2750E+02	43.20
		4	-0.4800E+00	0.8919E+00	0.0000E+00	-0.1559E+02	0.00
	2	1	-0.4800E+00	0.2098E+01	-0.1559E+02	0.2750E+02	43.20
		4	-0.4800E+00	0.8919E+00	0.0000E+00	-0.1559E+02	0.00
	3	1	-0.5480E+01	0.2443E+01	-0.1737E+02	0.2938E+02	43.20
		4	-0.5480E+01	0.9320E+00	0.0000E+00	-0.1737E+02	0.00
	4	1	-0.5480E+01	0.2425E+01	-0.1571E+02	0.3025E+02	41.40
		4	-0.5480E+01	0.9504E+00	0.0000E+00	-0.1571E+02	0.00
5	1	3	-0.4800E+00	-0.2098E+01	0.1559E+02	0.1559E+02	0.00
		5	-0.4800E+00	-0.8919E+00	0.0000E+00	-0.2750E+02	43.20
	2	3	-0.4800E+00	-0.2098E+01	0.1559E+02	0.1559E+02	0.00
		5	-0.4800E+00	-0.8919E+00	0.0000E+00	-0.2750E+02	43.20
	3	3	-0.5480E+01	-0.2443E+01	0.1737E+02	0.1737E+02	0.00
		5	-0.5480E+01	-0.9320E+00	0.0000E+00	-0.2938E+02	43.20
	4	3	-0.5480E+01	-0.2425E+01	0.1571E+02	0.1571E+02	0.00
		5	-0.5480E+01	-0.9504E+00	0.0000E+00	-0.3025E+02	41.40

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, Slab on Top	CHK BY:		

Design Information:

Data below are from analysis performed by CFRAME

Design Service Load

A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Middle	*0.89*	0.48	9.21	0.93	5.50	201.30	0.93	5.50	201.30	0.95	5.50	182.20
Side Wall @ Middle	*0.48*	2.10	27.50	5.48	2.40	17.40	5.48	2.40	29.40	5.48	2.40	30.20
Side Wall @Bottom	*0.48*	2.10	15.60	5.48	2.40	29.40	5.48	2.40	17.40	5.48	2.40	15.70
Bottom Slab @ Side wall	*2.10*	0.35	15.59	2.43	0.35	24.10	2.43	0.35	24.10	2.43	0.61	15.70
Bottom Slab @ Middle	*2.10*	0.10	22.30	2.43	0.35	24.10	2.43	0.35	24.10	2.43	0.01	27.30

Design Load Factor

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Side Wall @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Side Wall @Bottom	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Side wall	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66

Design Factored Load

A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Top Slab @ Middle	*1.97*	*1.06*	*20.35*	*1.54*	*9.13*	*334.16*	*1.54*	*9.13*	*334.16*	*1.58*	*9.13*	*302.45*
Side Wall @ Middle	*1.06*	*4.64*	*60.78*	*9.10*	*3.98*	*28.88*	*9.10*	*3.98*	*48.80*	*9.10*	*3.98*	*50.13*
Side Wall @Bottom	*1.06*	*4.64*	*34.48*	*9.10*	*3.98*	*48.80*	*9.10*	*3.98*	*28.88*	*9.10*	*3.98*	*26.06*
Bottom Slab @ Side wall	*4.64*	*0.77*	*34.45*	*4.03*	*0.58*	*40.01*	*4.03*	*0.58*	*40.01*	*4.03*	*1.01*	*26.06*
Bottom Slab @ Middle	*4.64*	*0.22*	*49.28*	*4.03*	*0.58*	*40.01*	*4.03*	*0.58*	*40.01*	*4.03*	*0.02*	*45.32*

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, Slab on Top	CHK BY:		

Top Slab @ Middle

Thickness	1.00	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	0.750	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	9.130	kips
Moment (M) =	27.847	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 9.13 kips

d min =	8.02	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	8.63			
ϕ Vc =	9.82	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.74	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**27.85**	**kip-ft**	[(M)(DLF)]
As =	0.77	in^2	[solved for based on above formula]

As Minimum

As, min =	0.35	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	1.02	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.13	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.20	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	6.00	in	**Use # 6 @ 6"**
Total Steel =	0.88	in^2	

Spacing Maximum

			fs = 4.93 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, Slab on Top	CHK BY:		

Side Wall @ Maximum Positive Momment Near Middle

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	1.00
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	2.21

Moment and Shear

Shear (V) =	4.641	kips
Moment (M) =	5.065	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	4.64	kips		
d min =	4.08	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**5.06**	**kip-ft**	[(M)(DLF)]
As =	0.11	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.14	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

			fs = 1.22 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, Slab on Top	CHK BY:		

Side Wall @Bottom

Thickness	1.17	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.000	inches	ϕ shear =	0.75
T & S Steel Dia. =	0.75	inches	ϕ moment =	0.90
Required Concrete Cover =	3.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

<u>Moment and Shear</u>

Shear (V) =	3.984	kips
Moment (M) =	4.067	kip-ft

<u>Minimum Depth based on Shear</u>

Vu=(DLF)(V) ==> Vu =	3.98	kips		
d min =	3.50	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50			
ϕ Vc =	11.96	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

<u>As Maximum</u>

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.90	in^2	[(ρ max)(bw)(d)]	

<u>As Required</u>

ϕMn = Mu   where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**4.07**	**kip-ft**	[(M)(DLF)]
As =	0.09	in^2	[solved for based on above formula]

<u>As Minimum</u>

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.12	in^2	[4/3 As required]	ACI 10.5.3

<u>As Temperature and Shrinkage (per side)</u>

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

<u>As Design</u>

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

<u>Spacing Maximum</u>

		fs = 0.98	=M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00 in**	[(15*(40/fs)-2.5Cc]		ACI 10.6.4

Bottom Slan @ Side Wall

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear =	0.75
T & S Steel Dia. =	1.000	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) = 0.581 kips

Moment (M) = 3.334 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 0.58 kips

d min =	0.51	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**3.33**	**kip-ft**	[(M)(DLF)]
As =	0.07	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.10	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum — fs = 0.81 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*(40/fs)-2.5Cc] ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, Slab on Top	CHK BY:		

Bottom Slab @ Middle

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	φ shear =	0.75
T & S Steel Dia. =	1.000	inches	φ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	1.00
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	2.21

Moment and Shear

Shear (V) = 0.221 kips
Moment (M) = 4.107 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	0.22	kips		
d min =	0.19	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
φ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**4.11**	**kip-ft**	[(M)(DLF)]
As =	0.09	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.12	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

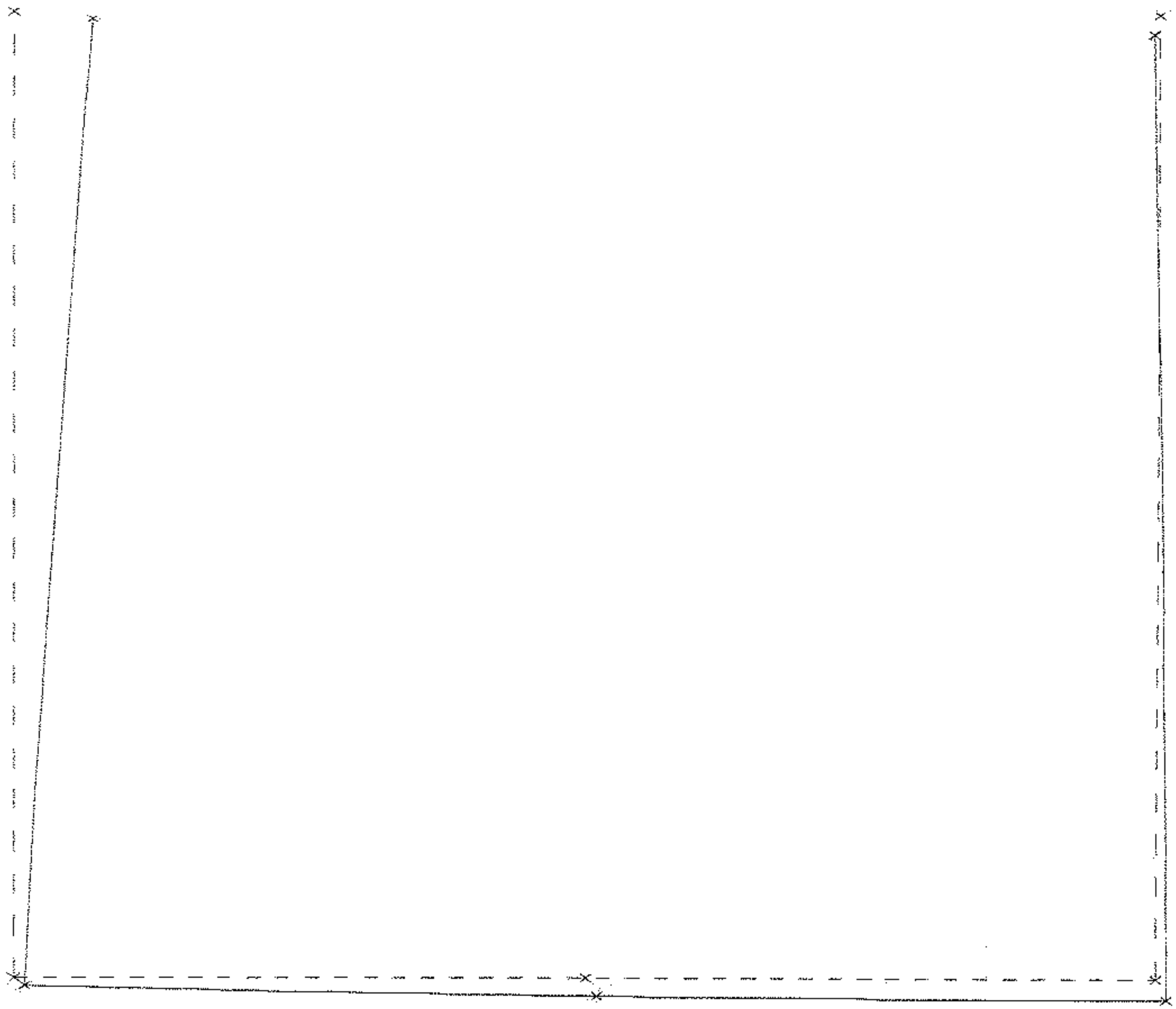
As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum — fs = 1.00 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*(40/fs)-2.5Cc] ACI 10.6.4

CFRAME BASS PONDS BLUE LAKE WATCONTROL STRUCTURE 1 BAY U @ End



= 0.14 IN DEFLECTION 10/12/2018 10:43:47

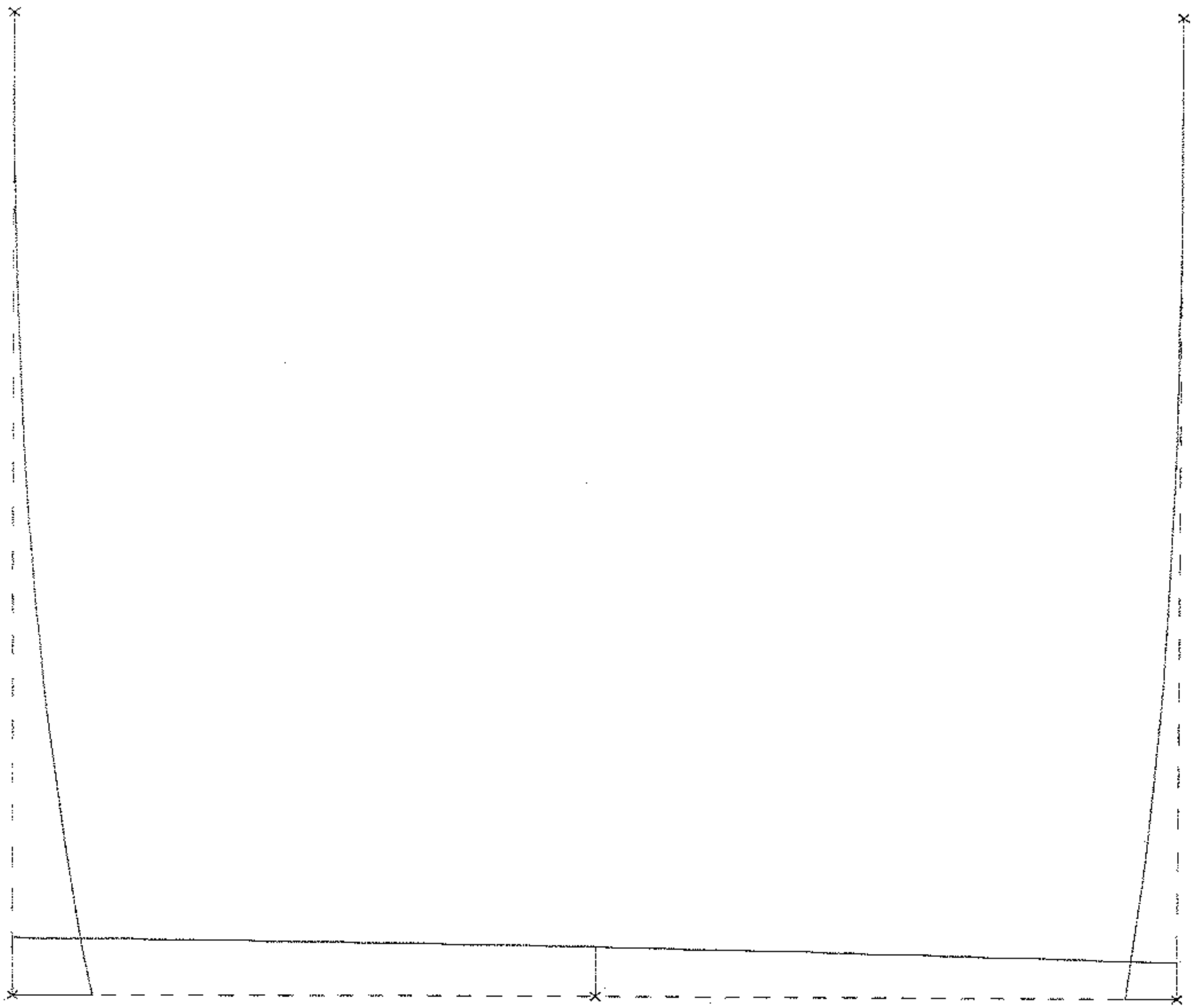
LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE R/CONTROL STRUCTURE 1 BAY U

= 4.31 KIP SHEAR 10/12/2018 10:43:47

LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

CFRAME BASS PONDS BLUE LAKE WATCONTROL STRUCTURE 1 BAY U



= 157.38 IN-KIP MOMENT 10/12/2018 10:43:47

LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

PROGRAM CFRAME V02.05 24JUL84
--*-*-*-*-*-*-*-*-*-*-*-*-*-*-*

RUN DATE = 10/11/2018
RUN TIME = 13:44:10

CFRAME BASS PONDS BLUE LAKE WATER CONTROL STRUCTURE 1 BAY U

*** JOINT DATA ***

JOINT	X	Y	X	Y	R	KX	KY	KR
	---FT	---				---KIP /IN	---	IN -KIP/RAD
1	0.00	0.00				0.100E-01	0.500E+02	
2	3.20	0.00					0.100E-01	
3	6.40	0.00				0.500E+02	0.500E+02	
4	0.00	7.50				0.100E-01		
5	6.40	7.50				0.100E-01		

(FIXITY spans columns X Y R through KR)

*** MEMBER DATA ***

MEMBER	END A	END B	LENGTH FT	I IN **4	A IN **2	AS IN **2	E KSI	G KSI
1	1	2	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
2	2	3	3.20	0.3375E+04	0.1800E+03	0.1800E+03	0.3000E+04	0.1250E+04
3	1	4	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04
4	3	5	7.50	0.2744E+04	0.1680E+03	0.1680E+03	0.3000E+04	0.1250E+04

*** LOAD CASE 1 NORMAL WATER

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	0.9000E+00	7.50	0.0000E+00	0.00
3	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
4	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
4	0.00	0.2200E+00	3.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 2 NORMAL WATER PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
1	0.00	0.2200E+00	3.20	0.2200E+00	0.00
2	0.00	-0.3000E+00	3.20	-0.3000E+00	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	0.2200E+00	3.20	0.2200E+00	0.00
3	0.00	0.9000E+00	7.50	0.0000E+00	0.00
3	0.00	-0.2200E+00	3.50	0.0000E+00	0.00
3	0.00	0.0000E+00	7.50	0.2500E+00	0.00
4	0.00	-0.9000E+00	7.50	0.0000E+00	0.00
4	0.00	0.2200E+00	3.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00
2	0.00	-0.8000E-01	3.20	-0.8000E-01	0.00
2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.9000E+00	7.50	0.0000E+00	0.00
3	0.00	0.0000E+00	7.50	0.2500E+00	0.00
4	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

*** LOAD CASE 4 CONSTRUCTION PLUS TRUCK

MEMBER	LA FT	PA KIP /FT	LB FT	PB KIP /FT	ANGLE DEG
1	0.00	0.1900E+00	3.20	0.1900E+00	0.00

2	0.00	0.1900E+00	3.20	0.1900E+00	0.00
3	0.00	0.9000E+00	7.50	0.0000E+00	0.00
3	0.00	0.0000E+00	7.50	0.2500E+00	0.00
4	0.00	-0.9000E+00	7.50	0.0000E+00	0.00

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT FT -KIP
1	0.0000E+00	-0.1310E+01	0.0000E+00
3	0.0000E+00	-0.1310E+01	0.0000E+00

1 LOAD CASE 1 NORMAL WATER

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.4250E-03	-0.3324E-01	-0.3804E-03
2	0.2124E-03	-0.4065E-01	0.0000E+00
3	0.0000E+00	-0.3324E-01	0.3804E-03
4	0.5443E-01	-0.3324E-01	-0.6500E-03
5	-0.5401E-01	-0.3324E-01	0.6500E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.2989E+01	0.3518E+00	0.9581E+02	0.1026E+03	38.40
	2	-0.2989E+01	0.1983E-03	0.1026E+03	0.9581E+02	0.00
2	2	-0.2989E+01	0.2082E-03	0.1026E+03	0.1026E+03	0.00
	3	-0.2989E+01	0.3518E+00	0.9581E+02	0.9581E+02	38.40
3	1	0.0000E+00	0.2989E+01	-0.9581E+02	0.1872E-03	88.20
	4	0.0000E+00	0.5443E-03	0.0000E+00	-0.9581E+02	0.00
4	3	0.0000E+00	-0.2989E+01	0.9581E+02	0.9581E+02	0.00
	5	0.0000E+00	-0.5401E-03	0.0000E+00	-0.1795E-03	88.20

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	0.0000E+00	0.1662E+01	0.0000E+00
2	0.0000E+00	0.4065E-03	0.0000E+00
3	0.0000E+00	0.1662E+01	0.0000E+00
4	-0.5443E-03	0.0000E+00	0.0000E+00
5	0.5401E-03	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.3324E+01	

1 LOAD CASE 2 NORMAL WATER PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1928E-01	-0.1862E-01	-0.9065E-03
2	0.1900E-01	-0.4270E-01	-0.3662E-03
3	0.1872E-01	-0.4785E-01	0.6764E-04
4	0.1361E+00	-0.1862E-01	-0.1406E-02
5	-0.7149E-02	-0.4785E-01	0.3375E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.3926E+01	-0.3791E+00	0.1520E+03	0.1520E+03	0.00
	2	-0.3926E+01	0.7311E+00	0.1307E+03	0.1307E+03	38.40
2	2	-0.3926E+01	-0.7307E+00	0.1307E+03	0.1307E+03	0.00
	3	-0.3926E+01	0.1083E+01	0.9585E+02	0.9585E+02	38.40
3	1	0.0000E+00	0.3926E+01	-0.1520E+03	0.0000E+00	90.00
	4	0.0000E+00	0.1361E-02	0.0000E+00	-0.1520E+03	0.00
4	3	0.0000E+00	-0.2990E+01	0.9585E+02	0.9585E+02	0.00
	5	0.0000E+00	-0.7149E-04	0.0000E+00	0.0000E+00	90.00

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1928E-03	0.9309E+00	0.0000E+00
2	0.0000E+00	0.4270E-03	0.0000E+00
3	-0.9360E+00	0.2393E+01	0.0000E+00
4	-0.1361E-02	0.0000E+00	0.0000E+00
5	0.7149E-04	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.3324E+01	

1 LOAD CASE 3 NO WATER INSIDE PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1933E-01	-0.1862E-01	-0.9269E-03
2	0.1903E-01	-0.4309E-01	-0.3662E-03
3	0.1872E-01	-0.4785E-01	0.8807E-04
4	0.1386E+00	-0.1862E-01	-0.1434E-02
5	-0.9563E-02	-0.4785E-01	0.3648E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.4311E+01	-0.3791E+00	0.1574E+03	0.1574E+03	0.00
	2	-0.4311E+01	0.7311E+00	0.1361E+03	0.1361E+03	38.40
2	2	-0.4311E+01	-0.7307E+00	0.1361E+03	0.1361E+03	0.00
	3	-0.4311E+01	0.1083E+01	0.1012E+03	0.1012E+03	38.40
3	1	0.0000E+00	0.4311E+01	-0.1574E+03	0.0000E+00	90.00
	4	0.0000E+00	0.1386E-02	0.0000E+00	-0.1574E+03	0.00
4	3	0.0000E+00	-0.3375E+01	0.1012E+03	0.1012E+03	0.00
	5	0.0000E+00	-0.9563E-04	0.0000E+00	0.0000E+00	90.00

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1933E-03	0.9309E+00	0.0000E+00
2	0.0000E+00	0.4309E-03	0.0000E+00
3	-0.9360E+00	0.2393E+01	0.0000E+00
4	-0.1386E-02	0.0000E+00	0.0000E+00
5	0.9563E-04	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.3324E+01	

1 LOAD CASE 4 CONSTRUCTION PLUS TRUCK

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	0.1933E-01	-0.2374E-01	-0.9393E-03
2	0.1903E-01	-0.4853E-01	-0.3662E-03
3	0.1872E-01	-0.5297E-01	0.1005E-03
4	0.1397E+00	-0.2374E-01	-0.1446E-02
5	-0.1068E-01	-0.5297E-01	0.3772E-03

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	-0.4311E+01	-0.1232E+00	0.1574E+03	0.1574E+03	0.00
	2	-0.4311E+01	0.7312E+00	0.1410E+03	0.1410E+03	38.40
2	2	-0.4311E+01	-0.7307E+00	0.1410E+03	0.1410E+03	0.00
	3	-0.4311E+01	0.1339E+01	0.1012E+03	0.1012E+03	38.40
3	1	0.0000E+00	0.4311E+01	-0.1574E+03	0.0000E+00	90.00
	4	0.0000E+00	0.1397E-02	0.0000E+00	-0.1574E+03	0.00
4	3	0.0000E+00	-0.3375E+01	0.1012E+03	0.1012E+03	0.00
	5	0.0000E+00	-0.1068E-03	0.0000E+00	0.0000E+00	90.00

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN -KIP
1	-0.1933E-03	0.1187E+01	0.0000E+00
2	0.0000E+00	0.4853E-03	0.0000E+00
3	-0.9360E+00	0.2649E+01	0.0000E+00
4	-0.1397E-02	0.0000E+00	0.0000E+00
5	0.1068E-03	0.0000E+00	0.0000E+00
TOTAL	-0.9375E+00	0.3836E+01	

1 MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN -KIP	MOMENT EXTREMA IN -KIP	LOCATION IN
1	1	1	-0.2989E+01	0.3518E+00	0.9581E+02	0.1026E+03	38.40
		2	-0.2989E+01	0.1983E-03	0.1026E+03	0.9581E+02	0.00
	2	1	-0.3926E+01	-0.3791E+00	0.1520E+03	0.1520E+03	0.00
		2	-0.3926E+01	0.7311E+00	0.1307E+03	0.1307E+03	38.40
	3	1	-0.4311E+01	-0.3791E+00	0.1574E+03	0.1574E+03	0.00
		2	-0.4311E+01	0.7311E+00	0.1361E+03	0.1361E+03	38.40
	4	1	-0.4311E+01	-0.1232E+00	0.1574E+03	0.1574E+03	0.00
		2	-0.4311E+01	0.7312E+00	0.1410E+03	0.1410E+03	38.40
2	1	2	-0.2989E+01	0.2082E-03	0.1026E+03	0.1026E+03	0.00
		3	-0.2989E+01	0.3518E+00	0.9581E+02	0.9581E+02	38.40
	2	2	-0.3926E+01	-0.7307E+00	0.1307E+03	0.1307E+03	0.00
		3	-0.3926E+01	0.1083E+01	0.9585E+02	0.9585E+02	38.40
	3	2	-0.4311E+01	-0.7307E+00	0.1361E+03	0.1361E+03	0.00
		3	-0.4311E+01	0.1083E+01	0.1012E+03	0.1012E+03	38.40
	4	2	-0.4311E+01	-0.7307E+00	0.1410E+03	0.1410E+03	0.00
		3	-0.4311E+01	0.1339E+01	0.1012E+03	0.1012E+03	38.40
3	1	1	0.0000E+00	0.2989E+01	-0.9581E+02	0.1872E-03	88.20
		4	0.0000E+00	0.5443E-03	0.0000E+00	-0.9581E+02	0.00
	2	1	0.0000E+00	0.3926E+01	-0.1520E+03	0.0000E+00	90.00
		4	0.0000E+00	0.1361E-02	0.0000E+00	-0.1520E+03	0.00
	3	1	0.0000E+00	0.4311E+01	-0.1574E+03	0.0000E+00	90.00
		4	0.0000E+00	0.1386E-02	0.0000E+00	-0.1574E+03	0.00
	4	1	0.0000E+00	0.4311E+01	-0.1574E+03	0.0000E+00	90.00
		4	0.0000E+00	0.1397E-02	0.0000E+00	-0.1574E+03	0.00
4	1	3	0.0000E+00	-0.2989E+01	0.9581E+02	0.9581E+02	0.00
		5	0.0000E+00	-0.5401E-03	0.0000E+00	-0.1795E-03	88.20
	2	3	0.0000E+00	-0.2990E+01	0.9585E+02	0.9585E+02	0.00
		5	0.0000E+00	-0.7149E-04	0.0000E+00	0.0000E+00	90.00
	3	3	0.0000E+00	-0.3375E+01	0.1012E+03	0.1012E+03	0.00
		5	0.0000E+00	-0.9563E-04	0.0000E+00	0.0000E+00	90.00
	4	3	0.0000E+00	-0.3375E+01	0.1012E+03	0.1012E+03	0.00
		5	0.0000E+00	-0.1068E-03	0.0000E+00	0.0000E+00	90.00

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: **TSF**	DATE: **10/15/2018**	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, U at Upper	CHK BY:		

Design Information:

Data below are from analysis performed by CFRAME

Design Service Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	*0.00*	3.00	95.80	0.00	3.90	152.00	0.00	4.30	157.40	0.00	4.30	157.40
Bottom Slab @ Side wall	*2.99*	0.35	95.80	3.93	0.38	152.00	2.43	0.38	157.40	3.93	0.12	157.40
Bottom Slab @ Middle	*2.99*	0.00	102.90	3.93	0.00	130.70	2.43	0.00	126.10	3.93	0.00	141.00

Design Load Factor

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Side wall	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
Bottom Slab @ Middle	2.21	2.21	2.21	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66

Design Factored Load A in Kip, V in Kip, M in Kip-IN

Location	LC1			LC2			LC3			LC4		
	A	V	M	A	V	M	A	V	M	A	V	M
Side Wall @Bottom	*0.00*	*6.63*	*211.72*	*0.00*	*6.47*	*252.32*	*0.00*	*7.14*	*261.28*	*0.00*	*7.14*	*261.28*
Bottom Slab @ Side wall	*6.61*	*0.77*	*211.72*	*6.52*	*0.63*	*252.32*	*4.03*	*0.63*	*261.28*	*6.52*	*0.20*	*261.28*
Bottom Slab @ Middle	*6.61*	*0.00*	*227.41*	*6.52*	*0.00*	*216.96*	*4.03*	*0.00*	*209.33*	*6.52*	*0.00*	*234.06*

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, U at Upper	CHK BY:		

Side Wall @Bottom

Thickness	*1.17* feet		λ = , ACI 8.6.1	*1.00*
Flexure Steel Dia. =	*1.000* inches		ϕ shear =	*0.75*
T & S Steel Dia. =	*0.75* inches		ϕ moment =	*0.90*
Required Concrete Cover =	*3.00* inches		Load Condition Factor (LCF) =	*0.75*
fy =	*60.00* ksi		Hydraulic Load Factor (HLF) =	*1.30*
f'c =	*4.00* ksi		Load Factor (LF) =	*1.70*
			Design Load Factor (DLF) =	*1.66*

Moment and Shear

Shear (V) = 7.138 kips

Moment (M) = 21.774 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 7.14 kips

d min =	6.27 in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.50		
ϕ Vc =	11.96 kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced			EM 1110-2-2104
β1=	0.85	[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######	[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######	[.25(ρ balanced)]	
As Maximum =	0.90 in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**21.77 kip-ft**	[(M)(DLF)]
As =	0.48 in^2	[solved for based on above formula]

As Minimum

As, min =	0.42 in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.64 in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15 in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24 in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44 in^2	As Based on As, min
Steel Spacing =	*12.00* in	**Use # 6 @ 12"**
Total Steel =	0.44 in^2	

Spacing Maximum

fs = 5.26 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*(40/fs)-2.5Cc] ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, U at Upper	CHK BY:		

Bottom Slan @ Side Wall

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	ϕ shear =	0.75
T & S Steel Dia. =	1.000	inches	ϕ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) = 0.199 kips
Moment (M) = 21.774 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu = 0.20 kips

d min =	0.17	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
ϕ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**21.77**	**kip-ft**	[(M)(DLF)]
As =	0.48	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.64	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

Spacing Maximum

fs = 5.30 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*(40/fs)-2.5Cc] ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds HREP	CMP BY: TSF	DATE: 10/15/2018	SHEET:
	SUBJECT TITLE: Water Control Structure, 1-Bay, U at Upper	CHK BY:		

Bottom Slab @ Middle

Thickness	1.25	feet	λ = , ACI 8.6.1	1.00
Flexure Steel Dia. =	1.128	inches	φ shear =	0.75
T & S Steel Dia. =	1.000	inches	φ moment =	0.90
Required Concrete Cover =	4.00	inches	Load Condition Factor (LCF) =	0.75
fy =	60.00	ksi	Hydraulic Load Factor (HLF) =	1.30
f'c =	4.00	ksi	Load Factor (LF) =	1.70
			Design Load Factor (DLF) =	1.66

Moment and Shear

Shear (V) =	0.000	kips
Moment (M) =	19.505	kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	0.00	kips		
d min =	0.00	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.44			
φ Vc =	11.88	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	######		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	######		[.25(ρ balanced)]	
As Maximum =	0.89	in^2	[(ρ max)(bw)(d)]	

As Required

φMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**19.51**	**kip-ft**	[(M)(DLF)]
As =	0.43	in^2	[solved for based on above formula]

As Minimum

As, min =	0.42	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.57	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

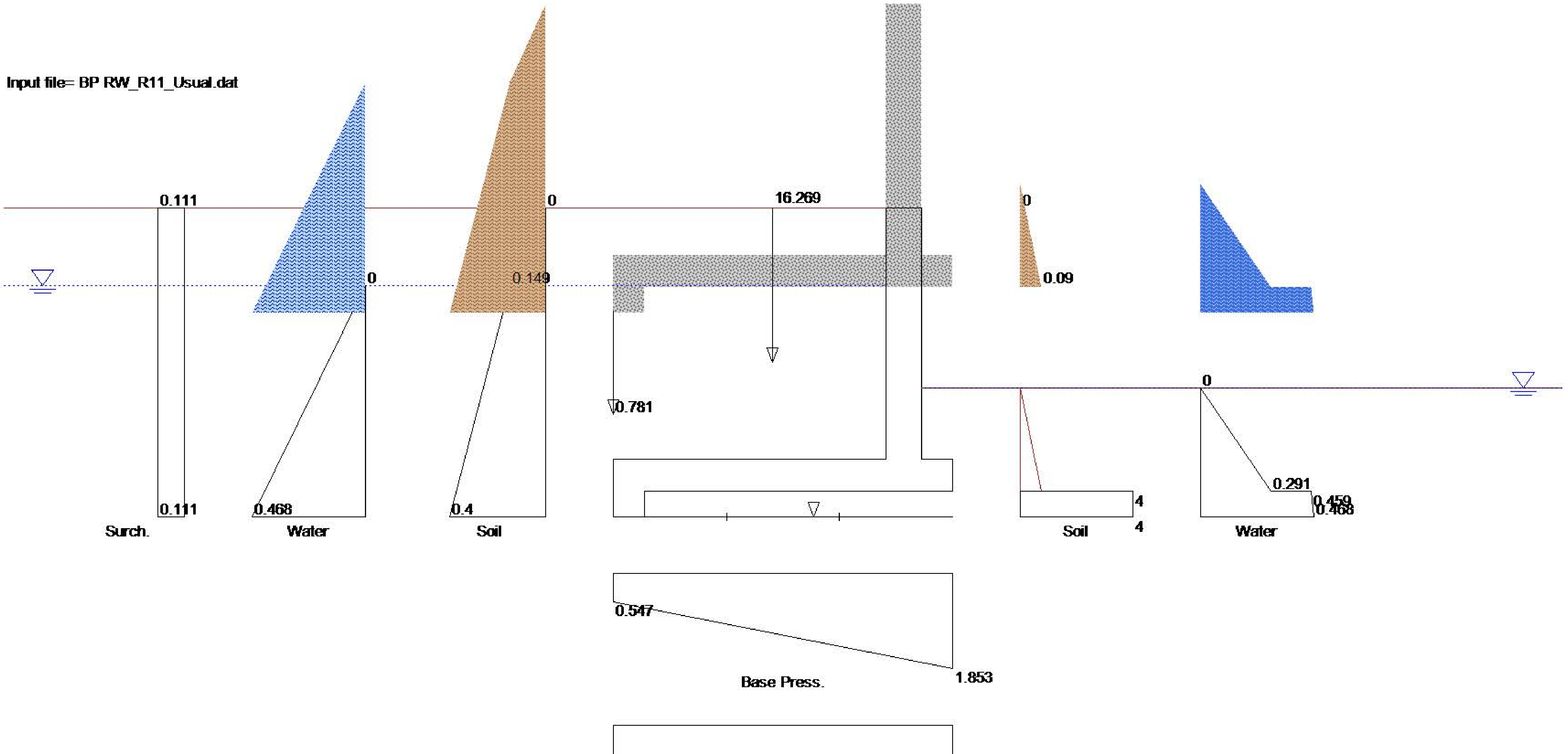
As Design =	0.44	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 6 @ 12"**
Total Steel =	0.44	in^2	

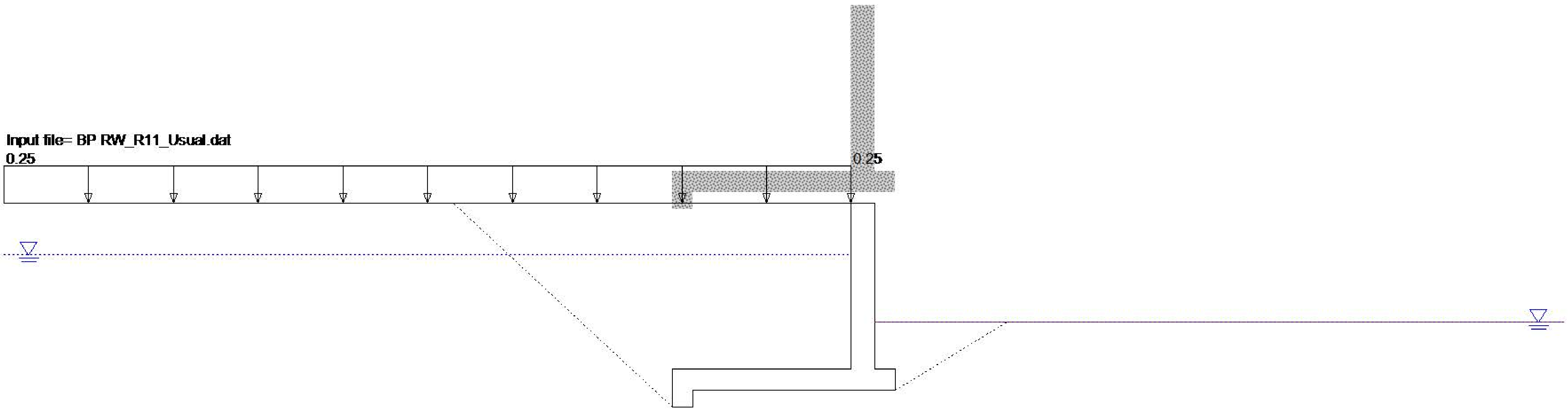
Spacing Maximum

			fs = 4.75 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

Retaining Walls

Input file= BP RW_R11_Usual.dat





Input file= BP RW_R11_Usual.dat
0.25
0.25

****************** Echoprint of Input Data ******************

Date: 2018/ 9/20 Time: 14.33.12

Structural geometry data:

Elevation of top of stem (ELTS)	=	700.00	ft
Height of stem (HTS)	=	9.75	ft
Thickness top of stem (TTS)	=	1.17	ft
Thickness bottom of stem (TBS)	=	1.17	ft
Dist. of batter at bot. of stem (TBSR)	=	0.00	ft
Depth of heel (THEEL)	=	2.25	ft
Distance of batter for heel (BTRH)	=	0.00	ft
Depth of toe (TTOE)	=	1.25	ft
Width of toe (TWIDTH)	=	1.00	ft
Distance of batter for toe (BTRT)	=	0.00	ft
Width of base (BWIDTH)	=	11.00	ft
Depth of key (HK)	=	1.00	ft
Width of bottom of key (TK)	=	1.00	ft
Dist. of batter at bot. of key (BTRK)	=	0.00	ft

Structure coordinates:

x (ft)	y (ft)
0.00	688.00
0.00	690.25
8.83	690.25
8.83	700.00
10.00	700.00
10.00	690.25
11.00	690.25
11.00	689.00
1.00	689.00
1.00	688.00

NOTE: X=0 is located at the left-hand side of the structure. The Y values correspond to the actual elevation used.

Structural property data:
Unit weight of concrete = 0.150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
28.00	0.000	0.112	0.115	11.00	700.00

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	10.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1501.17	700.00
2	8.83	700.00

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
28.00	0.000	0.112	0.115	693.00	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	10.00	693.00
2	510.00	693.00

Foundation property data:
- phi for soil-structure interface = 22.00 (deg)
- c for soil-structure interface = 0.000 (ksf)
- phi for soil-soil interface = 22.00 (deg)
- c for soil-soil interface = 0.000 (ksf)

Water data:
- Driving side elevation = 697.00 ft
- Resisting side elevation = 693.00 ft
- Unit weight of water = 0.0624 kcf
- Seepage pressures computed by Line of Creep method.

Uniform load data:
- Magnitude of load = 0.2500 k/ft

Minimum required factors of safety:
- Sliding FS = 1.50
- Overturning = 100.00% base in compression

Crack options:

```
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.6667

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.



***** Summary of Results *****

***************    *** Satisfied ***
* Overturning *    Required base in comp. = 100.00 %
***************    Actual base in comp.   = 100.00 %
                   Overturning ratio      =   2.46

Xr (measured from toe) =   4.50 ft
Resultant ratio        = 0.4093
Stem ratio             = 0.0909
Base pressure at heel =    0.5470 ksf
Base pressure at toe  =    1.8525 ksf

***********    *** Satisfied ***
* Sliding *    Min. Required =   1.50
***********    Actual FS     =   1.59

***********
* Bearing *
***********

Net ultimate bearing pressure =     1.0731 (ksf)
Factor of safety =      0.714


********************** Output Results **********************

Date: 2018/ 9/20                               Time: 14.33.12


***************************
**  Overturning Results  **
***************************

Solution converged in  1 iterations.

SMF used to calculate K's =   0.6667
```

```
Alpha for the SMF          = -48.6701
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4426
  Driving side at rest Kc   =   0.6483
  Resisting side at rest K  =   0.5305
  Resisting side at rest Kc =   0.7284
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       697.00     0.0000
       688.00     0.4682

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       700.00     0.0000
       697.00     0.1487
       688.00     0.3996

  Surcharge pressures:
       Elev.   Press.
       (ft)    (ksf)
    ===================
       700.00    0.111
       688.00    0.111

** Resisting side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       693.00     0.0000
       689.00     0.2911
       689.00     0.4586
       688.00     0.4682

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       693.00     0.0000
       689.00     0.0896

  Balancing earth pressures:
    Elevation   Pressure
```

(ft)	(ksf)
689.00	4.8998
688.00	4.8998

** Uplift pressures **

Water pressures:

x-coord. (ft)	Pressure (ksf)
0.00	0.4682
1.00	0.4586
1.00	0.3867
11.00	0.2911

** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Moment (ft-k)
Structure:				
Structure weight...........	3.924		-3.98	-15.63
Structure, driving side:				
Moist soil.................	2.967		-6.58	-19.54
Saturated soil.............	6.854		-6.59	-45.14
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.000		0.00	0.00
External vertical loads....	2.207		-6.59	-14.54
Ext. horz. pressure loads..		0.000	0.00	0.00
Ext. horz. line loads......		0.000	0.00	0.00
Structure, resisting side:				
Moist soil.................	0.000		0.00	0.00
Saturated soil.............	0.316		-0.50	-0.16
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.000		0.00	0.00
Driving side:				
Effective earth loads......		2.690	3.32	8.94
Shear (due to delta).......	0.781		-11.00	-8.59
Horiz. surcharge effects...		1.328	5.00	6.64
Water loads................		2.107	2.00	4.22
Resisting side:				
Effective earth loads......		-0.179	1.34	-0.24
Balancing earth load.......		-4.900	-0.52	2.53
Water loads................		-1.046	0.51	-0.53
Foundation:				
Vertical force on base.....	-13.197		-4.50	59.42
Uplift.....................	-3.852		-5.87	22.61
** Statics Check ** SUMS =	0.000	0.000		0.00

Angle of base = 5.19 degrees
Normal force on base = 13.587 kips

Shear force on base = 3.685 kips
Max. available shear force = 5.698 kips

Base pressure at heel = 0.5470 ksf
Base pressure at toe = 1.8525 ksf

Xr (measured from toe) = 4.50 ft
Resultant ratio = 0.4093
Stem ratio = 0.0909
Base in compression = 100.00 %
Overturning ratio = 2.46

Volume of concrete = 0.97 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

****
** Sliding Results **
****

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	0.000	2.708
2	0.000	2.207
3	0.000	0.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.0000	0.4682		
2			0.0000	0.4682
2			11.0000	0.2911
3	0.0000	0.2911		

Points of sliding plane:
Point 1 (left), x = 0.00 ft, y = 688.00 ft
Point 2 (right), x = 11.00 ft, y = 689.00 ft

```
Depth of cracking =     0.00 ft

         Failure   Total    Weight    Submerged   Uplift
  Wedge   angle    length  of wedge    length     force
  number  (deg)     (ft)    (kips)      (ft)      (kips)
  =========================================================
     1   -47.933   16.165     7.388   12.123     2.838
     2     5.194   11.045    14.579   11.045     4.193
     3    35.987    6.807     1.267    6.807     0.991

  Wedge     Net force
  number     (kips)
  ===================
     1       -6.066
     2        4.833
     3        1.234
  ===================
     SUM =    0.000

+-----------------------------+
| Factor of safety =    1.590 |
+-----------------------------+



**********************
**  Bearing Results  **
**********************

            Base width =     11.045 (ft)
                    Xr =      4.502 (ft)
  Effective base width =      9.042 (ft)
   (measured along slope)
            Base slope =     5.1944 (deg)

                   phi =     22.000 (deg)
                     c =      0.000 (ksf)
       Effective gamma =     0.0526 (kcf)

           Normal load =     13.587 (kips)
      Load inclination =     15.174 (deg)
     Load eccentricity =      1.002 (ft)

             Surcharge =     0.2104 (ksf)
             Embedment =      4.000 (ft)
          Ground slope =     0.0000 (deg)


          Bearing Capacity Factors
=============================================
                    C        Q         G
=============================================
Bearing         16.8829    7.8211    4.0662
```

Embedment	1.1312	1.0656	1.0656
Inclination	0.6912	0.6912	0.0963
Base Tilt	0.9175	0.9281	0.9281
Ground Slope	1.0000	1.0000	1.0000

Net ultimate bearing pressure = 1.0731 (ksf)

```
+--------------------------------+
| Factor of safety =      0.714 |
+--------------------------------+
```

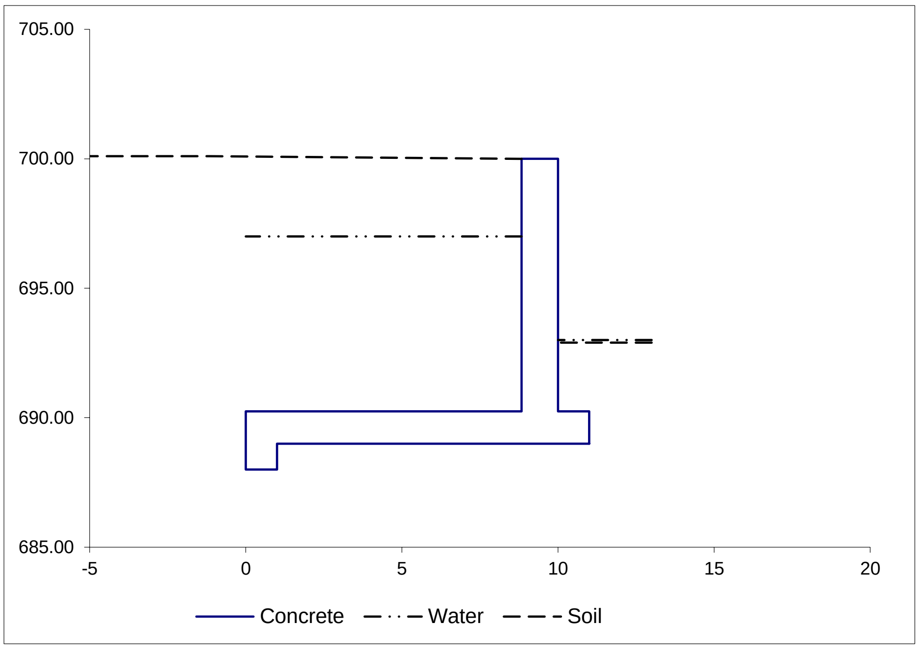
US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R11-Usual	CHK BY:	COMPUTER FILE:	

Design Information:

Note: Data located with-in a black box is an input, not a calculated value.

Labels and data below are from an overturning and sliding analysis performed by CTWALL

Top of Stem El	*700.00*	feet	Toe Thickness	*1.25*	feet
Height of Stem	*9.75*	feet	Toe Width	*1.00*	feet
Top Stem Thickness	*1.17*	feet	Toe Slope	*0.00*	feet
Base Stem Thickness	*1.17*	feet	Total Base Width	*11.00*	feet
Stem Batter	*0.00*	feet	Key Depth	*1.00*	feet
Heel Thickness	*1.25*	feet	Key Thickness	*1.00*	feet
Heel Slope	*0.00*	feet	Key Slope	*0.00*	feet



Weight of Water (γw) =	*62.50*	lbs/cu.ft	fy =	*60*	ksi
Water Ele. L. (HwL) =	*697.00*	feet	f'c =	*4*	ksi
Water Ele. R. (HwR) =	*693.00*	feet	λ = , ACI 8.6.1	*1.00*	
B. Wt. of Soil (γb) =	*49.50*	lbs/cu.ft	ϕ shear =	*0.75*	
Soil Ele. L. (HsL) =	*700.00*	feet	ϕ moment =	*0.90*	
Soil Ele. R. (HsR) =	*692.90*	feet	Load Condition Factor (LCF) =	*1.00*	
Weight of Conc. (γc) =	*150.00*	lbs/cu.ft	Hydraulic Load Factor (HLF) =	*1.30*	
M. Wt. of Soil (γμ) =	*112.00*	lbs/cu.ft	Load Factor (LF) =	*1.70*	
Batter of soil L =	100				
Bottom of Footing =	689.00		Design Load Factor (DLF) =	*2.21*	
Height of Water above slab L.	6.75	feet	Ko adjusted for sloped backfill	0.51	
Height of Water above slab R.	2.75	feet	Driving side at rest K=	0.5	
Height of Boyant Soil above slab L.	6.75	feet	Resisting side at rest K=	0.53	
Height of Boyant Soil above slab R.	2.65	feet	Surcharge=	*0.25*	ksf
Height of Soil above water L.	3.00	feet	Length of soil batter	10	ft
Height of Soil above water R.	0.00	feet			

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R11-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (STEM)

Moment and Shear

Force due to water and soil (V) =	4.296	kips		
Moment at bottom (M) =	16.030	kip-ft		

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	9.49	kips	Flexure Steel Dia. = 0.750	inches
			T & S Steel Dia. = 0.75	inches
			Required Concrete Cover = 3.00	inches
d min =	8.34	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	10.67			
ϕ Vc =	12.14	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	0.0285		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071		[.25(ρ balanced)]	
As Maximum =	0.91	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**35.43**	**kip-ft**	[(M)(DLF)]
As =	0.78	in^2	[solved for based on above formula]

As Minimum

As, min =	0.43	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	1.04	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.79	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 8 @ 12"**
Total Steel =	0.79	in^2	

Spacing Maximum

			fs = 2.33 =M/(As*(d-(As*Fy*2)/(f'c*12)))	
S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R11-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (HEEL)   At Stem

Calculation of Moment and Shear   (Counter Clock Wise Positive)

Length of Base Press.=	11.000	feet	Sheetpile cutoff ?	NO	(YES or NO)
Base pressure at toe =	1.853	ksf	Distance to Cutoff =	0.000	feet
Base press. at heel =	0.547	ksf			
Hydro. Press. at toe =	0.291	ksf			
Hydro. Press. at heel =	0.468	ksf			

Base Pressure - Rectangular portion of base pressure

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	-0.547	-0.547	-4.830	4.42	-21.32

Base Pressure - Triangular portion of base pressure (Assumes maximum pressure is at Toe)

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	0	-1.048	-4.629	2.94	-13.62

Uplift Pressure - upstream of sheetpile, if sheetpile

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	8.83	0.00	0.000	0.000	0.000	8.83	0.00

Uplift Pressure - downstream of sheetpile, if sheetpile, Assumes rest of base is on Granular Fill

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	0.000	0.000	0.000	4.42	0.00

Uplift Pressure - With no sheetpile, under portion of base not in compression

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	8.83	0.00	-0.468	-0.468	0.000	8.83	0.00

Uplift Pressure - triangular uplift if no sheetpile

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	-0.142	0	-0.627	5.89	-3.69

Uplift Pressure - rectangular uplift if no sheetpile

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	-0.326	-0.326	-2.878	4.42	-12.71

Weight of Water on Heel

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	0.000	0.000	0.000	4.42	0.00

Weight of Soil on Heel

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	1.092	1.092	9.642	4.42	42.57
10.00	0.00	10.00	0.18667	0.000	0.933	6.67	6.22
8.83	10.00	-1.17	0.25	0.25	-0.293	9.42	-2.75

Weight of Heel Concrete

x1	x2	Length	p1	p2	Shear	arm	Moment
8.83	0.00	8.83	0.1875	0.1875	1.656	4.42	7.31
8.83	0.00	8.83	0	0	0.000	2.94	0.00

Total Shear (V) = -1.025 kips

Total Moment (M) = 2.003 kip-ft

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R11-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (HEEL) **At Stem**

Moment and Shear
Total Shear (V) = -1.0 kips
Total Moment (M) = 2.0 kip-ft

Minimum Depth based on Shear

Flexure Steel Dia. = 0.875 inches
T & S Steel Dia. = *0.75* inches
Required Concrete Cover = *3.00* inches

Vu=(DLF)(V) ==> Vu = -2.26 kips
Is design slab or beam? *slab*
d min = -1.99 in "=Vu/(phi shear)(λ)(2)(sqrt(f'c))(bw) ACI 11.2.1.1
Actual depth d = 11.56
ϕ Vc = 13.16 kips =(phi shear)(λ)(2)(sqrt(f'c))(b d)] ACI 11.2.1.1

As Maximum
ρ max = .25 ρ balanced EM 1110-2-2104

β1=	0.85	[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	0.0285	[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071	[.25(ρ balanced)]	
As Maximum =	0.99 in^2	[(ρ max)(bw)(d)]	

As Required
ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**4.43 kip-ft**	[(M)(DLF)]	
As =	0.09 in^2	[solved for based on above formula]	

As Minimum

As, min =	0.46 in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.11 in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16 in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25 in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.60 in^2	Use # 7 @ 12"
Steel Spacing =	*12.00* in	
Total Steel =	0.60 in^2	

Spacing Maximum fs = 0.33 =M/(As*(d-(As*Fy*2)/(f'c*12)))
S = 12.00 in [(15*40/fs)-2.5Cc] < 12" ACI 10.6.4

Calculations: (Bottom of Toe)

Calculation of Moment and Shear (Counter Clock Wise Positive)

Base Pressure - Rectangular portion of base pressure

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	1.734	1.734	1.734	0.50	0.87

Base Pressure - Triangular portion of base pressure (Assumes maximum pressure is at Toe)

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0	0.119	0.059	0.67	0.04

Uplift Pressure - triangular uplift. With a sheetpile cuttoff, assumes no head loss across base.

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0.016	0	0.008	0.33	0.00

Uplift Pressure - rectangular uplift

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0.291	0.291	0.291	0.50	0.15

Weight of Soil on Toe

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	-1.092	-1.092	-1.092	0.50	-0.55

Weight of Concrete

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	-0.1875	-0.1875	-0.188	0.50	-0.09

Reaction Force From Stoplog Frame

Shear	arm	Moment
0.000	0.00	0.00

Total Shear (V) = 0.813 kips

Total Moment (M) = 0.415 kip-ft

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R11-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (Bottom of Toe)

Moment and Shear

Total Shear (V) = 0.8 kips

Total Moment (M) = 0.4 kip-ft

Minimum Depth based on Shear

			Flexure Steel Dia. =	0.875	inches
Vu=(DLF)(V) ==> Vu =	1.80	kips	T & S Steel Dia. =	0.750	inches
			Required Concrete Cover =	3.00	inches
d min =	1.58	in	=Vu/(phi shear)(λ)(2)(sqrt(f'c))(bw)		ACI 11.2.1.1
Actual depth d =	11.56				
ϕ Vc =	13.16	kips	=(phi shear)(l)(2)(sqrt(f'c))(b d)]		ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85	[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	0.0285	[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071	[.25(ρ balanced)]	
As Maximum =	0.99 in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**0.92 kip-ft**	[(M)(DLF)]
As =	0.02 in^2	[solved for based on above formula]

As Minimum

As, min =	0.46 in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.02 in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16 in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25 in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.60 in^2	Temp and Shrinkage
Steel Spacing =	12.00 in	
Total Steel =	0.60 in^2	Use # 7@ 12"

Spacing Maximum

fs = 0.07 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*40/fs)-2.5Cc] < 12" ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall–LC R11-Usual	CHK BY:	COMPUTER FILE:	

Calculations - Bearing Capacity: (EM 1110-2-2502, Chapter 5)

BEARING CAPACITY = Q

$Q= B_1[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB_1§Nr)/2]$ EQU. 5-2

FOOTING WIDTH, (B)=	11.00	ft.
SOIL DEPTH TOE SIDE (D)=	3.90	ft.
SATURATION HT.TOE SIDE (Dw)=	4.00	ft.
BASE SLOPE, alpha, (α)=	*0.00*	degrees
FRICTION ANGLE OF SOIL (0f)=	*33.00*	deg., Below Footing
FRICTION ANGLE OF SOIL (03)=	*33.00*	deg., Resisting Wedge
COHESION OF FOUNDATION Cfr=	*0.18*	k / ft^2
SOIL UNIT Wt.,MOIST (§m)=	*0.112*	k / ft^3
SOIL UNIT Wt.,SATUR. (§s)=	*0.115*	k / ft^3
WATER UNIT WEIGHT (§w)=	0.0625	k / ft^3
SOIL UNIT Wt.,BOUYANT (§b)=	0.0525	k / ft^3
NET HORIZONTAL FORCE (SUM H)=	*5.19*	kip
NET VERTICAL FORCE (SUM V)=	*13.59*	kip
Xr (measured from toe) =	*4.50*	ft.
SURCHARGE LOADING=	*0.25*	ksf
SOIL SURFACE SLOPE,RISE/RUN=	*0.00*	deg.
BETA ANGLE (β)=	0.00	deg.

EFF. WIDTH OF BASE B_1 = B-2e = 2Xr = 9

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502

Nq = 26.09
Nc = 38.64
Nr = 26.17

EMBEDMENT FACTORS

Ecd =	$1+0.2(D/B_1)TAN(45+\phi/2)$ =	1.160	EQU.5-4a	
Eqd=Erd =	=	1.000	EQU.5-4b	IF(ϕ = O)
Eqd=Erd =	$1+0.1(D/B_1)TAN(45+\phi/2)$ =	1.080	EQU.5-4c	IF(ϕ >10)
Eqd=Erd =	=	1.080		

INTERPOLATE BETWEEN EQU. 5-4b AND 4c FOR (O<ϕ<=1O)

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall–LC R11-Usual	CHK BY:	COMPUTER FILE:	

INCLINATION FACTORS

§o =	ARCTAN[(SUM H)/SUM V] =	20.902	DEG.	
Eqi=Eci =	(1-§o/90)^2 =	0.589		EQU.5-5a
Eri =	IF §o > ϕ, THEN Eri = 0,			ELSE,
Eri =	(1-§o/ϕ)^2 =	0.134		EQU.5-5b

BASE TILT FACTORS (α IN RADIANS)

Eqt=Ert =	(1-α*TANϕ)^2 =	1.000	EQU.5-6a
Ect =	1-(2*α/π+2) =	1.000	EQU.5-6b
Ect =	Eqt-[(1-Eqt)/(NcTANϕ)] =	1.000	EQU.5-6c
Ect =		1.000	

GROUND SLOPE FACTORS (β is positive when the ground slopes down and away from the footing.)

Erg=Eqg =	[1-TAN(-β)]^2 =	1.000	EQU.5-7a
Ecg =	1-[2*(-β)/(PI+2)] =	1.000	EQU.5-7b
Ecg =	Eqg-[(1-Eqg)/Nc*TANϕ] =	1.000	EQU.5-7d
Ecg =		1.000	

EFFECTIVE OVERBURDEN PRESSURE

qo =	(Q+§*D)*COS(β) =	0.455		EQU.5-8a
		0.205	§b*D	

EFFECTIVE SOIL UNIT WEIGHT

§ =	IF(Dw=0,§m,§b)=	0.0525	ksf

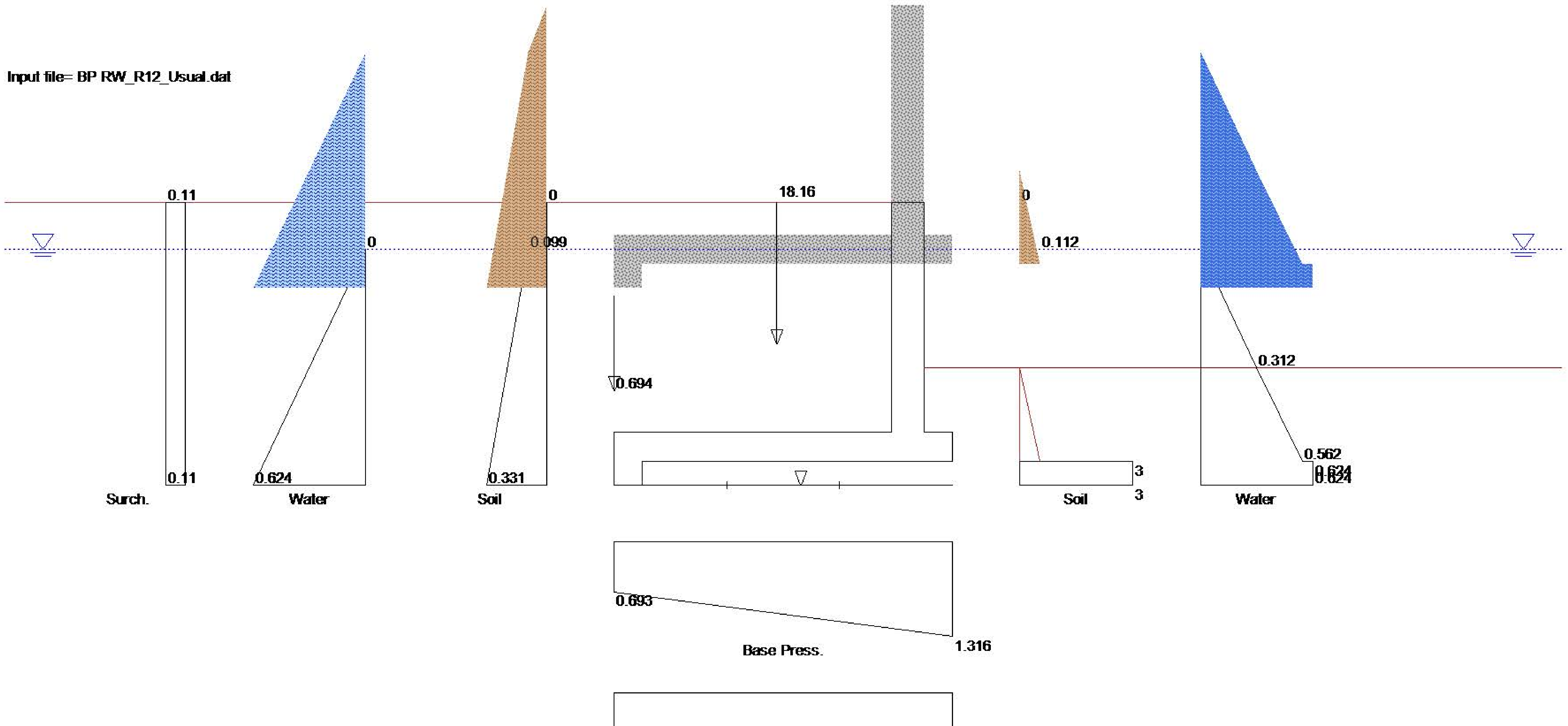
BEARING CAPACITY = 118.59 kips EQU. 5-2

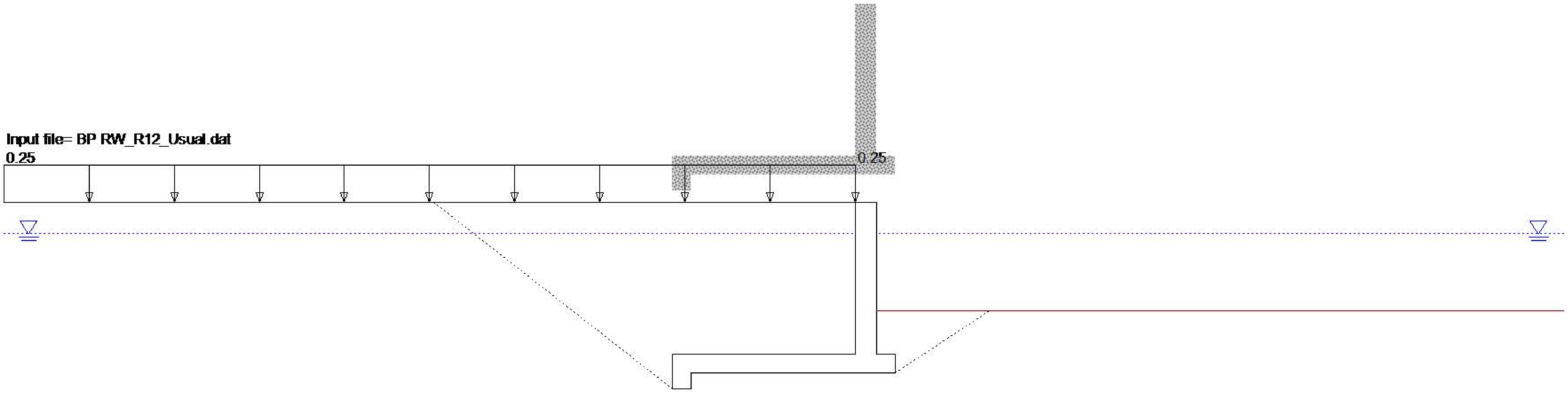
F.O.S. = Q/SUM V= 8.73 EQU. 5-1

F.O.S. Required For (R2) = 2.0

Thus, Design is OK

Input file= BP RW_R12_Usual.dat





Input file= BP RW_R12_Usual.dat
0.25
0.25

```
****************** Echoprint of Input Data ******************

Date: 2018/ 9/20                                Time: 14.49.37

Structural geometry data:
  Elevation of top of stem (ELTS)        =   700.00 ft
  Height of stem (HTS)                   =     9.75 ft
  Thickness top of stem (TTS)            =     1.17 ft
  Thickness bottom of stem (TBS)         =     1.17 ft
  Dist. of batter at bot. of stem (TBSR)=     0.00 ft
  Depth of heel (THEEL)                  =     2.25 ft
  Distance of batter for heel (BTRH)     =     0.00 ft
  Depth of toe (TTOE)                    =     1.25 ft
  Width of toe (TWIDTH)                  =     1.00 ft
  Distance of batter for toe (BTRT)      =     0.00 ft
  Width of base (BWIDTH)                 =    12.00 ft
  Depth of key (HK)                      =     1.00 ft
  Width of bottom of key (TK)            =     1.00 ft
  Dist. of batter at bot. of key (BTRK) =     0.00 ft

Structure coordinates:

   x (ft)    y (ft)
  ==================
      0.00    688.00
      0.00    690.25
      9.83    690.25
      9.83    700.00
     11.00    700.00
     11.00    690.25
     12.00    690.25
     12.00    689.00
      1.00    689.00
      1.00    688.00

NOTE: X=0 is located at the left-hand side
      of the structure.  The Y values correspond
      to the actual elevation used.

Structural property data:
  Unit weight of concrete =    0.150 kcf

Driving side soil property data:

                      Moist   Saturated          Elev.
   Phi        c      Unit wt.  unit wt.  Delta   soil
  (deg)     (ksf)     (kcf)     (kcf)    (deg)   (ft)
=======================================================
   28.00    0.000     0.112     0.115    11.00  700.00
```

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	10.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1500.17	700.00
2	9.83	700.00

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
28.00	0.000	0.112	0.115	693.00	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	11.00	693.00
2	511.00	693.00

Foundation property data:
phi for soil-structure interface = 22.00 (deg)
c for soil-structure interface = 0.000 (ksf)
phi for soil-soil interface = 22.00 (deg)
c for soil-soil interface = 0.000 (ksf)

Water data:
Driving side elevation = 698.00 ft
Resisting side elevation = 698.00 ft
Unit weight of water = 0.0624 kcf
Seepage pressures computed are hydrostatic.

Uniform load data:
Magnitude of load = 0.2500 k/ft

Minimum required factors of safety:
Sliding FS = 1.50
Overturning = 100.00% base in compression

Crack options:

```
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.6667

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.



***** Summary of Results *****

***************    *** Satisfied ***
* Overturning *    Required base in comp. = 100.00 %
***************    Actual base in comp.   = 100.00 %
                   Overturning ratio      =   2.06

Xr (measured from toe) =   5.38 ft
Resultant ratio        = 0.4483
Stem ratio             = 0.0833
Base pressure at heel =    0.6931 ksf
Base pressure at toe  =    1.3157 ksf

***********    *** Satisfied ***
* Sliding *    Min. Required =   1.50
***********    Actual FS     =   2.07

***********
* Bearing *
***********

Net ultimate bearing pressure =     1.4036 (ksf)
Factor of safety =      1.233



********************** Output Results **********************


Date: 2018/ 9/20                               Time: 14.49.37


***************************
**  Overturning Results  **
***************************

Solution converged in  1 iterations.

SMF used to calculate K's =   0.6667
```

```
Alpha for the SMF          = -47.5920
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4414
  Driving side at rest Kc   =   0.6554
  Resisting side at rest K  =   0.5305
  Resisting side at rest Kc =   0.7284
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       698.00     0.0000
       688.00     0.6240

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       700.00     0.0000
       698.00     0.0989
       688.00     0.3311

  Surcharge pressures:
       Elev.   Press.
       (ft)    (ksf)
    ===================
       700.00    0.110
       688.00    0.110

** Resisting side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       698.00     0.0000
       693.00     0.3120
       689.00     0.5616
       689.00     0.6240
       688.00     0.6240

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       693.00     0.0000
       689.00     0.1116

  Balancing earth pressures:
```

Elevation (ft)	Pressure (ksf)
689.00	3.3183
688.00	3.3183

** Uplift pressures **

Water pressures:

x-coord. (ft)	Pressure (ksf)
0.00	0.6240
1.00	0.6240
1.00	0.5616
12.00	0.5616

** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Moment (ft-k)
Structure:				
Structure weight...........	4.111		-4.36	-17.94
Structure, driving side:				
Moist soil.................	2.202		-7.09	-15.60
Saturated soil.............	8.761		-7.09	-62.07
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.000		0.00	0.00
External vertical loads....	2.457		-7.09	-17.41
Ext. horz. pressure loads..		0.000	0.00	0.00
Ext. horz. line loads......		0.000	0.00	0.00
Structure, resisting side:				
Moist soil.................	0.000		0.00	0.00
Saturated soil.............	0.316		-0.50	-0.16
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.312		-0.50	-0.16
Driving side:				
Effective earth loads......		2.249	3.39	7.62
Shear (due to delta).......	0.694		-12.00	-8.33
Horiz. surcharge effects...		1.324	5.00	6.62
Water loads................		3.120	2.34	7.29
Resisting side:				
Effective earth loads......		-0.223	1.35	-0.30
Balancing earth load.......		-3.318	-0.52	1.72
Water loads................		-3.151	2.31	-7.29
Foundation:				
Vertical force on base.....	-12.053		-5.38	64.84
Uplift.....................	-6.802		-6.05	41.15
** Statics Check ** SUMS =	0.000	0.000		0.00

Angle of base = 4.76 degrees

Normal force on base = 12.287 kips
Shear force on base = 2.306 kips
Max. available shear force = 5.196 kips

Base pressure at heel = 0.6931 ksf
Base pressure at toe = 1.3157 ksf

Xr (measured from toe) = 5.38 ft
Resultant ratio = 0.4483
Stem ratio = 0.0833
Base in compression = 100.00 %
Overturning ratio = 2.06

Volume of concrete = 1.02 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

****
** Sliding Results **
****

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	0.000	3.213
2	-0.780	2.770
3	0.000	1.577

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.0000	0.6240		
2			0.0000	0.6240
2			12.0000	0.5616
3	0.3120	0.5616		

Points of sliding plane:
Point 1 (left), x = 0.00 ft, y = 688.00 ft
Point 2 (right), x = 12.00 ft, y = 689.00 ft

```
Depth of cracking =     0.00 ft

          Failure   Total    Weight    Submerged   Uplift
  Wedge    angle    length  of wedge    length     force
  number   (deg)     (ft)    (kips)      (ft)      (kips)
  ==========================================================
     1   -43.036    17.584      8.797   14.653     4.572
     2     4.764    12.042     15.965   12.042     7.138
     3    38.362     6.445      1.162    6.445     2.815

  Wedge     Net force
  number     (kips)
  ===================
     1       -7.103
     2        4.658
     3        2.446
  ===================
     SUM =    0.001

+------------------------------+
| Factor of safety =    2.074 |
+------------------------------+




***********************
**  Bearing Results  **
***********************

            Base width =     12.042 (ft)
                    Xr =      5.380 (ft)
  Effective base width =     10.797 (ft)
   (measured along slope)
            Base slope =     4.7636 (deg)

                   phi =     22.000 (deg)
                     c =      0.000 (ksf)
       Effective gamma =     0.0526 (kcf)

           Normal load =     12.287 (kips)
      Load inclination =     10.629 (deg)
     Load eccentricity =      0.622 (ft)

             Surcharge =     0.2104 (ksf)
             Embedment =      4.000 (ft)
          Ground slope =     0.0000 (deg)


          Bearing Capacity Factors
=============================================
                    C        Q         G
=============================================
```

Bearing	16.8829	7.8211	4.0662
Embedment	1.1098	1.0549	1.0549
Inclination	0.7777	0.7777	0.2671
Base Tilt	0.9243	0.9339	0.9339
Ground Slope	1.0000	1.0000	1.0000

Net ultimate bearing pressure = 1.4036 (ksf)

```
+--------------------------------+
| Factor of safety =       1.233 |
+--------------------------------+
```

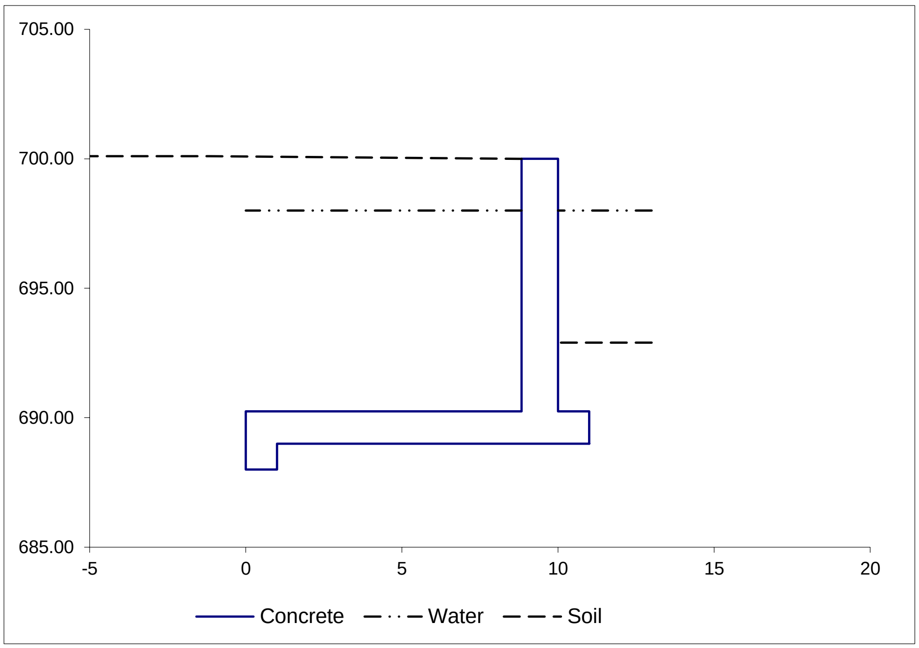
US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Design Information:

Note: Data located with-in a black box is an input, not a calculated value.

Labels and data below are from an overturning and sliding analysis performed by CTWALL

Top of Stem El	*700.00*	feet	Toe Thickness	*1.25*	feet
Height of Stem	*9.75*	feet	Toe Width	*1.00*	feet
Top Stem Thickness	*1.17*	feet	Toe Slope	*0.00*	feet
Base Stem Thickness	*1.17*	feet	Total Base Width	*11.00*	feet
Stem Batter	*0.00*	feet	Key Depth	*1.00*	feet
Heel Thickness	*1.25*	feet	Key Thickness	*1.00*	feet
Heel Slope	*0.00*	feet	Key Slope	*0.00*	feet



Weight of Water (γw) =	*62.50*	lbs/cu.ft	fy =	*60*	ksi
Water Ele. L. (HwL) =	*698.00*	feet	f'c =	*4*	ksi
Water Ele. R. (HwR) =	*698.00*	feet	λ = , ACI 8.6.1	*1.00*	
B. Wt. of Soil (γb) =	*49.50*	lbs/cu.ft	ϕ shear =	*0.75*	
Soil Ele. L. (HsL) =	*700.00*	feet	ϕ moment =	*0.90*	
Soil Ele. R. (HsR) =	*692.90*	feet	Load Condition Factor (LCF) =	*1.00*	
Weight of Conc. (γc) =	*150.00*	lbs/cu.ft	Hydraulic Load Factor (HLF) =	*1.30*	
M. Wt. of Soil (γμ) =	*112.00*	lbs/cu.ft	Load Factor (LF) =	*1.70*	
Batter of soil L =	100				
Bottom of Footing =	689.00		Design Load Factor (DLF) =	*2.21*	
Height of Water above slab L.	7.75	feet	Ko adjusted for sloped backfill	0.51	
Height of Water above slab R.	7.75	feet	Driving side at rest K=	0.5	
Height of Boyant Soil above slab L.	7.75	feet	Resisting side at rest K=	0.53	
Height of Boyant Soil above slab R.	2.65	feet	Surcharge=	*0.25*	ksf
Height of Soil above water L.	2.00	feet	Length of soil batter	10	ft
Height of Soil above water R.	0.00	feet			

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (STEM)

Moment and Shear

Force due to water and soil (V) = 2.879 kips

Moment at bottom (M) = 12.212 kip-ft

Minimum Depth based on Shear			Flexure Steel Dia. =	0.750	inches
Vu=(DLF)(V) ==> Vu =	6.36	kips	T & S Steel Dia. =	0.75	inches
			Required Concrete Cover =	3.00	inches
d min =	5.59	in	=Vu/(phi shear)(2)(λ)(sqrt(f'c))(bw)		ACI 11.2.1.1
Actual depth d =	10.67				
ϕ Vc =	12.14	kips	=(phi shear)(2)(λ)(sqrt(f'c))(b d)		ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced				EM 1110-2-2104
β1=	0.85		[1.05-.05(f'c)] .65 <= β1 <= .85	
ρ balanced =	0.0285		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071		[.25(ρ balanced)]	
As Maximum =	0.91	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]

solve for As to determine area of steel necessary to resist moment

Mu =	**26.99**	**kip-ft**	[(M)(DLF)]
As =	0.59	in^2	[solved for based on above formula]

As Minimum

As, min =	0.43	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.78	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.15	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.24	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.79	in^2	As Based on As, min
Steel Spacing =	12.00	in	**Use # 8 @ 12"**
Total Steel =	0.79	in^2	

Spacing Maximum

fs = 1.78 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S =	**12.00**	**in**	[(15*(40/fs)-2.5Cc]	ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (HEEL)   At Stem

Calculation of Moment and Shear   (Counter Clock Wise Positive)

Length of Base Press.=	*11.000*	feet	Sheetpile cutoff ?	*NO*	(YES or NO)
Base pressure at toe =	*1.316*	ksf	Distance to Cutoff =	*0.000*	feet
Base press. at heel =	*0.693*	ksf			
Hydro. Press. at toe =	*0.562*	ksf			
Hydro. Press. at heel =	*0.624*	ksf			

	x1	x2	Length	p1	p2	Shear	arm	Moment
Base Pressure - Rectangular portion of base pressure								
	8.83	0.00	8.83	-0.693	-0.693	-6.119	4.42	-27.02
Base Pressure - Triangular portion of base pressure (Assumes maximum pressure is at Toe)								
	8.83	0.00	8.83	0	-0.500	-2.208	2.94	-6.50
Uplift Pressure - upstream of sheetpile, if sheetpile								
	8.83	8.83	0.00	0.000	0.000	0.000	8.83	0.00
Uplift Pressure - downstream of sheetpile, if sheetpile, Assumes rest of base is on Granular Fill								
	8.83	0.00	8.83	0.000	0.000	0.000	4.42	0.00
Uplift Pressure - With no sheetpile, under portion of base not in compression								
	8.83	8.83	0.00	-0.624	-0.624	0.000	8.83	0.00
Uplift Pressure - triangular uplift if no sheetpile								
	8.83	0.00	8.83	-0.050	0	-0.220	5.89	-1.29
Uplift Pressure - rectangular uplift if no sheetpile								
	8.83	0.00	8.83	-0.574	-0.574	-5.070	4.42	-22.39
Weight of Water on Heel								
	8.83	0.00	8.83	0.000	0.000	0.000	4.42	0.00
Weight of Soil on Heel								
	8.83	0.00	8.83	1.092	1.092	9.642	4.42	42.57
	10.00	0.00	10.00	0.18667	0.000	0.933	6.67	6.22
	8.83	10.00	-1.17	0.25	0.25	-0.293	9.42	-2.75
Weight of Heel Concrete								
	8.83	0.00	8.83	0.1875	0.1875	1.656	4.42	7.31
	8.83	0.00	8.83	0	0	0.000	2.94	0.00

Total Shear (V) = -1.678 kips

Total Moment (M) = -3.846 kip-ft

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (HEEL) At Stem

Moment and Shear

Total Shear (V) = -1.7 kips
Total Moment (M) = -3.8 kip-ft

Minimum Depth based on Shear

Vu=(DLF)(V) ==> Vu =	-3.71	kips	Flexure Steel Dia. =	0.875	inches
Is design slab or beam?	*slab*		T & S Steel Dia. =	*0.75*	inches
			Required Concrete Cover =	*3.00*	inches
d min =	-3.26	in	"=Vu/(phi shear)(λ)(2)(sqrt(f'c))(bw)		ACI 11.2.1.1
Actual depth d =	11.56				
ϕ Vc =	13.16	kips	=(phi shear)(λ)(2)(sqrt(f'c))(b d)]		ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	0.0285		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071		[.25(ρ balanced)]	
As Maximum =	0.99	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**-8.50**	**kip-ft**	[(M)(DLF)]
As =	-0.16	in^2	[solved for based on above formula]

As Minimum

As, min =	0.46	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	-0.22	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.60	in^2	Use # 7 @ 12"
Steel Spacing =	*12.00*	in	
Total Steel =	0.60	in^2	

Spacing Maximum — fs = -0.64 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = -949.50 in [(15*40/fs)-2.5Cc] < 12" ACI 10.6.4

Calculations: (Bottom of Toe)

Calculation of Moment and Shear (Counter Clock Wise Positive)

Base Pressure - Rectangular portion of base pressure

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	1.259	1.259	1.259	0.50	0.63

Base Pressure - Triangular portion of base pressure (Assumes maximum pressure is at Toe)

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0	0.057	0.028	0.67	0.02

Uplift Pressure - triangular uplift. With a sheetpile cuttoff, assumes no head loss across base.

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0.006	0	0.003	0.33	0.00

Uplift Pressure - rectangular uplift

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	0.562	0.562	0.562	0.50	0.28

Weight of Soil on Toe

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	-1.092	-1.092	-1.092	0.50	-0.55

Weight of Concrete

x1	x2	Length	p1	p2	Shear	arm	Moment
0.00	1.00	1.00	-0.1875	-0.1875	-0.188	0.50	-0.09

Reaction Force From Stoplog Frame

Shear	arm	Moment
0.000	0.00	0.00

Total Shear (V) = 0.573 kips

Total Moment (M) = 0.291 kip-ft

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Calculations: (Bottom of Toe)

Moment and Shear

Total Shear (V) = 0.6 kips
Total Moment (M) = 0.3 kip-ft

Minimum Depth based on Shear

Flexure Steel Dia. = 0.875 inches
T & S Steel Dia. = 0.750 inches
Required Concrete Cover = 3.00 inches

Vu=(DLF)(V) ==> Vu = 1.27 kips

d min =	1.11	in	=Vu/(phi shear)(λ)(2)(sqrt(f'c))(bw)	ACI 11.2.1.1
Actual depth d =	11.56			
ϕ Vc =	13.16	kips	=(phi shear)(l)(2)(sqrt(f'c))(b d)]	ACI 11.2.1.1

As Maximum

ρ max = .25 ρ balanced — EM 1110-2-2104

β1=	0.85		[1.05-.05(f'c)]	.65 <= β1 <= .85
ρ balanced =	0.0285		[((.85 β1 f'c)/fy)(87000/(87000+fy))]	
ρ max =	0.0071		[.25(ρ balanced)]	
As Maximum =	0.99	in^2	[(ρ max)(bw)(d)]	

As Required

ϕMn = Mu where Mn = (As fy d)[1-(As fy)/(1.7 f'c b d)]
solve for As to determine area of steel necessary to resist moment

Mu =	**0.64**	**kip-ft**	[(M)(DLF)]
As =	0.01	in^2	[solved for based on above formula]

As Minimum

As, min =	0.46	in^2	[(3 sqrt(f'c)/fy)(b d) > or = 200 b d/fy]	ACI 10.5.1
As, min =	0.02	in^2	[4/3 As required]	ACI 10.5.3

As Temperature and Shrinkage (per side)

As =	0.16	in^2	[.0018 bw h / 2 sides]	ACI 7.12.2.1
As =	0.25	in^2	[.0028 bw h / 2 sides]	EM 1110-2-2104

As Design

As Design =	0.60	in^2	Temp and Shrinkage
Steel Spacing =	12.00	in	
Total Steel =	0.60	in^2	Use # 7@ 12"

Spacing Maximum

fs = 0.05 =M/(As*(d-(As*Fy*2)/(f'c*12)))

S = 12.00 in [(15*40/fs)-2.5Cc] < 12" ACI 10.6.4

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bass Ponds Water Control Structure	CMP BY: TSF	DATE: 9/20/2018	SHEET:
	SUBJECT TITLE: Retaining Wall_LC R12-Usual	CHK BY:	COMPUTER FILE:	

Calculations - Bearing Capacity: (EM 1110-2-2502, Chapter 5)

BEARING CAPACITY = Q

$Q= B_1[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB_1\S Nr)/2]$ EQU. 5-2

FOOTING WIDTH, (B)=	11.00	ft.
SOIL DEPTH TOE SIDE (D)=	3.90	ft.
SATURATION HT.TOE SIDE (Dw)=	9.00	ft.
BASE SLOPE, alpha, (α)=	0.00	degrees
FRICTION ANGLE OF SOIL (0f)=	33.00	deg., Below Footing
FRICTION ANGLE OF SOIL (03)=	33.00	deg., Resisting Wedge
COHESION OF FOUNDATION Cfr=	0.18	k / ft^2
SOIL UNIT Wt.,MOIST (§m)=	0.112	k / ft^3
SOIL UNIT Wt.,SATUR. (§s)=	0.115	k / ft^3
WATER UNIT WEIGHT (§w)=	0.0625	k / ft^3
SOIL UNIT Wt.,BOUYANT (§b)=	0.0525	k / ft^3
NET HORIZONTAL FORCE (SUM H)=	2.31	kip
NET VERTICAL FORCE (SUM V)=	12.29	kip
Xr (measured from toe) =	5.38	ft.
SURCHARGE LOADING=	0.25	ksf
SOIL SURFACE SLOPE,RISE/RUN=	0.00	deg.
BETA ANGLE (β)=	0.00	deg.

EFF. WIDTH OF BASE B_1 = B-2e = 2Xr = 10.76

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502

Nq = 26.09
Nc = 38.64
Nr = 26.17

EMBEDMENT FACTORS

Ecd =	$1+0.2(D/B_1)TAN(45+\phi/2)$ =	1.134	EQU.5-4a	
Eqd=Erd =	=	1.000	EQU.5-4b	IF(ϕ = O)
Eqd=Erd =	$1+0.1(D/B_1)TAN(45+\phi/2)$ =	1.067	EQU.5-4c	IF(ϕ >10)
Eqd=Erd =	=	1.067		

INTERPOLATE BETWEEN EQU. 5-4b AND 4c FOR (O<ϕ<=1O)

INCLINATION FACTORS

§o =	ARCTAN[(SUM H)/SUM V] =	10.630	DEG.	
Eqi=Eci =	(1-§o/90)^2 =	0.778		EQU.5-5a
Eri =	IF §o > ϕ, THEN Eri = 0,			ELSE,
Eri =	(1-§o/ϕ)^2 =	0.460		EQU.5-5b

BASE TILT FACTORS (α IN RADIANS)

Eqt=Ert =	(1-α*TANϕ)^2 =	1.000	EQU.5-6a
Ect =	1-(2*α/π+2) =	1.000	EQU.5-6b
Ect =	Eqt-[(1-Eqt)/(NcTANϕ)] =	1.000	EQU.5-6c
Ect =		1.000	

GROUND SLOPE FACTORS (β is positive when the ground slopes down and away from the footing.)

Erg=Eqg =	[1-TAN(-β)]^2 =	1.000	EQU.5-7a
Ecg =	1-[2*(-β)/(PI+2)] =	1.000	EQU.5-7b
Ecg =	Eqg-[(1-Eqg)/Nc*TANϕ] =	1.000	EQU.5-7d
Ecg =		1.000	

EFFECTIVE OVERBURDEN PRESSURE

qo =	(Q+§*D)*COS(β) =	0.455		EQU.5-8a
		0.205	§b*D	

EFFECTIVE SOIL UNIT WEIGHT

§ =	IF(Dw=0,§m,§b)=	0.0525	ksf

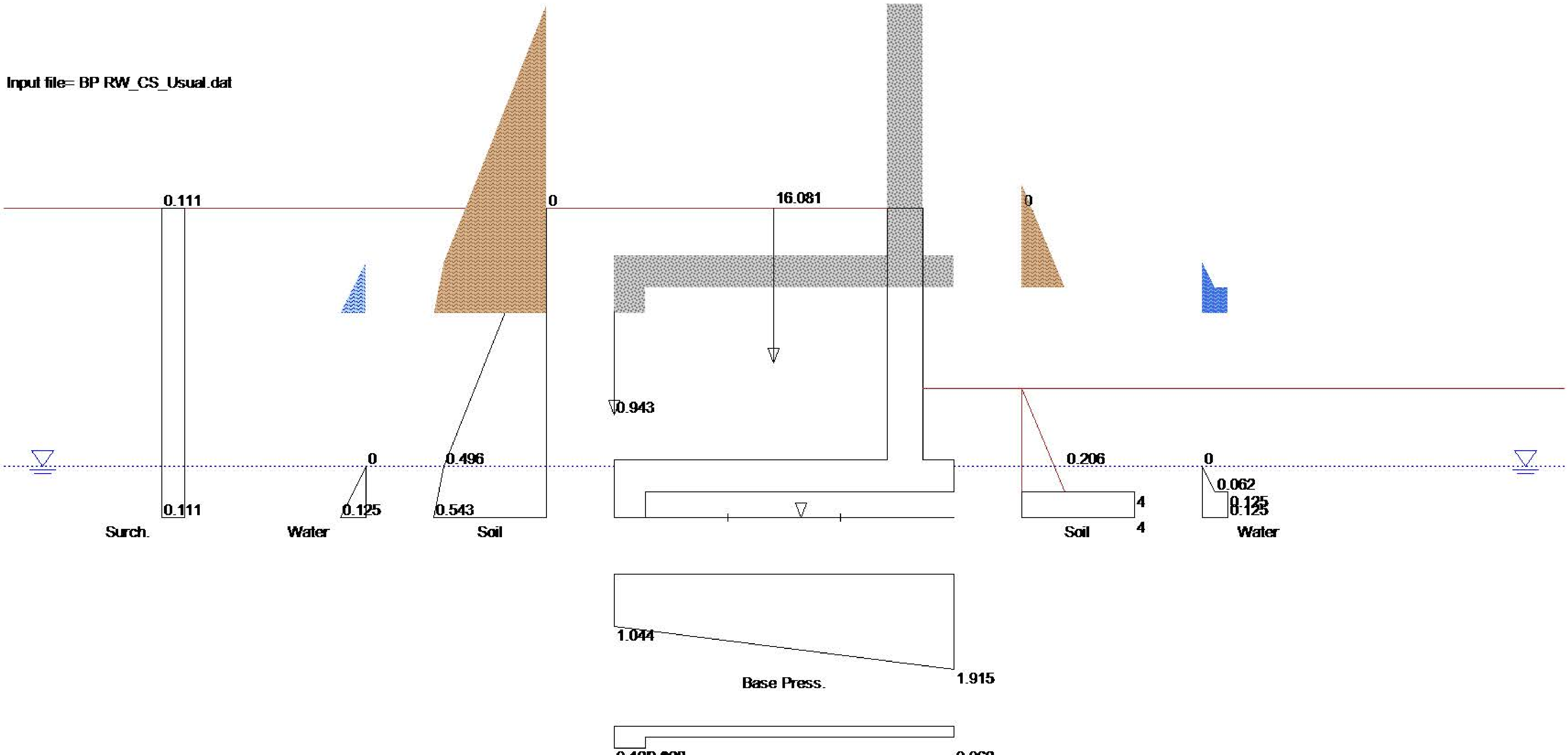
BEARING CAPACITY = 210.51 kips EQU. 5-2

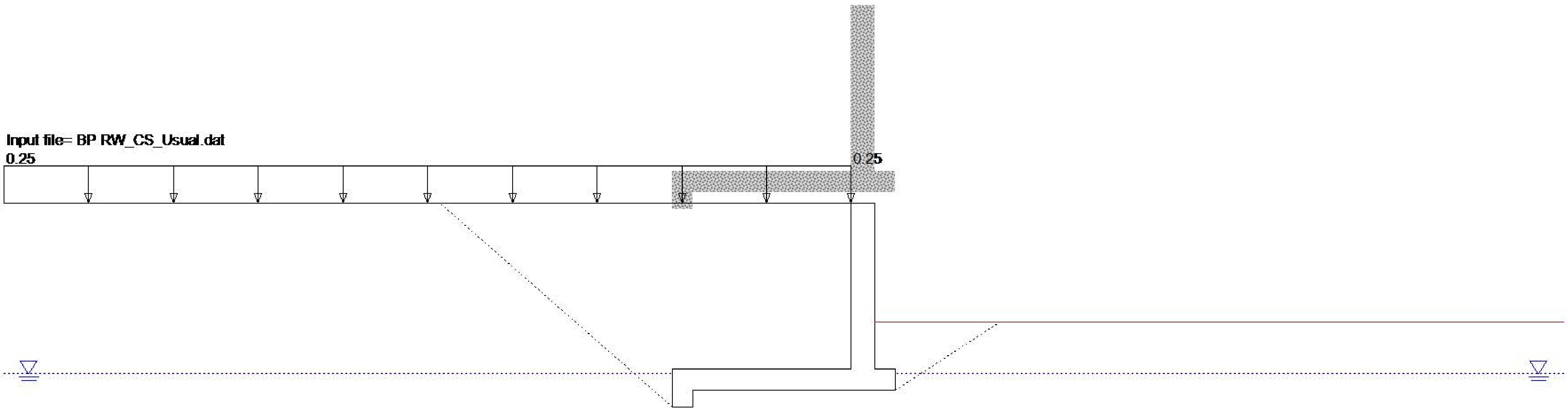
F.O.S. = Q/SUM V= 17.13 EQU. 5-1

F.O.S. Required For (R2) = 2.0

Thus, Design is OK

Input file= BP RW_CS_Usual.dat





Input file= BP RW_CS_Usual.dat
0.25
0.25

****************** Echoprint of Input Data ******************

Date: 2018/ 9/20 Time: 14.38.03

Structural geometry data:

Elevation of top of stem (ELTS)	=	700.00 ft
Height of stem (HTS)	=	9.75 ft
Thickness top of stem (TTS)	=	1.17 ft
Thickness bottom of stem (TBS)	=	1.17 ft
Dist. of batter at bot. of stem (TBSR)	=	0.00 ft
Depth of heel (THEEL)	=	2.25 ft
Distance of batter for heel (BTRH)	=	0.00 ft
Depth of toe (TTOE)	=	1.25 ft
Width of toe (TWIDTH)	=	1.00 ft
Distance of batter for toe (BTRT)	=	0.00 ft
Width of base (BWIDTH)	=	11.00 ft
Depth of key (HK)	=	1.00 ft
Width of bottom of key (TK)	=	1.00 ft
Dist. of batter at bot. of key (BTRK)	=	0.00 ft

Structure coordinates:

x (ft)	y (ft)
0.00	688.00
0.00	690.25
8.83	690.25
8.83	700.00
10.00	700.00
10.00	690.25
11.00	690.25
11.00	689.00
1.00	689.00
1.00	688.00

NOTE: X=0 is located at the left-hand side of the structure. The Y values correspond to the actual elevation used.

Structural property data:
  Unit weight of concrete = 0.150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
28.00	0.000	0.112	0.115	11.00	700.00

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	10.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1501.17	700.00
2	8.83	700.00

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
28.00	0.000	0.112	0.115	693.00	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	10.00	693.00
2	510.00	693.00

Foundation property data:
  phi for soil-structure interface = 22.00 (deg)
  c for soil-structure interface = 0.000 (ksf)
  phi for soil-soil interface = 20.00 (deg)
  c for soil-soil interface = 0.000 (ksf)

Water data:
  Driving side elevation = 690.00 ft
  Resisting side elevation = 690.00 ft
  Unit weight of water = 0.0624 kcf
  Seepage pressures computed are hydrostatic.

Uniform load data:
  Magnitude of load = 0.2500 k/ft

Minimum required factors of safety:
  Sliding FS = 1.25
  Overturning = 75.00% base in compression

Crack options:

```
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.6667

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.



***** Summary of Results *****

***************    *** Satisfied ***
* Overturning *    Required base in comp. =  75.00 %
***************    Actual base in comp.   = 100.00 %
                   Overturning ratio      =   4.79

Xr (measured from toe) =   4.96 ft
Resultant ratio        = 0.4509
Stem ratio             = 0.0909
Base pressure at heel =    1.0441 ksf
Base pressure at toe  =    1.9151 ksf

***********    *** Satisfied ***
* Sliding *    Min. Required =   1.25
***********    Actual FS     =   2.03

***********
* Bearing *
***********

Net ultimate bearing pressure =     1.8283 (ksf)
Factor of safety =      1.097


********************** Output Results **********************


Date: 2018/ 9/20                               Time: 14.38.03


***************************
**  Overturning Results  **
***************************

Solution converged in  1 iterations.

SMF used to calculate K's =   0.6667
```

```
Alpha for the SMF          = -50.3828
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4432
  Driving side at rest Kc   =   0.6385
  Resisting side at rest K  =   0.5305
  Resisting side at rest Kc =   0.7284
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       690.00     0.0000
       688.00     0.1248

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       700.00     0.0000
       690.00     0.4964
       688.00     0.5430

  Surcharge pressures:
       Elev.   Press.
       (ft)    (ksf)
    ===================
       700.00    0.111
       688.00    0.111

** Resisting side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       690.00     0.0000
       689.00     0.0624
       689.00     0.1248
       688.00     0.1248

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
       693.00     0.0000
       689.00     0.2062

  Balancing earth pressures:
    Elevation   Pressure
```

(ft)	(ksf)
689.00	4.4077
688.00	4.4077

** Uplift pressures **

Water pressures:

x-coord. (ft)	Pressure (ksf)
0.00	0.1248
1.00	0.1248
1.00	0.0624
11.00	0.0624

** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Moment (ft-k)
Structure:				
Structure weight...........	3.924		-3.98	-15.63
Structure, driving side:				
Moist soil.................	9.642		-6.59	-63.50
Saturated soil.............	0.000		0.00	0.00
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.000		0.00	0.00
External vertical loads....	2.207		-6.59	-14.54
Ext. horz. pressure loads..		0.000	0.00	0.00
Ext. horz. line loads......		0.000	0.00	0.00
Structure, resisting side:				
Moist soil.................	0.308		-0.50	-0.15
Saturated soil.............	0.000		0.00	0.00
Water above structure......	0.000		0.00	0.00
Water above soil...........	0.000		0.00	0.00
Driving side:				
Effective earth loads......		3.522	3.05	10.75
Shear (due to delta).......	0.943		-11.00	-10.37
Horiz. surcharge effects...		1.330	5.00	6.65
Water loads................		0.125	-0.33	-0.04
Resisting side:				
Effective earth loads......		-0.412	1.34	-0.55
Balancing earth load.......		-4.408	-0.49	2.17
Water loads................		-0.156	-0.35	0.05
Foundation:				
Vertical force on base.....	-16.276		-4.96	80.73
Uplift.....................	-0.749		-5.92	4.43
** Statics Check ** SUMS =	0.000	0.000		0.00

Angle of base = 5.19 degrees
Normal force on base = 16.608 kips

```
Shear force on base  =    2.916 kips
Max. available shear force =    6.232 kips

Base pressure at heel =   1.0441 ksf
Base pressure at toe  =   1.9151 ksf

Xr (measured from toe) =     4.96 ft
Resultant ratio        =   0.4509
Stem ratio             =   0.0909
Base in compression    =   100.00 %
Overturning ratio      =     4.79

Volume of concrete =     0.97 cubic yds/ft of wall
```

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

```
***********************
**  Sliding Results  **
***********************
```

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	0.000	2.866
2	0.000	2.207
3	0.000	0.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.0000	0.1248		
2			0.0000	0.1248
2			11.0000	0.0624
3	0.0000	0.0624		

```
Points of sliding plane:
  Point 1 (left),  x =     0.00 ft,   y =   688.00 ft
  Point 2 (right), x =    11.00 ft,   y =   689.00 ft
```

Depth of cracking = 0.00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-46.313	16.595	7.708	2.766	0.173
2	5.194	11.045	14.391	11.045	1.034
3	37.723	6.538	1.160	1.634	0.051

Wedge number	Net force (kips)
1	-5.860
2	4.374
3	1.486
SUM =	0.000

```
+-----------------------------+
| Factor of safety =    2.027 |
+-----------------------------+
```

```
**********************
**  Bearing Results  **
**********************
```

```
            Base width =     11.045 (ft)
                    Xr =      4.960 (ft)
  Effective base width =      9.962 (ft)
   (measured along slope)
            Base slope =     5.1944 (deg)

                   phi =     20.000 (deg)
                     c =      0.000 (ksf)
       Effective gamma =     0.0526 (kcf)

           Normal load =     16.608 (kips)
      Load inclination =      9.959 (deg)
     Load eccentricity =      0.542 (ft)

             Surcharge =     0.3886 (ksf)
             Embedment =      4.000 (ft)
          Ground slope =     0.0000 (deg)
```

Bearing Capacity Factors

	C	Q	G
Bearing	14.8347	6.3994	2.8709

```
Embedment        1.1147    1.0573    1.0573
Inclination      0.7909    0.7909    0.2521
Base Tilt        0.9231    0.9351    0.9351
Ground Slope     1.0000    1.0000    1.0000

Net ultimate bearing pressure =     1.8283 (ksf)

+--------------------------------+
| Factor of safety =      1.097 |
+--------------------------------+
```

Stoplogs Design

US Army Corps of Engineers Saint Paul Distict	PROJECT TITLE: Bass Ponds, HREP	COMPUTED TSF	DATE: 10/15/18	SHEET: /
	SUBJECT TITLE: Stoplogs Design	CHECKED B	DATE:	

Stoplog Selection

Location	Approx. Station	Opening Dim.(In)	Invert Elevation	Top Elevation	Height	Stoplog Length (ft)	Number of Logs	Weight of Log lbs
Control Structures at Ditch 18&61		60.00	691.26	698.81	7.55	5.50		29.93

Aluminum Stoplog Tube Dimensions and Properties

w	*4*	in	Iy	12.3	in^4	Stoplog Length =	5.50 ft
b	*6*	in	Sy	6.2	in^3	Weight =	30 lb
t	*0.25*	in	Ix	23.5	in^4		
A	4.75	in^2	J	2.2	in^2		
weight/ft	5.44	lb/ft	Av	2	in^2		

Aluminum Design per The Aluminum Design Manual, by the Aluminum Association

Allowable stress are given in Table 3.6, for 6061-T6 for bridge type structures
By Table 3.4-1, the basic factor of safety for bridge structures in yield is 1.85
By EM 1110-1-2101, Appendix III, the hydraulic factor of safety for aluminum structures is 1.95. The allowable stresses shall be decreased by 1.85 / 1.95 = 0.95.

Tension in Beams (bent about weak axis)

f_{bt} = *17* ksi x .95= 16.2 ksi

Compression in Beams (with flat plates supported on two edges)

S_1, b/t = *20* S_2, b/t = *33* b/t= 24.0

f_{bc} = 18.1 ksi x .95= 17.2 ksi [if b/t < S1, 17, if b/t < S2, 24.3-0.26b/t, 520/b/t]

Shear in Webs

f_v = *11* ksi x .95= 10.5 ksi

Location	Closure Height	Bottom Uni. Load		Supported Length	Bending Moment	Bending Stress	Shear	Shear Stress
Control Structures at Ditch 18&61	7.55	0.24		5.25	0.81	1.58	0.62	0.31

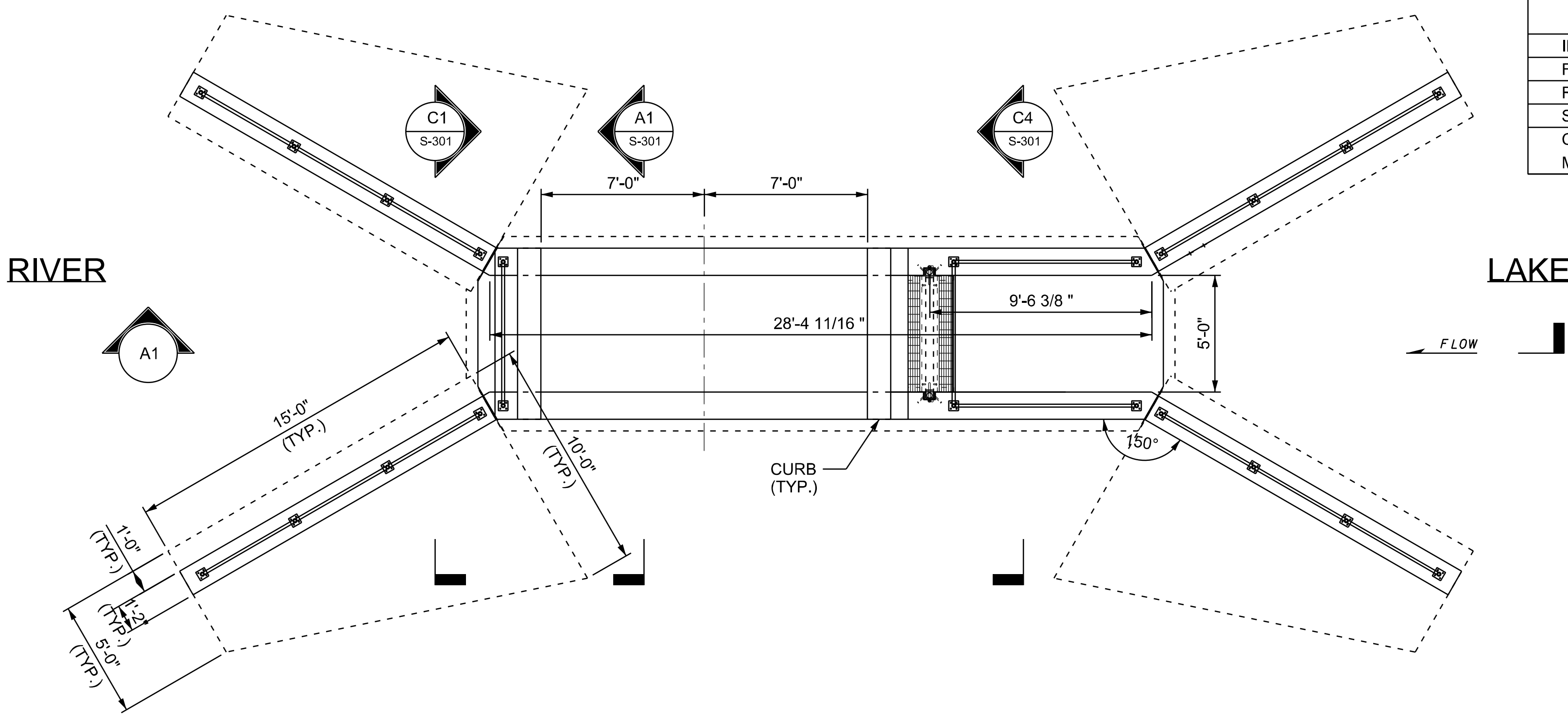
All Units are Kips and Feet

Bottom Uniform Load = Height * 0.0625 * b / 12
Bending Moment = (Bottom Uni. Load * Supported Length ^2 / 8)
Bending Stress = Bending Moment * 12 / Sy
Shear = Bottom Uni. Load * Supported Length/2
Shear Stress = Shear / Av

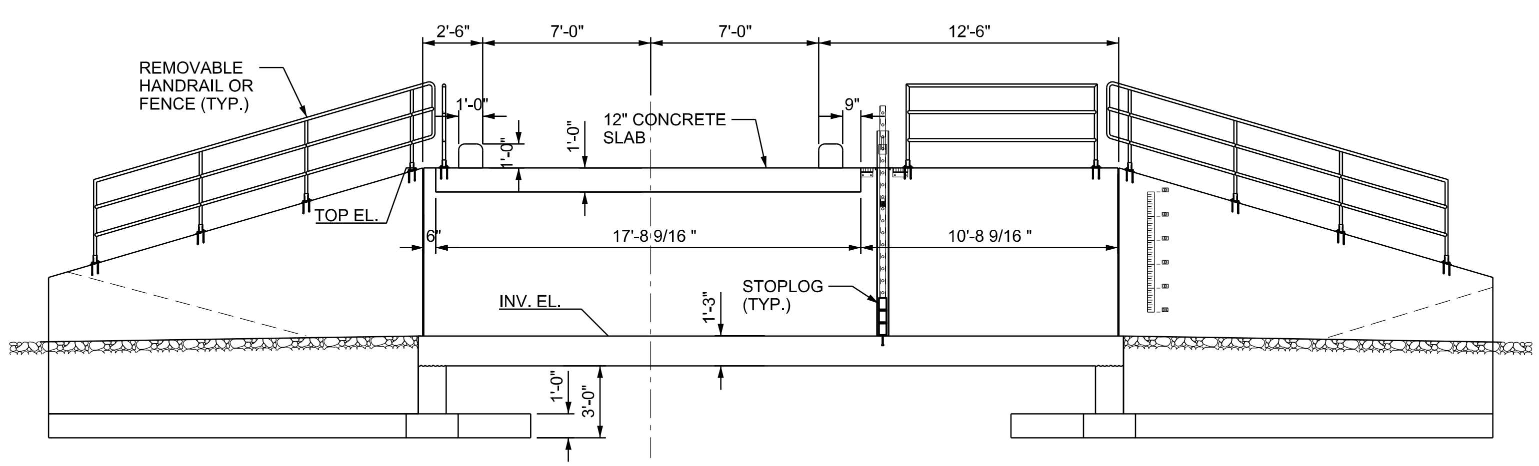
Life Load Factor	1.60	ACI 9.2.5
Hydraulic Load Factor	1.30	

Shear per stoplog	0.62 Kip
Factord load per 12" strip of groove	2.58 Kip

DATA					
NAME/S	TOP EL.	BOT. EL.	INV. EL.	FROM	TO
INTERLAKE	702.00	691.75	693.00	BLUE LAKE	FISHER LAKE
FISHER LAKE	701.00	691.75	693.00	FISHER LAKE	CHANNEL
RICE LAKE	704.60	691.75	693.00	RICE LAKE	CHANNEL
SECONDARY OUTLET	701.00	691.75	693.00	CHANNEL	MINNESOTA RIVER
CONTINENTAL GRAIN MARSH LAKE	701.50	691.75	693.00	CONTINENTAL GRAIN MARSH LAKE	MINNESOTA RIVER



B1 PLAN VIEW - ONE BAY CONTROL STRUCTURE
SCALE: 1/4" = 1'



A1 SECTION - CUT THROUGH MIDDLE
SCALE: 1/4" = 1'

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINE SCALED FACTOR (CSF):

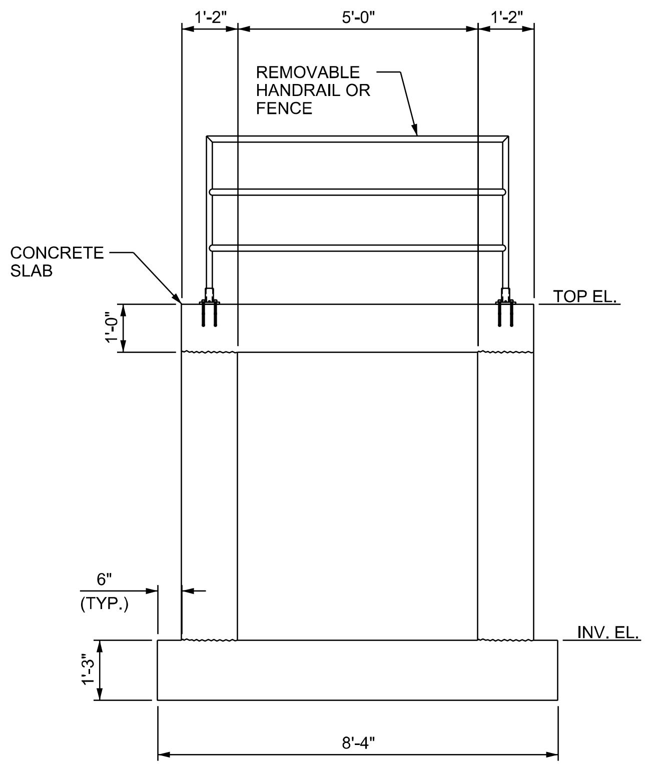
US Army Corps of Engineers

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

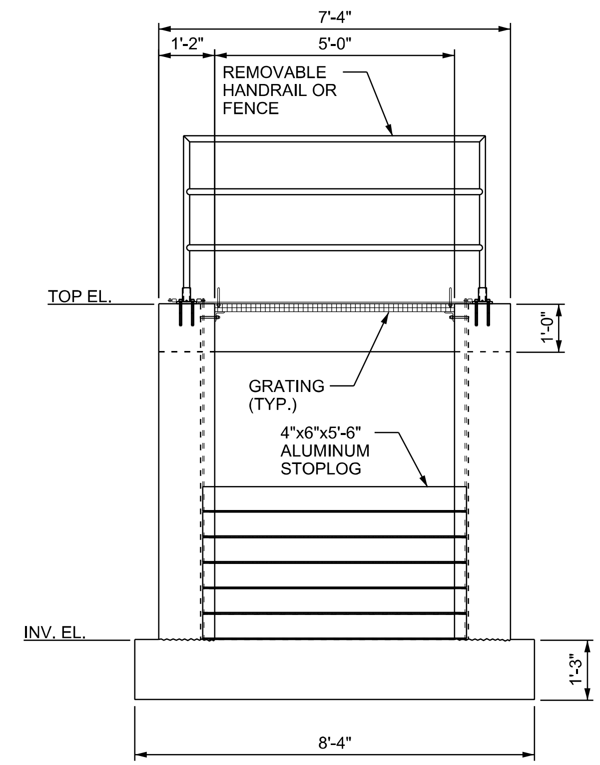
DESIGNED BY: TSF
DWN BY: NK
CKD BY:
SUBMITTED BY:
DATE: 2018/08/10
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
PLOT SCALE: 1/4" = 1'
PLOT DATE: 10/17/2018
SIZE: ANSI D
FILE NAME: BLPHR_S-101---.DGN

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN
ONE BAY CONTROL STRUCTURE
PLAN VIEW AND SECTION

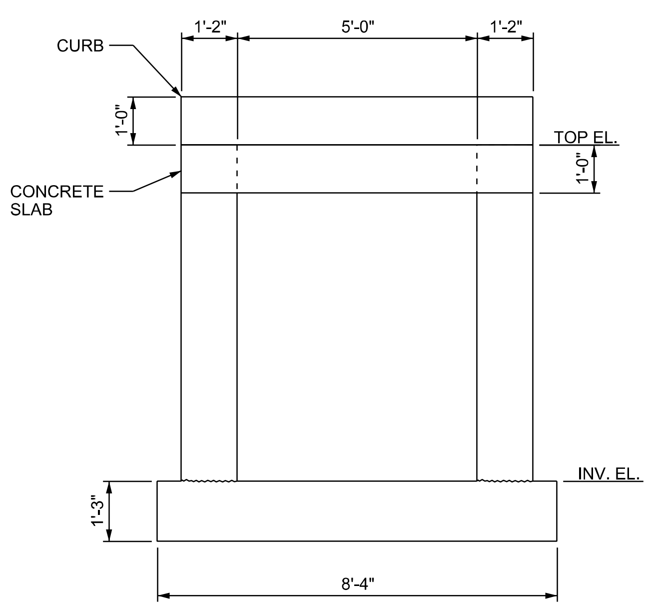
Sheet ID
S-101



C1 SECTION - CUT FROM RIVER SIDE
SCALE: 1/2" = 1'



C4 SECTION - CUT AT STOPLOG FROM LAKE SIDE
SCALE: 1/2" = 1'



A1 SECTION - CUT AT CURB
SCALE: 1/2" = 1'

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID 12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINE SCALED FACTOR (CSF):

US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR.

MARK	DESCRIPTION	DATE	APPR.

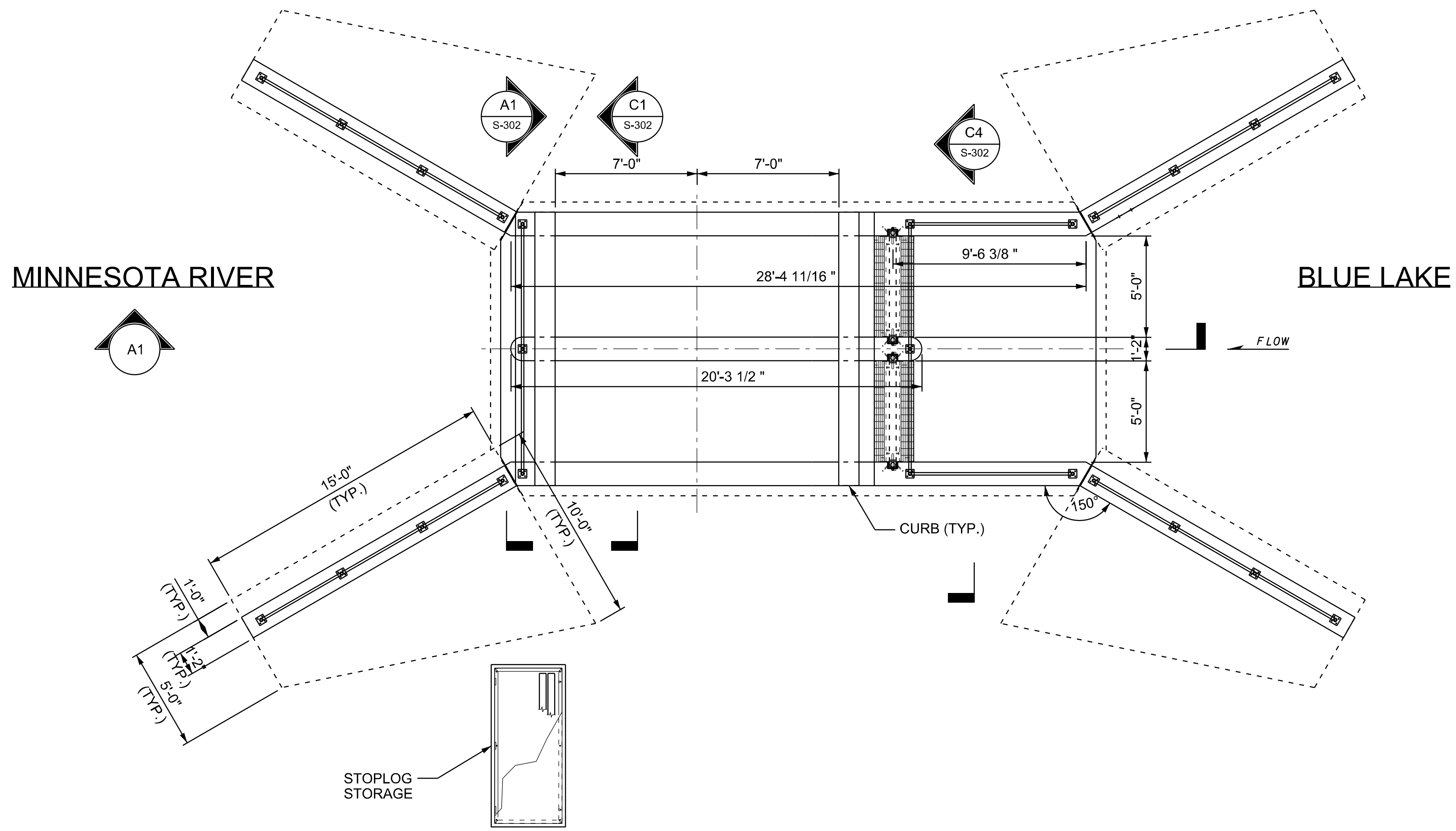
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

DESIGNED BY: TSF
DWN BY: NK
CKD BY:
SUBMITTED BY:
DATE: 2018/08/09
SOLICITATION NO.:
CONTRACT NO.:
PLOT SCALE: 1/2" = 1'
PLOT DATE: 10/17/2018
FILE NUMBER:
SIZE: ANSI D
FILE NAME: BLPHR_S-301---.DGN

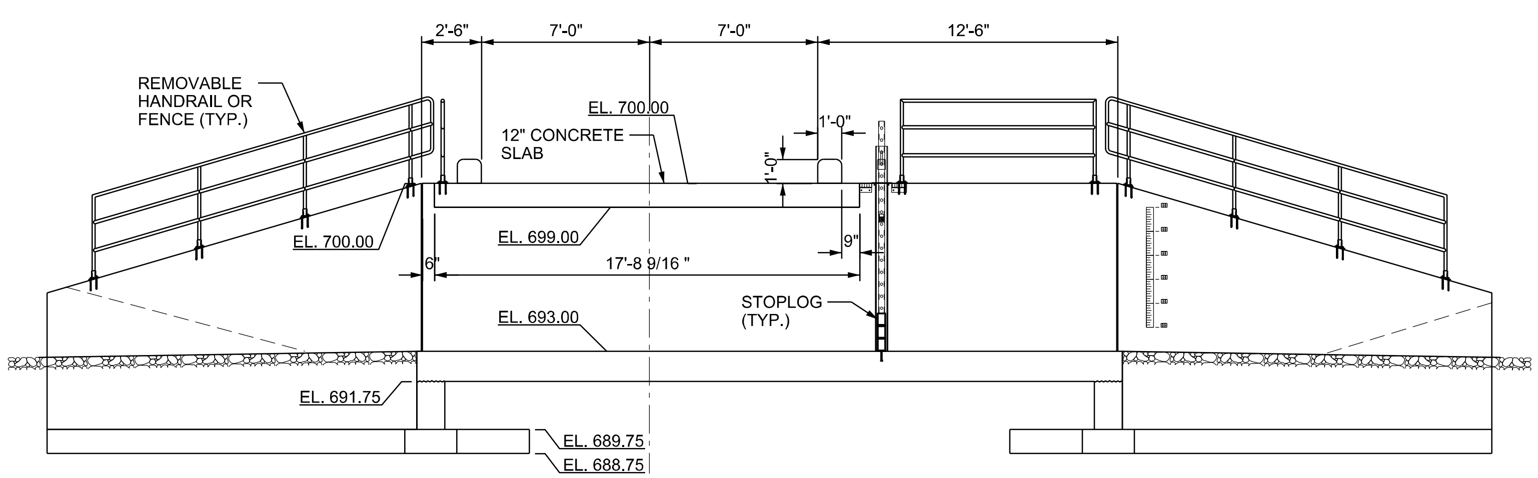
BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

ONE BAY CONTROL STRUCTURE
SECTIONS

Sheet ID
S-301



B1 PLAN VIEW - CONTROL STRUCTURE
SCALE: 1/4" = 1'



A1 SECTION - CUT THROUGH MIDDLE
SCALE: 1/4" = 1'

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88 GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL): NAD 83 (2011) MN SPCS, SOUTH ZONE-U.S. SURVEY FT. COMBINED FACTOR (CF):

US Army Corps of Engineers

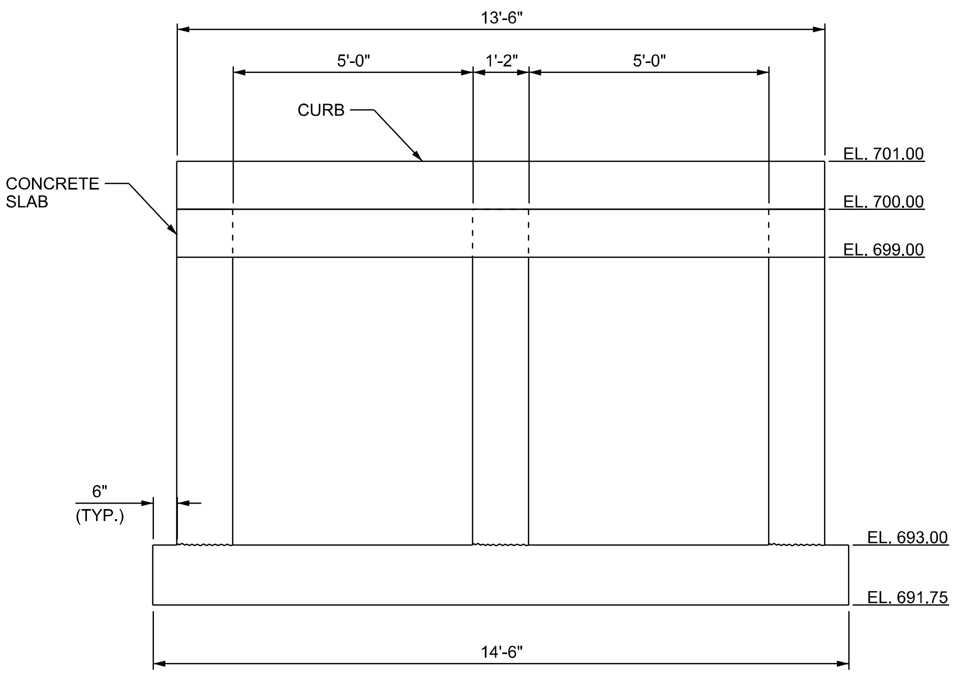
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

DESIGNED BY: TSF
DWN BY: NK
CKD BY:
SUBMITTED BY:
PLOT SCALE: 1/4" = 1'
PLOT DATE: 10/16/2018
SIZE:
FILE NAME: BLPHR_S-102---.DGN
DATE:
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

TWO BAYS CONTROL STRUCTURE
PLAN VIEW AND SECTION

Sheet ID
S-102



C1 SECTION - CUT AT CURB
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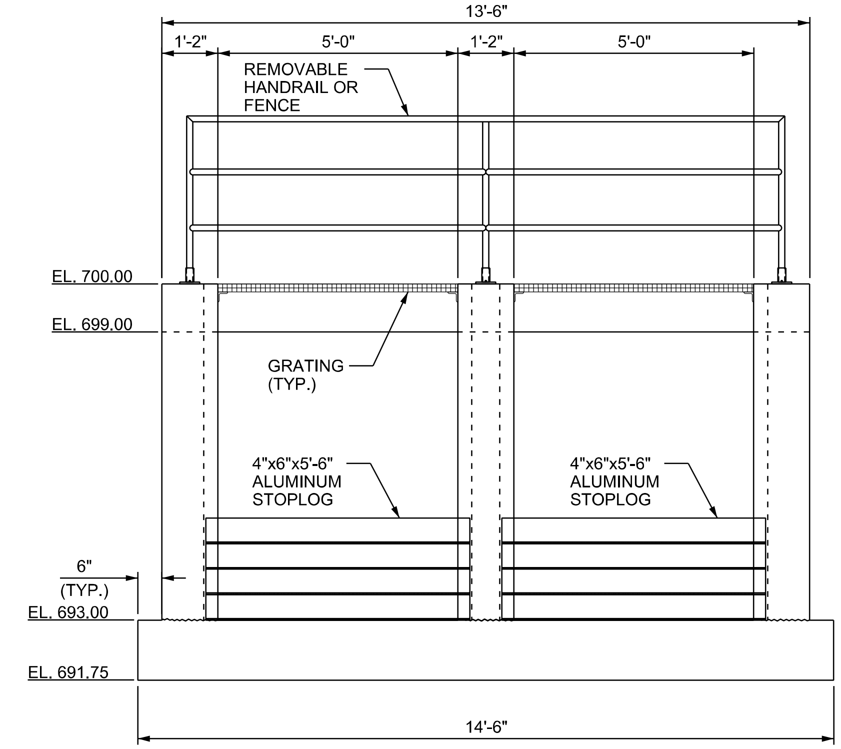

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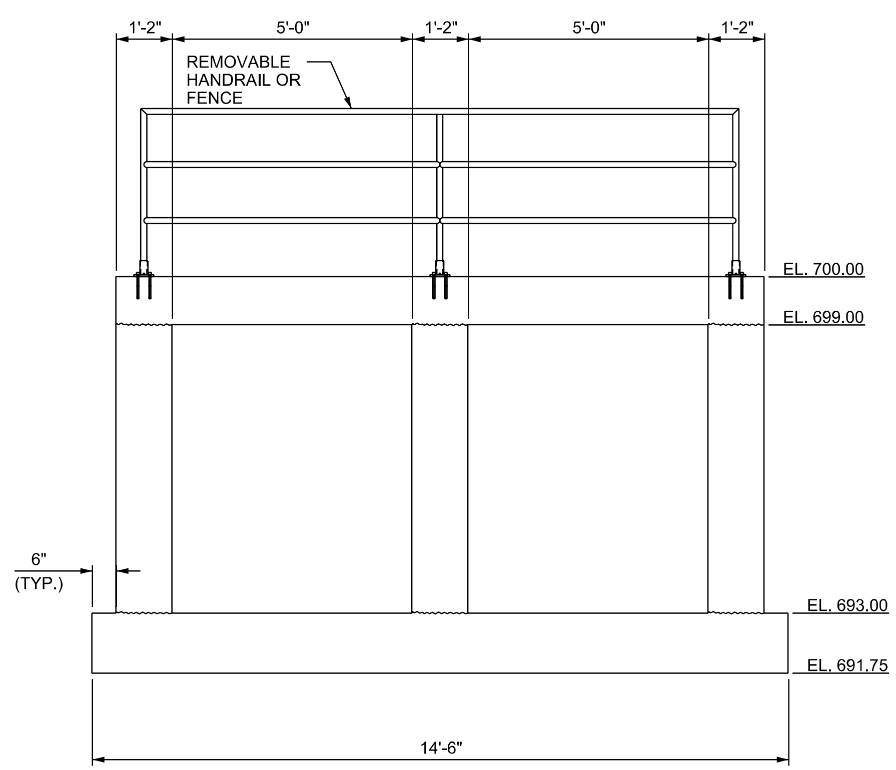

A1 SECTION - CUT AT STOPLOG FROM RIVER SIDE
SCALE: 1/2" = 1'

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88 GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL): NAD 83 (2011) MN SPCS, SOUTH ZONE-U.S. SURVEY FT. COMBINED FACTOR (CF):

US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR.

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

DESIGNED BY: TSF | DWN BY: NK | CKD BY: | SUBMITTED BY: | PLOT SCALE: 1/2" = 1' | PLOT DATE: 10/16/2018 | SIZE: | FILE NAME: BLPHR_S-302---.DGN | DATE: | SOLICITATION NO.: | CONTRACT NO.: | FILE NUMBER:

BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

TWO BAYS CONTROL STRUCTURE
SECTIONS

Sheet ID
S-302

US Army Corps of Engineers ®
St. Paul District

Appendix K: Monitoring and Adaptive Management

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix K

TABLE OF CONTENTS

1 Introduction 3

2 Project Objectives 4

3 Performance Indicators 4

3.1 Objective 1 – Increase the diversity and percent cover of desirable emergent aquatic plant species 4

3.2 Objective 2 – Increase the diversity and percent cover of desirable submergent aquatic plant species 5

3.3 Objective 3 – Provide quality feeding and resting habitat for a wide variety of waterfowl and water birds with particular emphasis on fall migrating waterfowl 6

4 Monitoring Schedule Summary 7

5 Drawdown Elevations 7

6 Adaptive Management and Monitoring Budget 10

7 Monitoring Roles and Responsibilities 10

8 Contingency Planning and Project Modification 10

9 Project Close Out 10

10 References 11

1 Introduction

The St. Paul District, U.S. Army Corps of Engineers (USACE), in conjunction with U.S. Fish and Wildlife Service (USFWS) and Minnesota Department of Natural Resources, has prepared a plan to improve habitat on Blue, Fisher and Rice lakes as well as Continental Grain Marsh. These resources are located within the Minnesota Valley National Wildlife Refuge and adjacent to the Minnesota River in Scott County, Minnesota. The project is being studied under the Upper Mississippi River Restoration (UMRR) program. Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, when conducting a Feasibility Study for ecosystem restoration, that the recommended project includes a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires that an Adaptive Management Plan be developed for all ecosystem restoration projects.

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within USACE restoration projects. Lessons learned in designing, constructing, and operating similar restoration projects have been incorporated into the planning and design of this project to identify a plan that represents the best available information on design and operation to achieve the project goal and objectives.

This adaptive management plan appendix outlines how the results of the project specific monitoring plan would be used to adaptively manage the project. Monitoring targets which demonstrate project success in meeting objectives are included. The intent of the project delivery team (PDT) was to develop monitoring and adaptive management actions appropriate for the project’s goal and objectives.

Adaptive management provides a process for making decisions in the face of uncertainty. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which can include an incomplete description and understanding of relevant ecosystem structure and function; imprecise relationships among project management actions and corresponding outcomes; engineering challenges in implementing project alternatives; and ambiguous management and decision-making processes.

Adaptive management may be achieved through either active or passive adaptive management techniques. Active adaptive management in the Bass Ponds project would involve iterative management decisions influenced by the results achieved by project features. Actions of active adaptive management for the project may include adjusting the timing, duration, frequency or rate of drawdowns, mechanical removal or chemical control of undesirable species, or planting emergent or submersed species. Tracking of project successes and failures will be accomplished through careful recording and monitoring.

Passive adaptive management uses the best available information to achieve management objectives, involves updating resource understanding through analysis of the monitoring data, and the incorporation of the updated understanding into future best management practices. For this project, passive adaptive management would include an assessment of feature functionality through observation and the documentation of lessons learned.

All monitoring and adaptive management components discussed below will be reviewed following preparation of detailed project plans and specifications to ensure each performance indicator is adequately addressed. Modifications and adjustments to this document will be made based on results observed in the field.

2 Project Objectives

The objectives of the project are to:

1. Increase the diversity and percent cover of desirable emergent aquatic plant species.
2. Increase the diversity and percent cover of desirable submergent aquatic plant species.
3. Provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl.

3 Performance Indicators

Performance indicators for the above objectives were developed with the best available knowledge. They were developed to be specific, measureable, attainable, realistic, and timely (SMART). The conceptual monitoring schedule and estimated costs are discussed in the following sections.

Each project objective is assessed by at least one performance indicator. For each performance indicator, the rationale behind the indicator and the methodology used is discussed. In addition, the monitoring targets (the desired outcomes) and action criteria (the adaptive management triggers) are listed. The action criteria are used to determine if and when adaptive management actions should be implemented.

3.1 Objective 1 – Increase the diversity and percent cover of desirable emergent aquatic plant species

3.1.1 Performance Indicator 1A: Emergent Vegetation Diversity and Cover (Adaptive Management)

3.1.1.1 Rationale

Diversity and cover of emergent vegetation is critical to increasing the habitat value for waterfowl and water birds by serving as a food source, providing thermal protection, and functioning as visual barriers.

3.1.1.2 Methodology

Vegetation monitoring will be conducted once prior to construction, once between years 4 and 6 (midpoint) and once between years 8 and 10 (final). Midpoint and final vegetation monitoring shall only be conducted if a drawdown has occurred in the previous years. The Long Term Resource Monitoring Program Procedures: Aquatic Vegetation Monitoring (Yin et al. 2000) methodology will be used. Surveys will take place in July, August or early September prior to duck hunting season. If sample points are not accessible by boat, an attempt will be made to access the point from land. Because vegetation sampling on approximately 1000 acres of wetlands is time intensive, sampling each waterbody may not be feasible; therefore, priority will be given to Fisher Lake, followed by Rice Lake and Blue Lake. Continental Grain Marsh will not be sampled due to difficulty in accessing the area.

3.1.1.3 Monitoring Targets (Desired Outcomes)

The targets for species diversity and cover are in accordance with the Minnesota Valley National Wildlife Refuge Habitat Management Plan (USFWS 2018) and include the following:

a. Percent Cover: ≥75% native, non-invasive plant species and <25% invasive and/or non-native plant species

b. Species Richness: ≥10 native, non-invasive plant species

c. Total cover for each aquatic resource: Combination of 80% cover of native emergent, submergent and floating leaved vegetation

3.1.1.4 Adaptive Management

Adaptive management actions should be implemented if any of the monitoring targets are not met. Adaptive management strategies could include, but are not limited to, adjusting the timing, duration, frequency or rate of drawdowns, mechanical removal or chemical control of undesirable species, or planting emergent species. The exact management action implemented will be decided by the site manager.

3.2 Objective 2 – Increase the diversity and percent cover of desirable submergent aquatic plant species

3.2.1 Performance Indicator 2A: Submergent Vegetation Density and Cover (Adaptive Management)

3.2.1.1 Rationale

Diversity and cover of submergent vegetation is critical to increasing the habitat value for waterfowl and water birds. Submergent vegetation serves as a direct food source (fruit, seeds, rhizomes and tubers) for waterfowl and supports a diversity of aquatic invertebrates which are a valuable source of protein during the breeding season.

3.2.1.2 Methodology

See Section 3.1.1.2.

3.2.1.3 Monitoring Targets (Desired Outcomes)

The targets for species diversity and cover are in accordance with the Minnesota Valley National Wildlife Refuge Habitat Management Plan (USFWS 2018) and include the following:

a. Percent Cover: ≥75 native, non-invasive plant species and <25% invasive and/or non-native plant species

b. Species Richness: ≥6 native, non-invasive plant species

c. Total cover for each aquatic resource: Combination of 80% cover of native emergent, submergent and floating leaved vegetation

3.2.1.4 Adaptive Management

Adaptive management actions should be implemented if any of the monitoring targets are not met. Adaptive management strategies could include, but are not limited to, mechanical removal or chemical control of undesirable species, planting submergent species, or adjusting the timing, duration, frequency or rate of drawdowns. The exact management action implemented will be decided by the site manager.

3.3 Objective 3 – Provide quality feeding and resting habitat for a wide variety of waterfowl and water birds with particular emphasis on fall migrating waterfowl

3.3.1 Performance Indicator 3A: Migratory Bird Use Rates (Monitoring)

3.3.1.1 Rationale

Migratory bird counts are commonly used to assess habitat use. Bird counts have been used as an effective sampling method in the past and can help to verify a biological response to the physical changes brought on by the project. Changes in data collected during bird counts would be a strong indicator of the availability of nesting and resting habitat for birds, particularly waterfowl.

3.3.1.2 Methodology

Waterbirds would be counted weekly for eight weeks during spring and fall migration. Data will be collected prior to construction, between years 4-6 (midpoint) and between years 8-10 (final). Due to hunting on Rice Lake, bird counts may be conducted monthly instead of weekly. Rice Lake may need to be closed to hunting during monitoring.

3.3.1.3 Monitoring Targets (Desired Outcomes)

The desired response would be increases in use by year 10 following project construction. An increase of at least 10% in total migratory bird numbers or any increase in species richness would be considered successful.

4 Monitoring Schedule Summary

Year	Activity	Timing
0	Vegetation monitoring	July, Aug, early September
	Bird monitoring	spring and fall
4 - 6	Vegetation monitoring	July, Aug, early September
	Bird monitoring	spring and fall
6*	USFWS bird monitoring write up due to USACE	Early December
	USACE to complete PER	Late December
8 - 10	Vegetation monitoring	July, Aug, early September
	Bird monitoring	spring and fall
10	USFWS bird monitoring write up due to USACE	Early December
	USACE to complete PER	Late December

*This will be completed if project success is documented after the first round on monitoring. If project success is not obtained, then monitoring will continue.

5 Drawdown Elevations

Bathymetry was used to categorize water depths, and a combination of aerial imagery, LIDAR elevation data and field observations were used to determine the estimated extent of wetland vegetation. Based on the data collected, elevations for optimal pool, partial drawdown and full drawdown were determined. Figures 1 – 4 show these elevations for Blue, Fisher and Rice Lakes and Continental Grain Marsh and can be used for vegetation extent estimates when conducting drawdowns in the project area.

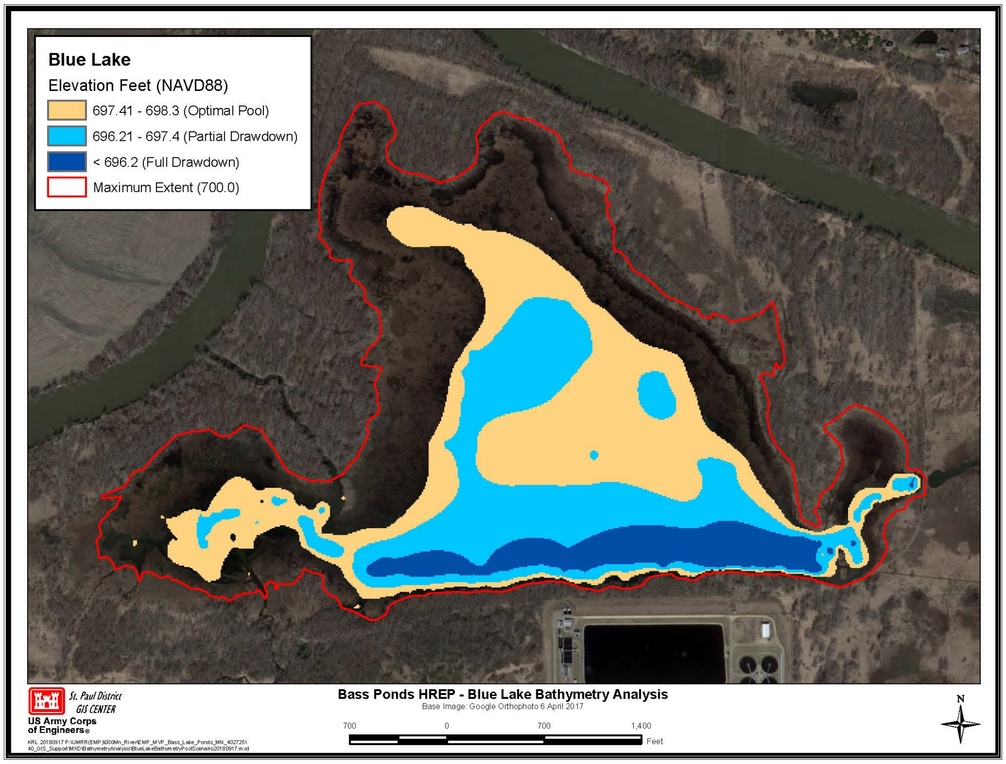

Figure 1. Blue Lake drawdown elevations

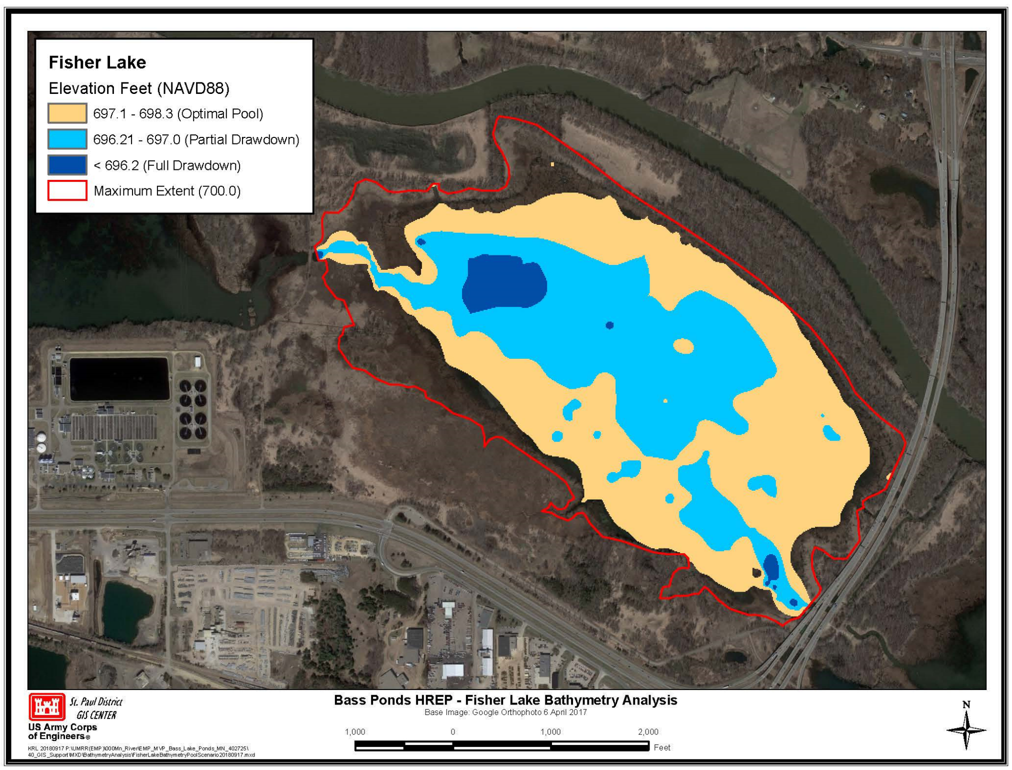

Figure 2. Fisher Lake drawdown elevations

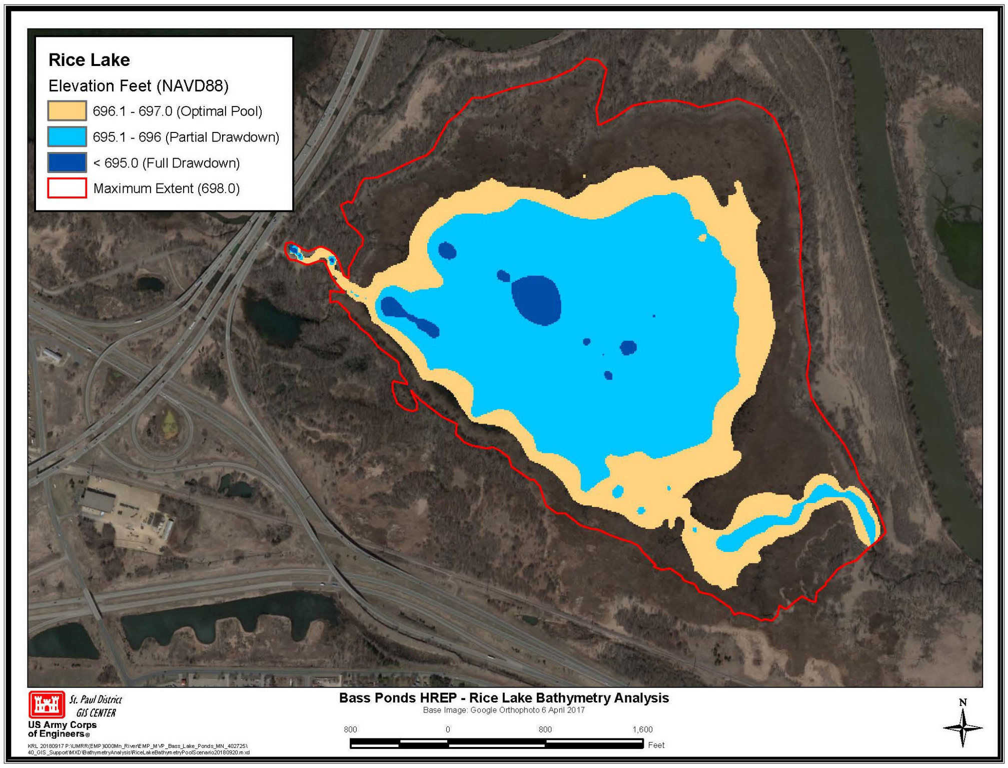

Figure 3. Rice Lake drawdown elevations

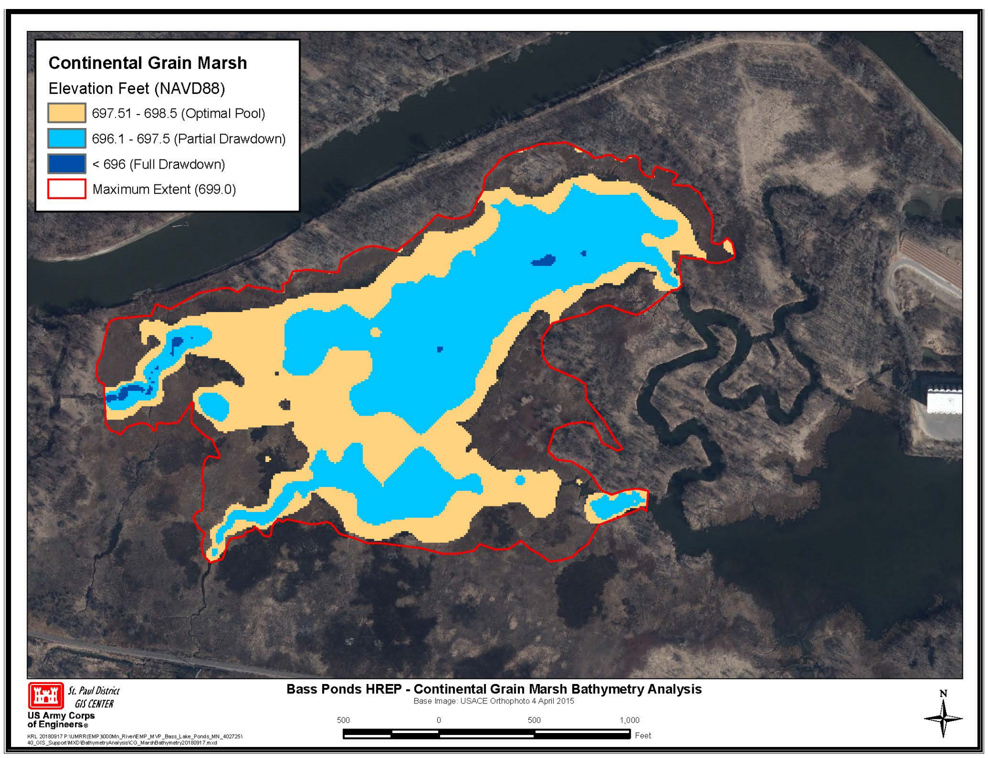

Figure 4. Continental Grain Marsh drawdown elevations

6 Adaptive Management and Monitoring Budget

Active adaptive management actions for the project may include wetland planting and invasive species control. Specific adaptive management strategies have not been developed, but would follow the development of a detailed planting or management plan. The budgeted cost for adaptive management is $37,670. The budgeted cost for monitoring is $45,600, which includes vegetation and bird surveys. Vegetation surveys would total $45,600 and bird surveys would total $44,730 over the 10-year monitoring period.

7 Monitoring Roles and Responsibilities

USACE is responsible for determining ecological success for the ecosystem restoration projects it constructs. Monitoring and adaptive management may extend for up to 10 years following project completion and would be federally funded. USACE, or its contractor, will be responsible for vegetation monitoring and data analysis as well as the final performance evaluation report (PER). USFWS will be responsible for bird monitoring and data analysis. USFWS will provide USACE with a write-up of the bird monitoring methods and results for incorporation into the PER. USFWS will be responsible for periodically inspecting the project features and documenting the inspection findings.

8 Contingency Planning and Project Modification

Monitoring will verify the effectiveness of restoration actions, including the ability to conduct drawdowns. Monitoring activities, including review of results, will be performed collaboratively between USACE and USFWS. If restoration features are not performing as they should, then the USFWS will work with USACE to identify what can be done to rectify remaining issues.

If project modifications fit within the budgeted adaptive management allocation, then adaptive project modifications can be done directly with HREP funds provided to St. Paul District. If project modifications exceed the allocated adaptive management budget, then needs for modification would be elevated through the River Resources Forum (RRF). The RRF can then prioritize modifications to Bass Ponds HREP within the overall UMRR construction schedule. Changes would then be made as a modification to an existing project. This would require additional planning evaluation, but would not require a complete feasibility study. Construction modifications can be made, provided that construction costs are justified based on resulting habitat benefits. It also assumes appropriations of federal funds to the UMRR program, and prioritization of project modifications at Bass Ponds with those appropriated funds.

9 Project Close Out

Close-out of the project would occur when the level of success of the project is determined adequate or when the maximum 10-year monitoring period has been reached. The level of success would be based on the extent to which the project objectives have been or will be met based upon the trends for the site conditions and processes.

Additionally, project close-out will include technology transfer. This includes the dissemination of project monitoring results, analyses performed, management decisions made (Adaptive Management features or adjustments), and lessons learned. Technology transfer will occur via publications, presentations and discussions with LTRM and stakeholders, among others.

10 References

USFWS (U.S. Fish and Wildlife Service). 2018. Minnesota Valley National Wildlife Refuge Habitat Management Plan. Bloomington, MN.

Yin, Y. J.S. Winkelman, and H.A. Langrehr. 2000. Long Term Monitoring Program procedure: Aquatic vegetation monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 2000. LTRMP 95-P002-7. 8pp + Appendices A-C.

US Army Corps
of Engineers ®
St. Paul District

GEOTECHNICAL & GEOLOGY BRANCH
180 5th Street East
St. Paul, MN 55101

PHASE I ENVIRONMENTAL SITE ASSESSMENT REPORT – BASS PONDS HABITAT REHABILITATION ENCHANCEMENT PROJECT

Bass Ponds HREP Feasibility Study
Scott County, Minnesota

31 January 2019

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Table of Contents

Section	*Page*
1.0 Abbreviations	1
2.0 Liability Statement	3
3.0 General Information	4
4.0 Executive Summary	5
4.1 Subject Property Description	5
4.2 Environmental Report Summary	5
4.3 Recommendations	5
5.0 Introduction	6
5.1 Purpose	6
5.2 Scope of Work	6
5.3 Limitations and Exceptions	7
6.0 Site Description	7
6.1 Location and Legal Description	7
6.2 Site and Vicinity Description	7
6.3 Current Use of the Property	8
6.4 Adjoining Property Information	8
6.5 Owner Provided Information	8
7.0 Records Review	9
7.1 Standard Environmental Records Sources	9
7.2 Physical Setting Sources	9

Table of Contents

Section	***Page***
7.3 Historical Use	10
7.3.1 Sanborn Fire Insurance Maps	10
7.3.2 City Directories	10
7.3.3 Topographical Maps	11
7.3.4 Aerial Photos	11
8.0 Site Reconnaissance	11
8.1 Methodology and Limiting Conditions	11
8.2 General Site Setting	11
8.3 Site Visit Findings	12
8.3.1 Subject Property	12
9.0 Conclusions	13

Appendices:

Appendix A: EDR Radius Map Reports with GeoCheck

Appendix B: Certified Sanborn Map Reports

Appendix C: EDR City Directory Image Reports

Appendix D: EDR Historical Topographic Map Reports

Appendix E: EDR Aerial Photo Decade Packages

Appendix F: Site Reconnaissance Photographs

1.0 Abbreviations

ACM	Asbestos Containing Material
AIRS	Aerometric Information Retrieval System
AST	Aboveground Storage Tank
AUL	Activity and Use Limitation
ASTM	American Society for Testing Materials
CDL	Clandestine Drug Labs
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CONSENT	Superfund Consent Decrees
CORRACTS	Corrective Action Report
DOD	Department of Defense Sites
EDR	Environmental Data Resources
EPA	United States Environmental Protection Agency
ERNS	Emergency Response Notification System
ESA	Environmental Site Assessment
FIFRA	Federal Insecticide, Fungicide, & Rodenticide Act
FINDS	Facility Index System
FOIA	Freedom of Information Act
FTTS	FIFRA/TSCA Tracking System
FUDS	Formerly Used Defense Sites
FR	Federal Register
HMIRS	Hazardous Materials Information Reporting System
LQG	Large Quantity Generators
LAST	Leaking Aboveground Storage Tank
LUCIS	Land Use Control Information System
LUST	Leaking Underground Storage Tank
MGS	Minnesota Geological Survey
MLTS	Material Licensing Tracking System
NFRAP	Former CERCLIS Sites
NPDES	National Pollutant Discharge Elimination
NPL	National Priorities List
NPL LIENS	Federal Superfund Liens
NWI	National Wetlands Inventory
ODI	Open Dump Inventory
PADS	PCB Activity Database System
PCBs	Polychlorinated Biphenyls
PDF	Portable Digital Format
PLP	Permanent List of Priorities
RAATS	RCRA Administrative Action Tracking System

RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
REC	Recognized Environmental Condition
ROD	Records of Decision
SEMS	Superfund Enterprise Management System Archive
SHWS	State Hazardous Waste Sites
SPILLS	Spills Database
SQG	Small Quantity Generators
SSTS	Section 7 Tracking Systems
SWF	Solid Waste Facility
SWRCY	Solid Waste Recycling
TRIS	Toxic Chemical Release Inventory System
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facilities
UMTRA	Uranium Mill Tailings Sites
USACE	United States Army Corps of Engineers
USC	United States Code
USGS	United States Geological Survey
UST	Underground Storage Tank
VCP	Voluntary Cleanup Program

2.0 Liability Statement

The following excerpts, unless otherwise noted, are from ASTM E 1527-13; Appendix X1.1.5.2; CERCLA Operator Liability:

'A person may be liable as a CERCLA operator when they exercise control over a facility.'

As defined in 42 U.S.C. 9601 (20) (A) The term "owner or operator" means (ii) in the case of an onshore facility or an offshore facility, any person owning or operating such facility.

As defined in 42 U.S.C. 9601 (9) (A) The term "facility" means any building, structure, installation, equipment, pipe or pipeline, well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or (B) any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located.

*'Some courts have held that **a person may be liable as a current CERCLA operator where the person did not exercise control over historic operations that caused the contamination but dispersed or moved around contaminated soil**…'*

*'Like a past CERCLA owner, a past operator must have exercised control over the site "at the time of disposal" to be liable as a CERCLA operator. Many courts have held that **disposal is not limited to the original release but can encompass subsequent dispersal or movement of hazardous substances.**'*

3.0 General Information

Project Information:	Bass Ponds HREP Feasibility Study
Site Information:	Minnesota Valley National Wildlife Refuge County-State Aid Highway 101 Shakopee and Savage, Minnesota
County:	Scott
Latitude, Longitude:	44.8033°, -93.4329° 44.7986°, -93.4098° 44.7843°, -93.3718°
Site Assessor:	______________________________ Colin A. Riddick, P.G. Geologist

Environmental Professional Qualification:

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in § 312.10 of 40 CFR 312.

I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. I have developed and performed all the appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

____

Colin A. Riddick, P.G.
Geologist

4.0 Executive Summary

4.1 Subject Properties Description

The subject properties are located along the Minnesota River between River Miles 15.0 and 20.0 above the mouth of the Minnesota River. These sites are in the floodplain of the Minnesota River and parallel to County-State Aid Highway 101. The subject properties dimensions are roughly 0.6 miles by 4.0 miles and encompassing an estimated 2.9 square miles.

Predominant land use in the immediate vicinity is primarily undeveloped and for recreational use. Light to heavy industrial areas are found along the southern edge of the property boundaries.

The subject properties currently do not contain any buildings and appear uninhabited. The sites are bottom land marsh and lakes with several recreational trails traversing the properties. These properties are bounded by the Minnesota River to the north and west, County-State Aid Highway 101 to the south, and heavy industrial properties to the east.

4.2 *Environmental Report Summary*

Currently the subject properties are primarily wildlife refuge land owned and managed by the U.S. Fish and Wildlife Service. Small dump sites are scattered across the subject properties containing a variety of construction debris, tires, and assorted vehicular fuel tanks. There is evidence of minor surface staining at the US Highway 169 roadway drainage discharge pipe outlets. The aforementioned items should not constitute a significant environmental risk.

4.3 *Recommendations*

Based on the information obtained during the site reconnaissance portion of the environmental site assessment a ***Phase II ESA would not be necessary*** for the subject properties. It should be noted that the complete report must be read in order to fully understand the findings associated with the subject properties.

5.0 Introduction

5.1 Purpose

The purpose of the Phase I ESA was to evaluate the current and historical conditions of the subject property in an effort to identify recognized environmental conditions (REC) in connection with the subject property and surrounding operations.

A recognized environmental condition is defined by ASTM E 1527-13 as:

The presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: (1) due to release to the environment; (2) under conditions indicative of a release to the environment; or (3) under conditions that pose a material threat of a future release to the environment. *De minimis* conditions are not recognized environmental conditions.

5.2 Scope of Work

The Phase I ESA conducted at the subject property was in accordance with ASTM Standard Practice E 1527-13 and further defined below:

- USACE has gathered and reviewed available historical data, including fire insurance maps, survey plat maps, aerial photography, topographic maps from the United States Geological Survey (USGS), hydrogeology maps from the Minnesota Geological Survey (MGS), geologic maps from MGS, and interviews with knowledgeable persons.

- USACE has reviewed state and federal environmental databases including NPL, CERCLIS, CORRACTS, RCRA, ERNS, SHWS, SWF, LUST, LAST, UST, AST, CDL, HMIRS, PADS, and SPILLS.

- USACE has physically inspected the subject property via walking survey, looking for signs of recognized environmental conditions such as stressed vegetation, soil staining, dumping, and evidence of aboveground and underground storage tanks.

- USACE has physically observed adjoining properties, paying particular attention to evidence of underground storage tanks, questionable housekeeping practices, or unusual business practices.

5.3 Limitations and Exceptions

The information, conclusions, and recommendations stated in the report are based upon work undertaken by trained professional and technical staff working for the U.S. Army Corps of Engineers, and also upon information provided by others. We have accepted as true and accurate the information provided by other sources, we cannot be held responsible for the accuracy of this information.

The Phase I ESA was conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the environmental profession under similar conditions. No other warranty or guarantee, expressed or implied, is included or intended in this report or otherwise.

The scope of this assessment does not purport to encompass every report, record, or other form of documentation relevant to the subject property being evaluated. The observations contained herein are made during site reconnaissance, review of ownership records, discussions with local government personnel, and review of readily accessible environmental databases. The Phase I ESA is based upon our professional judgment concerning the significance of the data collected and in no way attempts to forecast future site conditions.

6.0 Site Description

6.1 Location and Legal Description

Address: Minnesota Valley National Wildlife Refuge
County-State Aid Highway 101
Shakopee and Savage, Minnesota

Legal Description: Fifth Principal Meridian, Minnesota
Township 116 North, Range 22 West
Section 34, Southeast ¼
Section 35, South ½
Section 36, Southwest ¼
Township 115 North, Range 22 West
Section 1
Section 2, North ½
Section 3, Northeast ¼
Township 115 North, Range 21 West
Section 7, Northeast ¼
Section 8, North ½
The areas described contains 1,856 acres of land, more or less.

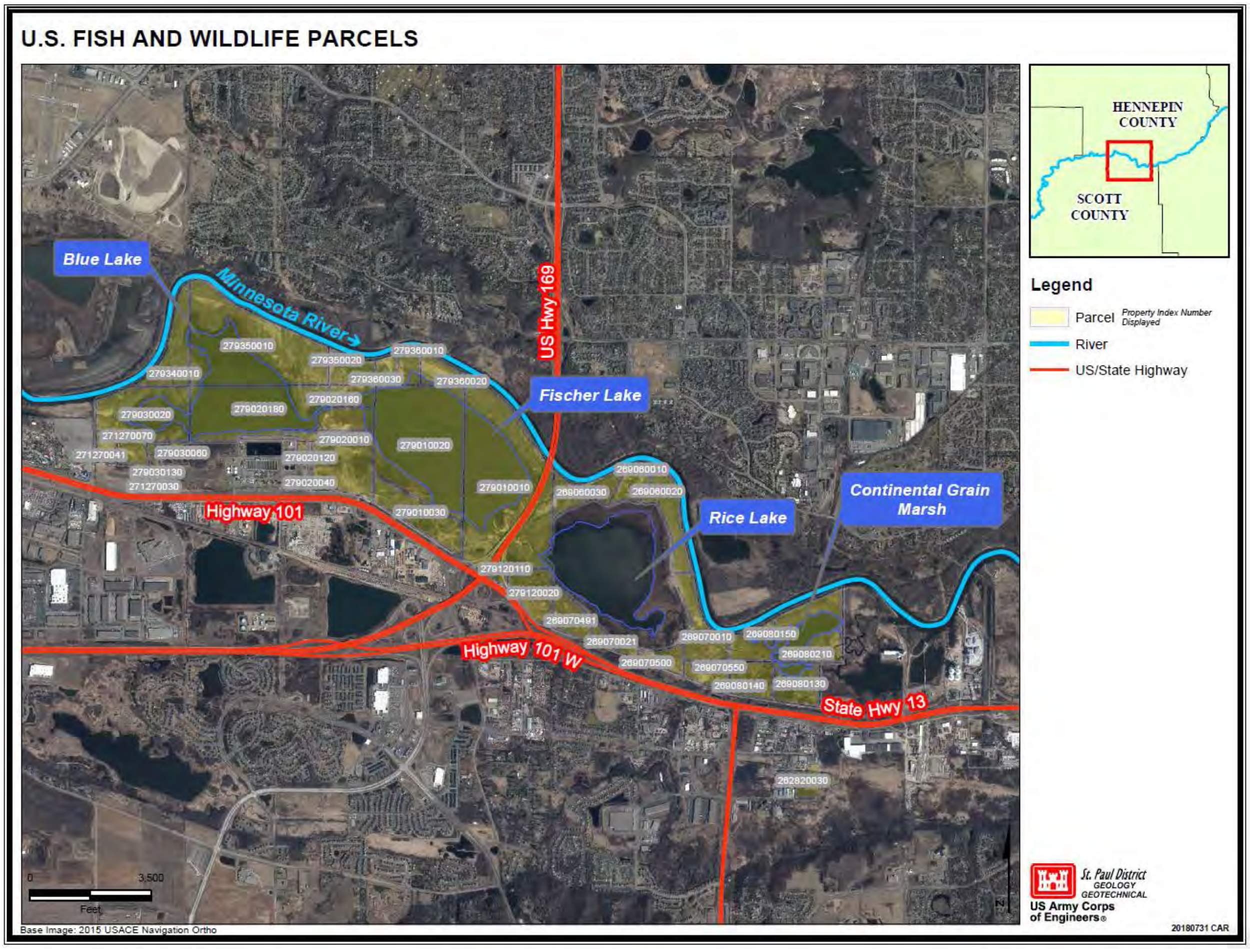

Figure 1. Parcel map with the properties of interest shown in yellow.

6.2 Site and Vicinity Description

The properties are currently uninhabited and primarily used for recreation and wildlife management, bounded by the Minnesota River to the north and west, County-State Aid Highway 101 to the south, and industrial property to the east.

The earliest use of these sites are unknown, but aerial photography reveals that by 1937 the subject properties were a mixture of bottomland marsh and agricultural fields. In 1976 the properties were established as habitat within the Minnesota Valley National Wildlife Refuge.

The properties do lie within the 100 year FEMA Federal Flood Zone and are comprised entirely of National Wetlands.

The sites are located within the city limits of Shakopee and Savage which have a population of 37,352 and 26,911 residents, respectively, according to the 2010 Census. Blue Lake Wastewater Treatment Plant is located on the southwestern extent of the subject area.

6.3 Current Use of the Property

The subject properties are currently owned by the U.S. Fish and Wildlife. The sites are part of a corridor along the Minnesota River comprised of wildlife habitat and recreation.

6.4 Adjoining Property Information

The adjoining properties are predominately recreational with a small fraction pertaining to light industrial/commercial areas and highway right-of-way. During the site reconnaissance the following properties were identified in the immediate vicinity:

Direction from Site	Use	Comments
North	Wetland/ River	Consists of the Minnesota River and associated wetlands
South	Commercial/ Industrial	Primarily highway right-of-way with the exception of the Blue Lake Wastewater Treatment Plant zoned as heavy industrial
West	Recreational/ River	Zoned as major recreation
East	Wetland/ Industrial	Zoned as heavy industrial

6.5 *Federal Government Refuge Management Provided Information*

The USACE conducted an in-person interview with Gerry Shimek, Refuge Manager, U.S. Fish and Wildlife. The purpose of the interview was to determine if there are any known past or present environmental concerns associated with the sites.

There were no unusual conditions identified from the interview.

7.0 Records Review

7.1 Standard Environmental Records Sources

At the request of the USACE, Environmental Data Resources, Inc. (EDR) conducted a search of Federal and State databases containing potential or known sites of environmental contamination. The number of listed sites identified within a one mile search radius are summarized in the following table. For a detailed listing of databases and findings, a copy of the EDR Radius Map Reports have been included in Appendix A of this report.

Database List	Subject Property Listings	Total Number of Listings	Environmental Concerns Posed to Subject Property
CDL Sites	N	1	None
Federal NPL Sites	N	0	None
Federal CERCLIS Sites	N	0	None
Federal CERCLIS NFRAP Sites	N	1	None
RCRA CORRACTS Sites	N	0	None
RCRA TSD Facilities	N	0	None
RCRA SQG	N	1	None
RCRA LQG	N	0	None
Federal ERNS Sites	N	20	None
SPILLS Reports	N	3	None
State HW Sites	N	0	None
State CERCLIS Sites	N	0	None
Landfill/SW Disposal Sites	N	0	None
LUST/LAST Sites	N	43	None
UST/AST Sites	Y	96	None
MN AIRS Sites	N	15	None

7.2 Physical Setting Sources

Physical setting sources were provided by the EDR GeoCheck Physical Setting Source Addendum unless otherwise noted. A copy of the GeoCheck report can be found in Appendix A of this report.

Groundwater flow direction was reported by the EDR AQUIFLOW Information System. Only one well to the southeast of the target property reported data, flow direction was reported as north-northeast. Flow direction was also interpolated from the Hydrogeology of Scott County report from the MGS. The general localized groundwater flow gradient across the assessment areas is north-northeast.

The general topographical gradient is north, based upon site setting and surrounding areas, there is a likelihood that contamination could be brought to the subject site.

The GeoCheck report revealed that no water supply or monitoring wells were identified on the subject properties. However, one commercial well is located at the Cargill West Elevator and several dewatering wells are located around the Blue Lake Wastewater Treatment Plant.

7.3 Historical Use

7.3.1 Sanborn Fire Insurance Maps

Historical fire insurance maps were requested from EDR and a search of the Sanborn Library, LLC was conducted. Historical maps are detailed drawings that show the locations and use of structures on a given property during a specific year. The maps were originally used by insurance companies to assess fire risk. A copy of the Sanborn Map Report can be found in Appendix B of this report.

EDR reported these as unmapped properties and no fire insurance maps were found.

7.3.2 City Directories

Historical and current city directories of the subject property and subject property street were requested from EDR. City directories were obtained for the following years: 1967, 1972, 1977, 1982, 1987, 1992, 1995, 2000, 2005, 2010, and 2014. City directories have been published for cities and towns across the United States since the 1700s. Originally a list of residents, the city directory developed into a tool for locating individuals and businesses. While city directory coverage is comprehensive for major cities, it may be limited for rural areas and small towns. A copy of the available information for the subject property can be found in Appendix C of this report.

There were no unusual entries identified from the city directories.

7.3.3 Topographical Maps

Historical topographic map coverage of the subject property was requested from EDR. 1896, 1901, and 1958 USGS 15 Minute Topographic quadrangles and 1954, 1967, 1972, 1980, 1993, and 2013 USGS 7.5 Minute Topographic quadrangles were obtained. The 1954 and 1967 topographic maps depict the subject property and adjoining properties as similar to what was observed at the time of the property reconnaissance. Partial copies of the topographic maps can be found in Appendix D of this report.

There were no unusual conditions identified from the topographic maps.

7.3.4 Aerial Photos

Historical aerial photos of the subject property were requested from EDR. Photo coverage was available for the following years: 1937, 1940, 1947, 1951, 1957, 1966, 1969, 1972, 1978, 1984, 1987, 1991, 1997, 2006, 2010, and 2015. Copies of the aerial photos can be found in Appendix E of this report.

There were no unusual conditions identified from the aerial photos.

8.0 Site Reconnaissance

8.1 Methodology and Limiting Conditions

The site reconnaissance was conducted on 1 June 2018 by Colin Riddick, geologist with the U.S. Army Corps of Engineers, St. Paul District. The inspector was unaccompanied during the site reconnaissance. Weather conditions at the time of the site reconnaissance were partly cloudy, warm (approximately 80° F), and light winds. During the inspection thick vegetation and tall grasses covered a vast majority of the inspection area obscuring the ground surface. Photographs taken during the site reconnaissance can be found in Appendix F of this report.

8.2 General Site Setting

The subject properties are located in the floodplain of the Minnesota River along the northern boundary of Shakopee and Savage, Minnesota city limits. The land is primarily undeveloped forest and wetlands. The soil consists of alluvial overbank sediments and shallow lacustrine to marsh deposits.

8.3 Site Visit Findings

Note: All referenced photos can be found in Appendix F of this report.

8.3.1 Subject Property

- Minor surface staining was observed at the US Highway 169 roadway drainage discharge pipe outlets (Fig. 44, 45, and 49).

- Small debris piles were observed around Blue Lake that contained tires, vehicular fuel tanks, and scattered plastic, glass, metal and lumber (Fig. 22, 25, 26, 32, and 33).

- Miscellaneous debris was observed along the Fischer/Rice outlet channel (Fig. 41).

9.0 Conclusions

The USACE has conducted a Phase I Environmental Site Assessment of the subject property in conformance with the scope and limitations of ASTM Standard Practice E 1527-13. This assessment revealed that there were no observed potential risks for contamination due to recognized environmental conditions on the subject property.

The multiple dump areas on the properties would be considered a *de minimis* condition, however, cleanup and removal of said items should be determined.

A Phase II Environmental Site Assessment is not recommended for the subject properties.

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Appendix A

EDR Radius Map with GeoCheck

This appendix is available for viewing upon request.

Appendix B

Certified Sanborn Map Reports

This appendix is available for viewing upon request.

Appendix C

EDR City Directory Image Reports

This appendix is available for viewing upon request.

Appendix D

EDR Historical Topographic Map Reports

This appendix is available for viewing upon request.

Appendix E

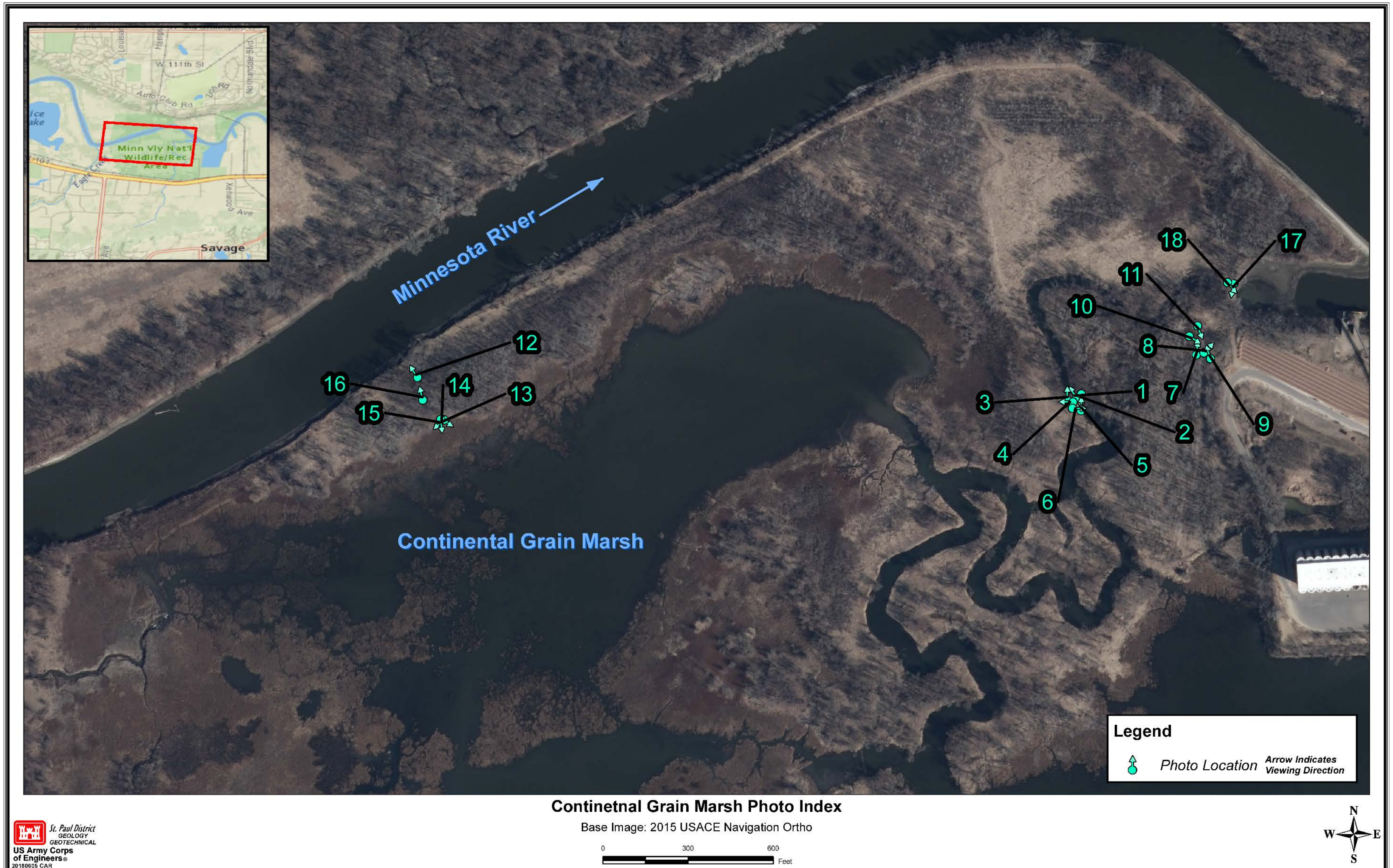
EDR Aerial Photo Decade Packages

This appendix is available for viewing upon request.

FIGURE **PAGE**

FIGURE 1. DOWNSTREAM VIEW OF CARGILL DRAINAGE CHANNEL 7
FIGURE 2. UPSTREAM VIEW OF CARGILL DRAINAGE CHANNEL 7
FIGURE 3. GEOTEXTILE AND RIPRAP WITHIN STOPLOG BYPASS CHANNEL 8
FIGURE 4. RIPRAP WITHIN STOPLOG BYPASS CHANNEL 8
FIGURE 5. SILTED IN STOPLOG STRUCTURE 9
FIGURE 6. GENERAL VIEW OF SILTED STOPLOG STRUCTURE 9
FIGURE 7. ABANDONED AND UNMAINTAINED STOPLOG STRUCTURE 10
FIGURE 8. VIEW INSIDE OF STOPLOG STRUCTURE 10
FIGURE 9. GENERAL VIEW OF ABANDONED STOPLOG STRUCTURE 11
FIGURE 10. VIEW OF ABANDONED STOPLOG STRUCTURE LOOKING TOWARDS CARGILL 11
FIGURE 11. OUTLET/DISCHARGE AREA OF ABANDONED STOPLOG STRUCTURE 12
FIGURE 12. MINNESOTA RIVER FROM EDGE OF CONTINENTAL GRAIN MARSH PROPERTY 12
FIGURE 13. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING EAST 13
FIGURE 14. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING WEST 13
FIGURE 15. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING SOUTH 14
FIGURE 16. DOWNSTREAM VIEW OF ROCK SPILLWAY STRUCTURE 14
FIGURE 17. ROAD CROSSING AT CARGILL BARGE LOADING FACILITY 15
FIGURE 18. CARGILL BARGE LOADING FACILITY AND HARBOR 15
FIGURE 19. UPSTREAM VIEW OF PRIMARY BLUE LAKE WATERSHED CONVEYANCE CHANNEL 16
FIGURE 20. DOWNSTREAM VIEW OF PRIMARY BLUE LAKE WATERSHED CONVEYANCE CHANNEL 16
FIGURE 21. CORRUGATED METAL PIPE CONVEYING PRIMARY BLUE LAKE WATERSHED CHANNEL 17
FIGURE 22. MISCELLANEOUS METAL SCRAP ON CULVERT DISCHARGE RIPRAP 17
FIGURE 23. DISCHARGE END OF 72-INCH CORRUGATED METAL PIPE 18
FIGURE 24. TYPICAL VIEW ALONG PERIMETER OF BLUE LAKE 18
FIGURE 25. RUSTY VEHICULAR FUEL TANK ALONG BLUE LAKE REFUGE TRAIL 19
FIGURE 26. TIRES AND OTHER DEBRIS ALONG BLUE LAKE REFUGE TRAIL 19
FIGURE 27. DISCHARGE END OF 12-INCH IRON PIPE UNDER BLUE LAKE REFUGE TRAIL 20
FIGURE 28. HIGH CONCENTRATIONS OF FE IN DISCHARGE WATER 20
FIGURE 29. LOOKING DOWNSTREAM OF IRON PIPE DISCHARGE 21
FIGURE 30. LOOKING UPSTREAM OF IRON PIPE INLET 21
FIGURE 31. OBSCURED INLET OF IRON PIPE 22
FIGURE 32. MISCELLANEOUS CONCRETE DEBRIS ALONG BLUE LAKE REFUGE TRAIL 22
FIGURE 33. RUSTY VEHICULAR FUEL TANK ALONG BLUE LAKE REFUGE TRAIL 23
FIGURE 34. VIEW OF BLUE LAKE FROM BLUE LAKE TREATMENT PLANT 23
FIGURE 35. SOUTHERN PROPERTY BOUNDARY OF BLUE LAKE TREATMENT PLANT LOOKING EAST 24
FIGURE 36. SOUTHERN PROPERTY BOUNDARY OF BLUE LAKE TREATMENT PLANT LOOKING WEST 24
FIGURE 37. 345 KV TRANSMISSION LINE ACROSS BLUE LAKE 25
FIGURE 38. MAN PLACED RIPRAP ALONG SOUTHERN SHORE OF BLUE LAKE 25
FIGURE 39. GRAVEL PARKING LOT UNDER US HIGHWAY 169 26
FIGURE 40. FISCHER LAKE OUTLET CHANNEL UNDER US HIGHWAY 169 26
FIGURE 41. MISCELLANEOUS DEBRIS ALONG FISCHER/RICE LAKE OUTLET CHANNEL 27
FIGURE 42. 2ND BLUE LAKE OUTLET BENEATH THE US HIGHWAY 169 BRIDGE 27
FIGURE 43. RICE LAKE OUTLET STRUCTURE 28
FIGURE 44. US HIGHWAY 169 ROADWAY DRAINAGE DISCHARGE PIPE SCOUR 28
FIGURE 45. US HIGHWAY 169 ROADWAY DRAINAGE DISCHARGE PIPES 29
FIGURE 46. UPSTREAM END OF SCOUR AROUND REINFORCED CONCRETE PIPE CULVERT 29
FIGURE 47. SCOUR CHANNEL AND MISCELLANEOUS UTILITIES TRAVERSING SITE 30
FIGURE 48. GENERAL VIEW LOOKING NORTH ALONG US HIGHWAY 169 30
FIGURE 49. SOUTHBOUND BRIDGE PRIER OF US HIGHWAY 169 31
FIGURE 50. GENERAL VIEW LOOKING NORTH ACROSS PARKING LOT BENEATH US HIGHWAY 169 31

Figure 51. Rice Lake boat launch 32
Figure 52. Rice Lake EMP West outlet stop log structure 32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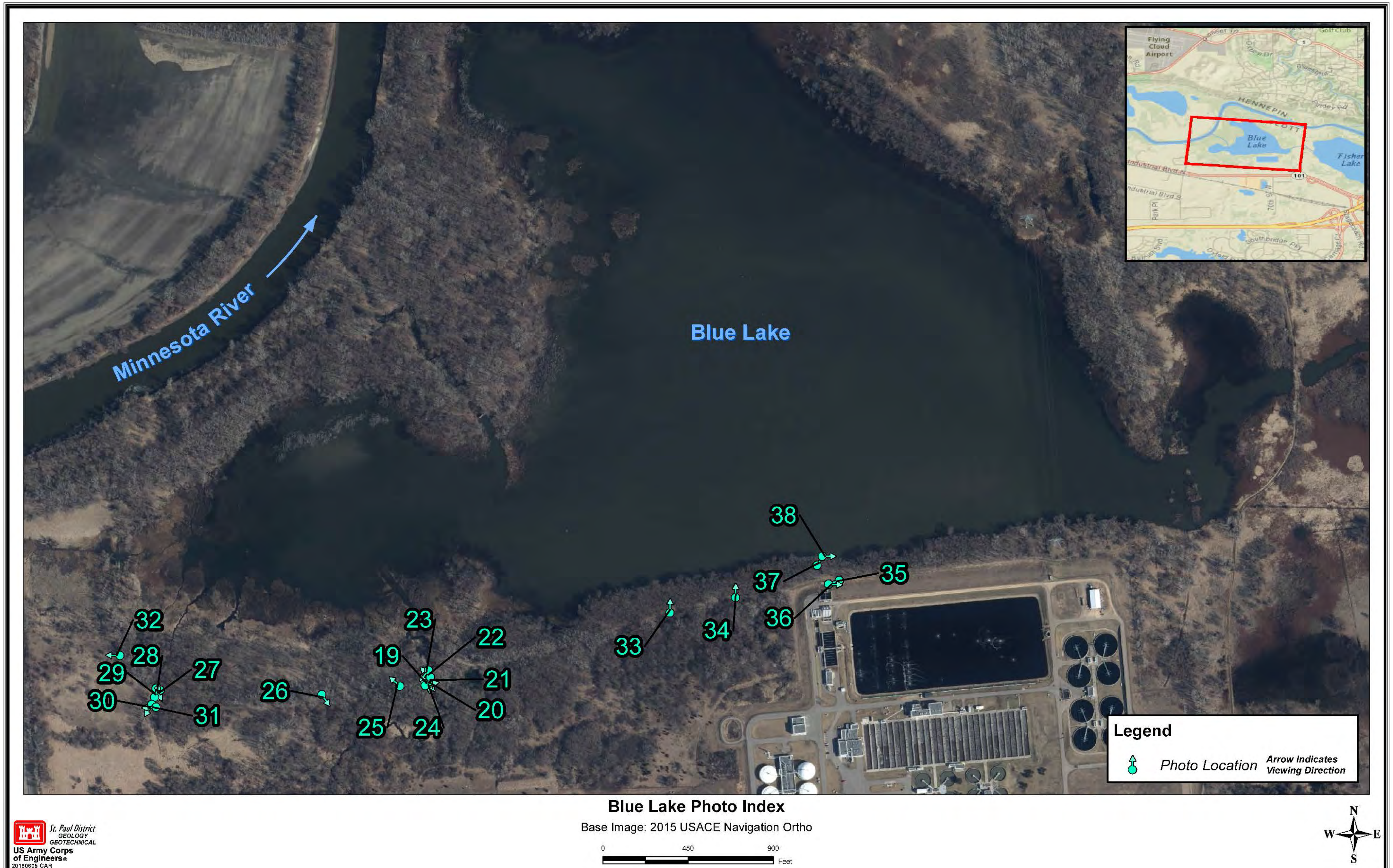
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Figure 1. Downstream view of Cargill drainage channel

Figure 2. Upstream view of Cargill drainage channel

Figure 3. Geotextile and riprap within stoplog bypass channel

Figure 4. Riprap within stoplog bypass channel

Figure 5. Silted in stoplog structure

Figure 6. General view of silted stoplog structure

Figure 7. Abandoned and unmaintained stoplog structure

Figure 8. View inside of stoplog structure

Figure 9. General view of abandoned stoplog structure

Figure 10. View of abandoned stoplog structure looking towards Cargill

Figure 11. Outlet/discharge area of abandoned stoplog structure

Figure 12. Minnesota River from edge of Continental Grain Marsh property

Figure 13. Typical view of Continental Grain Marsh looking east

Figure 14. Typical view of Continental Grain Marsh looking west

Figure 15. Typical view of Continental Grain Marsh looking south

Figure 16. Downstream view of rock spillway structure

Figure 17. Road crossing at Cargill barge loading facility

Figure 18. Cargill barge loading facility and harbor

Figure 19. Upstream view of primary Blue Lake Watershed conveyance channel

Figure 20. Downstream view of primary Blue Lake Watershed conveyance channel

Figure 21. Corrugated metal pipe conveying primary Blue Lake Watershed channel

Figure 22. Miscellaneous metal scrap on culvert discharge riprap

Figure 23. Discharge end of 72-inch corrugated metal pipe

Figure 24. Typical view along perimeter of Blue Lake

Figure 25. Rusty vehicular fuel tank along Blue Lake refuge trail

Figure 26. Tires and other debris along Blue Lake refuge trail

Figure 27. Discharge end of 12-inch iron pipe under Blue Lake refuge trail

Figure 28. High concentrations of Fe in discharge water

Figure 29. Looking downstream of iron pipe discharge

Figure 30. Looking upstream of iron pipe inlet

Figure 31. Obscured inlet of iron pipe

Figure 32. Miscellaneous concrete debris along Blue Lake refuge trail

Figure 33. Rusty vehicular fuel tank along Blue Lake refuge trail

Figure 34. View of Blue Lake from Blue Lake Treatment Plant

Figure 35. Southern property boundary of Blue Lake Treatment Plant looking east

Figure 36. Southern property boundary of Blue Lake Treatment Plant looking west

Figure 37. 345 kV transmission line across Blue Lake

Figure 38. Man placed riprap along southern shore of Blue Lake

Figure 39. Gravel parking lot under US Highway 169

Figure 40. Fischer Lake outlet channel under US Highway 169

Figure 41. Miscellaneous debris along Fischer/Rice Lake outlet channel

Figure 42. 2nd Blue Lake outlet beneath the US Highway 169 Bridge

Figure 43. Rice Lake outlet structure

Figure 44. US Highway 169 roadway drainage discharge pipe scour

Figure 45. US Highway 169 roadway drainage discharge pipes

Figure 46. Upstream end of scour around reinforced concrete pipe culvert

Figure 47. Scour channel and miscellaneous utilities traversing site

Figure 48. General view looking north along US Highway 169

Figure 49. Southbound bridge prier of US Highway 169

Figure 50. General view looking north across parking lot beneath US Highway 169

Figure 51. Rice Lake boat launch

Figure 52. Rice Lake EMP West outlet stop log structure

US Army Corps of Engineers ®
St. Paul District

Appendix M: Cultural Resources

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix M: Cultural Resources

TABLE OF CONTENTS

1 Introduction 2
  1.1 Cultural Resources within the Study Area 2
  1.2 Deep Site Testing (2018) 4

2 Impacts of the Recommended Plan to Cultural Resources 7
  2.1 Water Control Features 7
  2.2 Continental Grain Marsh Plug 7
  2.3 Access Roads 7

3 References Cited 8

LIST OF FIGURES

Figure 1: Location of No Longer Extant Historic Farmsteads or Outbuildings within the Project Area. 4
Figure 2: Deep Site Test 1, Continental Grain Marsh Levee. Terminated at 120 cm Below Surface Due to High Water. September 2018. 5
Figure 3: Test 2, Continental Grain Marsh Natural Levee. September 2018. View to Southwest. 6
Figure 4: Location of Deep Site Tests along the Continental Grain Marsh Natural Levee 6

LIST OF TABLES

Table 1: Recorded Cultural Resources Within One Mile of the Project Area. 2

1 Introduction

The Minnesota River Valley and surrounding environs has been a focus of human use and occupation for thousands of years as evidenced by the many archaeological sites associated with the diverse landscape and contemporary use of valley. The Minnesota River Valley, formed by drainage of Glacial Lake Agassiz through its southern outlet of Glacial River Warren, was regularly occupied by humans following the subsidence of high flows and episodic, catastrophic flooding approximately 9,500 years ago (e.g., Gibbon 2012; Wright et. al. 1998). The cultural sequence of the area includes Paleo, Archaic, Woodland, Mississippian/Plains Village, and Oneota traditions. The French were the first Europeans to explore the area in the mid-17th century although the effects of contact, such as trade goods, disease, and displaced peoples, were felt prior to direct interaction. Native American groups in the area at the time of French contact included the Dakota, Oto, Ioway and possibly the Illinois. Widespread agriculture and development coincided with American occupation of the area in the early 19th century (e.g., Gibbon and Anfinson 2008).

1.1 Cultural Resources within the Study Area

A total of 24 cultural resources (historic properties) are recorded within one mile of the project area (Table 1). No historic properties have been identified within the project area. Cultural resources include a variety of precontact and historic archaeological sites and standing structures. Precontact sites include lithic and artifact scatters, village sites, and burial mounds. Historic sites include structural ruins, artifacts scatters, early town sites, historic trails, and a World War II internment camp. Cultural resources in the area are situated on a variety of landforms, namely uplands and terraces. Several cultural resource sites within this locality are listed on the National Register of Historic Places (NRHP) or are eligible for listing on the NRHP.

Table 1: Recorded Cultural Resources Within One Mile of the Project Area.

Site Number	Site Name	Site Type	Cultural Period	Setting
21Hem	Hennepin	Ghost Town	Historic	Upland
21HE240	Hennepin Site III	Artifact Scatter	Precontact	Upland
21HE219	-	Artifact Scatter	Historic	Upland/Toeslope
21HE22	-	Burial Mounds	Precontact	Upland
21HE142	Riverview Heights	Artifact Scatter	Precontact	Upland
21HE92	Eck Burials	Cemetery	Precontact	Upland
21HE214	Fowler Mounds	Burial Mounds	Precontact	Upland
21HEp/HE-EPC-A36. Other segments not named.	North Minnesota Valley Trail, Schlampp Segment	Trail	Historic	Terrace
21HE17	Bloomington Ferry Mounds	Burial Mounds	Precontact	Upland
21HEi	-	Artifact Scatter	Historic	Terrace
21HE4	-	Burial Mounds	Precontact	Upland
21HE6	Cunningham Mounds	Burial Mounds	Precontact	Upland
21HE5	-	Burial Mounds	Precontact	Upland
21HE260	-	Lithic Scatter	Precontact	Upland
21SC19	Eagle Creek	Burial Mounds	Precontact	Terrace

21Scar	WW II Internment Camp	Structural Ruins	Historic	Terrace
21SC37	-	Artifact Scatter	Precontact	Terrace
21SC25	-	Burial Mounds	Precontact	Terrace
21SC80	Blue Lake #6	Village	Precontact	Terrace
21SC79	Blue Lake #5	Village	Precontact	Terrace
21SC78	Blue Lake #4	Single Artifact	Precontact	Terrace
21SC77	Blue Lake #3	Burial Mound	Precontact	Terrace
21SC76	Blue Lake #2	Lithic Scatter	Precontact	Terrace
21SC75	Blue Lake #1	Lithic Scatter	Precontact	Terrace

No cultural resources investigations have been conducted within the project area. A number of archaeological studies have occurred at sites along the uplands and more recently along the colluvial slopes and terraces in the valley both upstream and downstream of the project area (e.g., Madigan et. al 1998; Florin et. al. 2015). Several of the project features will be placed on natural levees. Natural levees have a high probability to contain deeply buried cultural deposits (e.g., Brown et. al. 2006; Monaghan et. al. 2006). While none of the previously recorded sites proximal to the project area are located on natural levees, numerous sites on natural levees have been identified in areas upstream and downstream of the project area and elsewhere on large rivers in the region (e.g., Minnesota State Historic Preservation Office Files: Stoltman 2005).

European development within the project area includes construction of roads, bridges, farmsteads, a grain elevator complex, and cultivation. All of the natural levees in the project area were cultivated, likely beginning in the late 19th century and visible in aerial photographs from the 1930s. Three farmsteads or outbuildings were located along the levees: outbuildings just downstream of the proposed water control structure at Continental Grain Marsh; one where the access road meets the natural levee and turns upstream to the Blue Lake structure; and, one where the western portion of the access road turns south to the Blue Lake structure (Figure 1). All of the farmsteads had access roads running along the natural levees. While these roads do not appear to be macadamized, it is unknown if they were gravel or two-track field roads.

Figure 1: Location of No Longer Extant Historic Farmsteads or Outbuildings within the Project Area.

Prior to the construction of the existing elevated HWY 169 crossing the Minnesota River, a road from the Bloomington Ferry Bridge to HWY 101 traversed the floodplain between Fisher and Rice lakes, with a bridge crossing the channel between the two lakes at the approximate location of the proposed water control structures in that area.

Water control structures were previously constructed at several locations along the natural levees and between Fisher and Rice lakes. Rip-rap was also placed along stretches of the Continental Grain Marsh natural levee.

Cursory surface examination of the areas previously occupied by farmsteads reveal no evidence of foundations or extant structures. None of the farmsteads in the area are extant following establishment of the refuge in 1976. Visible traces of the farmsteads include a fencerow and tree line running to the south/southwest of the farmstead situated to the north of the Blue Lake structure and an abandoned seed drill along the Continental Grain Marsh levee.

1.2 Deep Site Testing (2018)

In the autumn of 2018, U.S. Army Corps of Engineers (USACE, or Corps) and contract archaeologists completed limited deep site testing along portions of the natural levee at the Continental Grain Marsh between flood episodes. Three 8-inch (20-cm) bucket auger tests were completed, with the soil matrix passed through ¼ inch hardware cloth. The results of Tests 1-3 are discussed below.

Test 1 was placed approximately 185 m downstream of the proposed water control structure and approximately 150 m upstream of the farmstead/outbuildings identified from aerial photographs noted in Figure 1 (the southeastern most farmstead) and at a relatively low spot along the levee. Test 1 was terminated at 120 cm due to rising water and imminent submersion of the area (Figure 2). Test 2 was placed approximately 385 m downstream of the proposed water control structure and at the eastern edge of the farmstead or outbuildings mentioned above and adjacent to an abandoned ca. 1940s seed drill. The test area is on a relatively high portion of the levee (Figure 3). Test 3 was placed approximately 525 m downstream of the proposed water control structure and along the topographically highest portion of the levee. Figure 4 depicts the locations of the deep site tests along the natural levee at Continental Grain Marsh.

The soil profiles of the tests along the Continental Grain Marsh natural levee exhibited post settlement alluvium (PSA) from 15-40 cm below surface overlying a plowzone. Buried soil horizons (stable surfaces) were detected at depths of 40 cm, 185 cm, and 225 cm.

Test 1 contained six fragments of calcined bone between ca. 40-60 cm within the shallowest buried soil. The calcined bone suggests a cultural origin, although it is not definitive if the material represents an intact archaeological site or the age of the materials. While the faunal material is curated at the St. Paul District, and pending additional testing in the area, the find spot has not been classified as a cultural site. Several concrete fragments were observed from 10-20 cm below the surface in Test 2. No cultural materials were recovered from Test 3.

Figure 2: Deep Site Test 1, Continental Grain Marsh Levee. Terminated at 120 cm Below Surface Due to High Water. September 2018.

Figure 3: Test 2, Continental Grain Marsh Natural Levee. September 2018. View to Southwest.

Figure 4: Location of Deep Site Tests along the Continental Grain Marsh Natural Levee.

2 Impacts of the Recommended Plan to Cultural Resources

Surface reconnaissance and limited deep site testing within the project area indicate that the Recommended Plan would preliminarily have no impacts to historic properties. There would be no permanent indirect effects to proximal recorded historic properties.

2.1 Water Control Features

Construction of the water control features will occur within previously disturbed areas. The structure at Blue Lake will replace an existing structure within the same footprint with no new ground disturbance. The structures between Fisher and Rice lakes will occur in areas previously disturbed from road and bridge construction and placement of water control structures. This area has also suffered from erosion and placement of buried utility lines. The water control structure along the Continental Grain Marsh natural levee will be placed where a previous structure has washed out. Thus, placement of the new water control structures will have no effect to historic properties.

2.2 Continental Grain Marsh Plug

Construction of a plug between Eagle Creek and Continental Grain Marsh involves placement of material on the existing surface with no excavation. In addition, during the 1850s, Eagle Creek headed north out of the uplands and turned east in the area where the plug is proposed and entered the Minnesota River in the area where the grain elevator currently resides. It appears that the area where the plug is proposed has been modified following re-directing Eagle Creek's current debouchure with the Minnesota River. Therefore, there would be no effects to historic properties by construction of the plug.

2.3 Access Roads

Construction of access roads along the natural levee may impact deeply buried sites. However, there would be no effect to historic properties provided that any subsurface preparation for the roads would occur within the PSA. The effects of any access road construction (i.e., depth of excavation, weight of construction equipment, specs of base material, soil structure, etc.) on buried soil horizons/deeply buried sites will be reviewed using modified Boussinesq's Equation or other suitable models.

Additional archaeological investigations will be conducted prior to construction to verify the preliminary information. If significant archaeological phenomena are identified, steps would be taken to avoid, minimize, or mitigate adverse effects. Section 106 coordination and cultural resources management plans will be developed in consultation with various partners, such as the aforementioned Native American Groups, the Minnesota State Historic Preservation Office, the US Fish and Wildlife Service, and others.

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