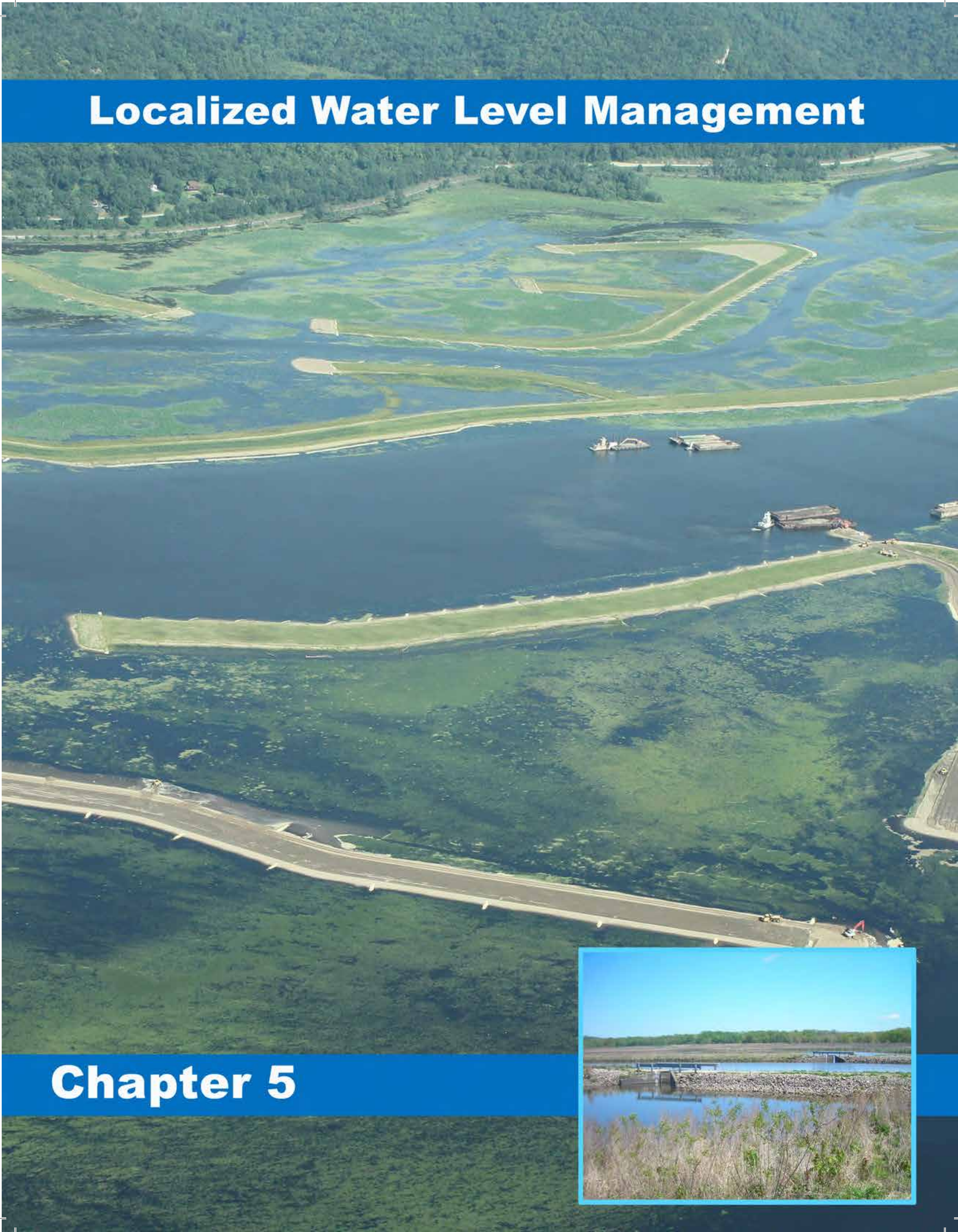
Localized Water Level Management

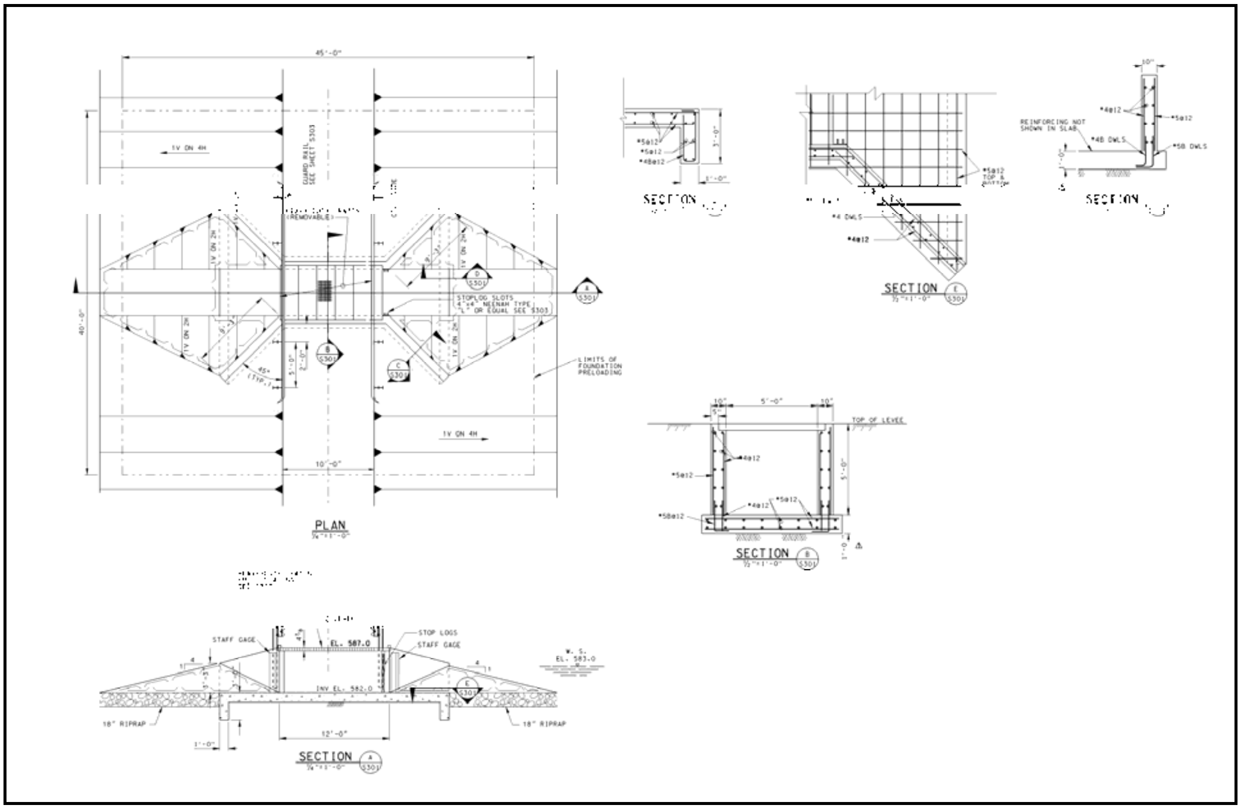


Chapter 5

UPPER MISSISSIPPI RIVER RESTORATION
ENVIRONMENTAL MANAGEMENT PROGRAM
ENVIRONMENTAL DESIGN HANDBOOK

CHAPTER 5

LOCALIZED WATER LEVEL MANAGEMENT



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UPPER MISSISSIPPI RIVER RESTORATION
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CHAPTER 5

LOCALIZED WATER LEVEL MANAGEMENT

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CHAPTER 5

LOCALIZED WATER LEVEL MANAGEMENT

A. RESOURCE PROBLEM AND OPPORTUNITIES

1. Pre-Inundation Conditions. Large river ecosystems such as the Upper Mississippi River System (UMRS) are characterized by seasonal cycles of flood and drought (or low flow). A variety of ecological functions and processes are linked to this cycle. Development of water resources for hydropower or navigation typically alters and disrupts these natural cycles. Fortunately in the UMRS, the flood stage of the hydrograph is relatively unaltered, but low stages have been eliminated to support commercial navigation.

2. Resource Problems. Much of the flora and fauna native to the Upper Mississippi River (UMR) region is adapted to the wide variations in water level that characterized the river and its floodplain prior to establishment of the lock and dam system. Since the implementation of the 9-Foot Channel Project, however, these variations have been truncated and the low river stage portion of the hydrograph has been increased to support commercial navigation. This water level control, coupled with other cumulative effects, has degraded ecosystem conditions, mainly the loss of backwater depth and aquatic plants in many areas.

3. Resource Opportunities. Numerous (27 as of 2005) Environmental Management Program (EMP) habitat projects have attempted to recreate this variability in specific areas to benefit such species. Several responses to water level management projects have been demonstrated since the 1997 Report to Congress. For example, Lake Chautauqua on the Illinois River near Havana, Illinois has been managed as a National Wildlife Refuge (NWR) since 1936, but wetland management capabilities and habitat quality had degraded over the years. Improved water level management capabilities in the southern pool completed in 1999 resulted in phenomenal wetland plant response, which, in turn, was met with the highest waterfowl use since the 1970s. Submersed aquatic vegetation and marsh plants colonized almost 1,400 acres after project completion. Fish response monitoring indicates the site can produce and export hundreds of millions of larval fish to the Illinois River.

B. HABITAT REHABILITATION AND ENHANCEMENT PROJECT (HREP) OBJECTIVES [1]

Recent evaluations of habitat objectives and opportunities through pool planning and the UMR-Illinois Waterway (IWW) Navigation Feasibility Study are revealing that water level management may be the only reliable mechanism in some instances to counteract the impacts of impoundment and floodplain development and thus achieve the desired habitat conditions. Evidence from EMP and other water level management projects indicates these projects can be effectively operated for multiple management objectives, including waterfowl, shorebirds, wading birds, reptiles, amphibians, and fisheries. However, water level management projects that include embankments, pumps, and control structures are more costly to build, maintain, and operate relative to other types of HREPs.

1. Hydraulics and Hydrology. Water level management is the direct manipulation of hydrology in a specific area with the purpose of eliciting a physical and biological response. Water level management is typically used on the river to restore the low-water portion of the natural seasonal hydrology, which was removed with the completion of the locks and dams. However, water level management strategies also include the active flooding of higher ground, as is the case with moist soil management techniques.

2. Geomorphology. Water level management can be used to influence geomorphology, though habitat and biological categories are more typically the focus. Water level management can be used to lower water levels to dry out and consolidate sediment. This can help stabilize sediment, reduce erosion and also counter the effects of past sedimentation. These effects can help meet bathymetric diversity objectives.

3. Biogeochemistry. Water level management can indirectly address biogeochemistry objectives through effects to vegetation. Lowering water levels during the growing season typically leads to a favorable response by aquatic and emergent vegetation, which can improve nutrient cycling and dissolved oxygen levels. Improved vegetation will also reduce sediment resuspension, leading to improved water quality.

4. Habitat. Water level management techniques are used to address habitat objectives by restoring hydrology to improve vegetation and/or the use of habitat by wildlife such as shorebirds and waterfowl. Drawdown in backwaters has been shown to help restore diverse and abundant native aquatic vegetation communities through the restoration of a more natural seasonal hydrograph. Moist soil management units (MSMU) can create important wetland habitat within the floodplain that serve waterfowl and shorebirds.

5. Biota. Water level management (and most features used in HREPs) indirectly affect biota through other effects to hydrology, geomorphology, biogeochemistry, and habitat. The effects to biota are seldom measurable in a manner that can clearly prove a cause and effect relationship with project features, so they are often assumed to correlate with physical habitat objectives.

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[1] For a detailed explanation of the overall EMP vision, goals, and objectives, see Chapter 2, *Habitat Rehabilitation and Enhancement Projects.*

C. TYPES OF WATER LEVEL MANAGEMENT

Water level management features are named differently depending on the type of habitat improvements and other considerations. For the purpose of this report, they are divided into two categories, MSMUs and backwater lakes. The features which can control water levels will apply regardless of which name is chosen for the habitat.

1. Moist Soil Management Units

a. General Overview. The basic operating plan for an MSMU is to keep water out in the late spring and summer and to gradually flood the area in the fall. In a multiple cell system, it is best to be able to control water levels independently. One way to accomplish this independent filling is to have the pump discharge into a water control structure along an interior berm. This structure would be designed to have structures at both ends to control flow to either cell. A gate structure would be installed within each cell to allow independent gravity drainage. Table 5-1 represents a typical annual management plan for an MSMU.

Table 5-1. Typical MSMU Annual Management Plan

Month	Action	Purpose
Jul to Sep	Maintain water levels to minimum extent possible	Expose and maintain mudflats to allow vegetation growth
Oct to Nov	Gradually increase water levels	Provide access to aquatic food plants for migratory waterfowl
Dec to Apr	Maintain water levels to maximum extent possible	Maintain winter furbearer habitat
May to Jun	Gradually decrease water levels	Prepare for aquatic plant germination

Moist Soil Management Units are typically designed to include water containment, water supply, and water control structures. Water containment is provided by construction of exterior berms, interior berms, and overflow spillways; which are used to impound water during seasonal waterfowl migrations or keep water out of the impounded area. Water supply may be provided by either river water or ground water through the use of a pump station or well, respectively. Water control structures are utilized to maintain desired water elevations throughout the year. There are many types of water control structures such as stoplog, gated, overflow weir, and fuse plug. The water control structures typically used for HREP projects include stoplog, gated or other measures.

Moist Soil Management Units are part of the HREPs listed here. The design features for MSMUs are described in Section D.

Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR
Batchtown HREP, Pool 25, UMR RM 242.5-246.0, Calhoun Co., IL, MVS
Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR
Calhoun Point HREP, Pool 26, UMR RM 221.0-221.0, Calhoun Co., IL, MVS
Clarksville Refuge HREP, Pool 24, UMR RM 275.0-275.0, Pike Co., MO, MVS
Dresser Island HREP, Pool 26, UMR RM 206.0-209.0, St. Charles Co., MO, MVS
Guttenberg Waterfowl Ponds HREP, Pool 11, UMR RM 614.0-615.0, Grant Co., WI, MVP
Pleasant Creek HREP, Pool 13, UMR RM 548.7-552.8, Jackson Co., IA, MVR
Pool Slough HREP, Pool 9, UMR RM 673.0-673.0, Allamakee Co., IA MVP
Potters Marsh HREP, Pool 13, UMR RM 522.5-526.0, Carroll Co. and Whiteside Co., IL, MVR
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Rice Lake HREP, LaGrange Pool, IWW RM 132.0-138.0, Fulton Co., IL, MVR
Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR
Stump Lake HREP, Alton Pool, IWW RM 7.2-12.7, Jersey Co., IL, MVS
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS
Trempealeau NWR HREP, Pool 6, UMR RM 718.0-724.0, Trempealeau Co., WI, MVP

MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

b. Biota and Habitat Considerations. Generally, the goal of an MSMU is wetland habitat enhancement with the objective of providing suitable habitat for waterfowl. Moist Soil Management Units are typically managed to include annual draw-downs. This technique is well accepted for wetland management and has been considered necessary for rejuvenating older, unproductive impoundments (Kadlec 1962). Stabilizing water levels, particularly at high levels, can be detrimental; and periodic drying and flooding is beneficial for establishment of desired aquatic vegetation (Weller 1978, 1981:70). The need for seasonal instability should not be equated with erratic water level changes at any time of the year (Weller 1981:70). Wildlife productivity will likely increase as wetlands experience a regular flooding cycle (Mitsch and Gosselink 1986:430).

2. Backwater Lakes With Water Level Management

a. General Overview. Prior to construction of the navigation system, water levels typically dropped during the summer months allowing backwater lakes to consolidate. This drying effect encouraged emergent aquatic plants, such as bulrush and arrowhead to grow. With the more stable water levels created by the navigation pools, this low-water effect and drying of sediments no longer occurs. Plant beds that depend on this drying process have decreased in extent or disappeared entirely. Stands of perennial emergent aquatic plants are important to fish and wildlife populations because they provide food, shelter, and dissolved oxygen. Hence, a backwater lake with water level management may be implemented to help improve conditions for the growth of aquatic vegetation.

Similar to MSMUs, backwater lakes with water level management are typically designed to include water containment, water supply, and water control structures. These are similar to those described for MSMUs. Backwater lakes with water level management are listed below. The design features for a backwater lake with water level management are described in Section D.

Batchtown HREP, Pool 25, UMR RM 242.5-246.0, Calhoun Co., IL, MVS
Banner Marsh HREP, LaGrange Pool, IWW RM 138.0-144.0, Fulton Co. and Peoria Co., IL, MVR
Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR
Bussey Lake HREP, Pool 10, UMR, Clayton Co., IA, MVP
Calhoun Point HREP, Pool 26, UMR RM 221.0-221.0, Calhoun Co., IL, MVS
Clarksville Refuge HREP, Pool 24, UMR RM 275.0-275.0, Pike Co., MO, MVS
Finger Lakes HREP, Pool 5, UMR, Wabasha Co., MN, MVP
Fox Island HREP, Pool 20, UMR RM 353.5-358.5, Clark Co., MO, MVR
Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR
Long Meadow Lake HREP, Minnesota River, Hennepin Co., MN, MVP
Peoria Lake HREP, Peoria Pool, IWW RM 162.0-181.0, Peoria Co. and Woodford Co., IL, MVR
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Rice Lake HREP, LaGrange Pool, IWW RM 132.0-138.0, Fulton Co., IL, MVR
Rice Lake HREP, Minnesota River RM 15.0-17.5, Scott Co. and Hennepin Co., MN, MVP
Small Scale Drawdown HREP, Pool 5, UMR RM 746.0-746.0, Buffalo Co., WI, MVP
Stump Lake HREP, Alton Pool, IWW RM 7.2-12.7, Jersey Co., IL, MVS
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS
Trempealeau NWR HREP, Pool 6, UMR RM 718.0-724.0, Trempealeau Co., WI, MVP
MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

b. Biota and Habitat Considerations. Generally, the goal of a backwater lake with water level management is aquatic habitat restoration with the objective of providing suitable habitat for waterfowl and fisheries. Water level management of a backwater lake consists of a temporary seasonal increase or decrease in water elevations to mimic natural hydrologic regimes in order to improve large areas of shallow aquatic habitat.

D. DESIGN FEATURES COMMON FOR WATER LEVEL MANAGEMENT

Water level management projects, to include MSMUs and backwater lakes, have several similar design features important to the proper operation and maintenance of these systems. These features are described in the following sections.

1. Exterior Berms, Interior Berms, and Overflow Spillways

a Design Considerations. Two general design criteria for this project feature are to construct a reliable embankment system that provides adequate flood protection to meet the sponsor's seasonal and/or annual management goals and locate borrow sites in areas that improve the suitable habitat for migratory birds.

b. Embankment Height. When designing the height of the embankment system, it is important to minimize interior sedimentation and to provide protection against frequent flooding for reliable water level management but on the other hand, it can also be important to maintain connectivity with the river. In addition, the desired operating levels of the system also need to be considered. Therefore, the embankment height needs to be carefully evaluated. One approach for determining the embankment height is to consider various flood elevations (2- year, 5-year, 10-year, 15-year, 20-year, 25-year, etc.) and determine how many times each flood elevation has been exceeded based on the data available. Then evaluate the additional cost of raising the embankment system to a higher flood elevation versus the decrease in the exceedance rate. The approximate embankment heights for some HREPs are listed in the table 5-2.

Table 5-2. HREP Embankment Height

Project	Feature	Embankment Height (Flood Level)
Andalusia	Levee	2 year
Banner Marsh	Levee	50 year
Bay Island	Levee	2 year
Clarksville	Levee	20 year
Lake Odessa	Levee	varies
	Upper Spillway	17 year
	Lower Spillway	10 year
Princeton	Levee	15 year
Rice Lake	Spillway	2 year
Spring Lake	Levee	50 year
	Cross Dike (Interior Berm)	5 year
Stump Lake	Levee	3 to 4 year

c. Embankment Slopes. If the exterior berm is located adjacent to a major river, its profile parallel to that river may be sloped upstream to allow for gradual overtopping during flood events, which could minimize damage potential. Top widths for exterior and interior berms are typically a minimum of 10 feet, especially for those embankment systems that are also used for access. (At times the top of the berms are used as a roadway for embankment inspections or maintenance.) Side slopes are typically a minimum of 3H:1V. Flatter side slopes can be desired to minimize rodent damage and to minimize erosion caused by overtopping. If site conditions vary, consider multiple design cross section templates as a single design cross section template doesn't always fit the actual field conditions encountered during construction. Design cross section templates should be applicable to all field conditions.

d. Cells. A MSMU may have a single exterior berm (1-celled) or consist of multiple cells through the construction of interior berms. When determining whether the embankment system should be single or multiple celled, consider the existing site topography. If the site is relatively flat, a single cell may be adequate. If the site varies in elevation, multiple cells may be desired to maximize the acreage of ideal water depth. In addition, large MSMUs may be portioned into multiple cells for management purposes. On the other hand, it can also be desired to minimize the number of cells to increase connectivity and create larger contiguous areas required by some species. The top elevation of an interior berm is typically set to provide a minimum freeboard of 2 feet during the highest ponding scenario.

e. Spillways. To provide controlled overtopping of an embankment system, overflow spillways are constructed, typically at the downstream end of the site, at an elevation lower than the exterior berm. This elevation provides for overtopping during a lesser flood event. During a flood event, the overflow spillway allows rapid filling of the MSMU interior prior to overtopping of the exterior berm. The spillway provides a defined location for filling the cells that can be adequately armored and protected against erosion. An overtopping analysis should be conducted to determine the elevation difference between the exterior berm and the overflow spillway.

f. Embankment Material. When considering options for borrow material for the embankment system, it may be beneficial to use on-site material that is suitable. The utilization of interior borrow areas offers additional habitat benefit by converting existing cropland to non-forested wetland. Ideally, these areas would be developed as large and shallow, which would not only maximize habitat benefits but may also yield the most suitable impervious borrow material. Essentially, these borrow areas may be considered potholes. Dredged material from within or outside the embankments may also be used to construct the berms. Using dredged material may provide additional aquatic habitat for the HREP.

g. Embankment Protection. HREPs that include moist soil units typically hold water for extended periods of time. To the greatest extent possible provide bank stabilization methods above and below the design operating water levels. Typically, vegetative bank stabilization is often planted on embankments to help prevent scouring. Stone protection may also be required in some instances. For embankments that will be exposed to frequent recreational traffic, consider establishing slow-no-wake zones to help minimize erosion, especially if the embankment is constructed of clay material and is not protected with riprap.

h. Maintenance. Maintenance of the exterior berms, interior berms, and overflow spillways should include project inspections on an annual basis (ideally after the area is drained) in addition to immediately following a high water event. Project inspections should determine if the following conditions exist:

- settlement, slough, or loss of section
- wave wash and scouring
- overtopping erosion
- inadequate vegetative cover (too much or not enough)
- unauthorized grazing or traffic

- encroachments
- unfavorable tree/shrub growth
- seepage distress

Corrective action should be taken upon discovery of any adverse conditions.

i. Case Studies. Constructed HREPs with an embankment feature are listed here.

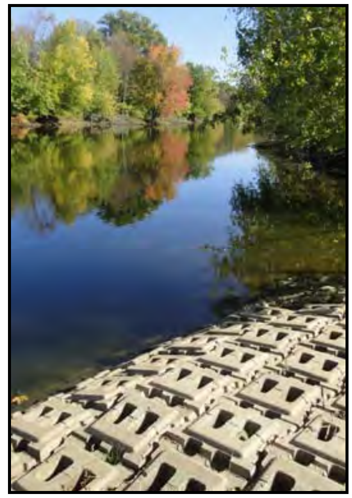
Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR
Banner Marsh HREP, LaGrange Pool, IWW RM 138.0-144.0, Fulton Co. and Peoria Co., IL, MVR
Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR
Clarksville Refuge HREP, Pool 24, UMR RM 275.0-275.0, Pike Co., MO, MVS
Guttenberg Waterfowl Ponds HREP, Pool 11, UMR RM 614.0-615.0, Grant Co., WI, MVP
Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR
Pharrs Island HREP, Pool 24, UMR, Pike Co., MO, MVS
Pool Slough HREP, Pool 9, UMR RM 673.0-673.0, Allamakee Co., IA MVP
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Rice Lake HREP, LaGrange Pool, IWW RM 132.0-138.0, Fulton Co., IL, MVR
Rice Lake HREP, Minnesota River RM 15.0-17.5, Scott Co. and Hennepin Co., MN, MVP
Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR
Stump Lake HREP, Alton Pool, IWW RM 7.2-12.7, Jersey Co., IL, MVS
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS
Trempealeau NWR HREP, Pool 6, UMR RM 718.0-724.0, Trempealeau Co., WI, MVP

MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

j. Photographs. Constructed HREPs with berms and/or spillways are shown here.

Photographs 5-1a and b. Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR

Photograph 5-2. Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR



Photographs 5-3a and b. Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR

k. References

EM 1110-2-1603, *Engineering and Design - Hydraulic Design of Spillways,* CECW-ED-H, 16 Jan 1990 (original) 31 Aug 1992 (errata #1)

EM 1110-2-1913, *Engineering and Design - Design and Construction of Levees*, CECW-EG, 30 Apr 2000

EP 415-1-261 (Volume 2), Construction - Quality Assurance Representative's Guide - Pile Driving, Dams, Levees and Related Items, CEMP-CE, 31 Mar 1992

2. Pump Stations and Wells

a. Design Considerations. Water can be introduced or removed from a MSMU or backwater lake through the use of a pump station, portable pumps, wells or a water control structure. Pumps can obtain either surface water, typically from a river, or groundwater.

b. Surface Water. When evaluating a pump station versus a well (i.e. surface water versus ground water), keep in mind that reuse of surface water is desired where practicable. Surface water is often used as a source due to its abundance and ease of access. When surface water is used, it can remove sediment from its source, and add potentially nutrient rich sediment to the MSMU or backwater lake. Additionally, the use of surface water can remove nitrogen and phosphorous from the river system, with the nutrients eventually being uptaken by plant organisms within the MSMU.

Inlet and/or outlet channels from the source of surface water to the pump stations if needed have routinely had sedimentation challenges. To the greatest extent possible, locate pump stations adjacent to the river or as close to the river as possible to minimize channel lengths.

c. Groundwater. The volume of water required will generally dictate whether a groundwater well can be feasibly constructed. Groundwater wells are limited in capacity due to available well yield from the aquifer, construction limitations, commercially available well pump size, and availability of utility power. There is also a potential of encountering poor groundwater quality such as high sulfur, etc. It may be necessary to incorporate provisions into the design to deal with situations where testing of groundwater quality reveals problems.

d. Pump Housing. Pump stations can be designed to have the intake sump and pumps with associated equipment all in one structure or they can be separate. The equipment for both pump stations and wells is required to be at or above certain flood elevations and will depend on where the project is located. Pumping stations can either be a permanent station or be mobile, including floating type pumping plants.

e. Water Direction. Pump stations can be designed to pump from the river to the MSMU, from the MSMU to the river, or be multi-directional to pump to multiple MSMU's as well as either way. Extra flexibility may be desired by the project sponsor, although water control could be obtained through the use of various closure structures if so designed.

f. Pump Size. When determining the size of the pumps for a pump station or well, a minimum of three variables need to be considered; the evaporation rate, the seepage rate, and the desired fill rate.

g. Access Hatches. Design hatches and grating to have locking mechanisms when open so that the hatches to do not close unexpectedly causing a safety hazard.

h. Power Source. Pumps may be electric or diesel driven depending upon the availability of utility power and user needs. Electric driven pump stations have the advantage of being quieter to operate (little vibration), easier automation, and less routine maintenance. They may also be submerged and require less labor time to operate. Some of the disadvantages are that the electrical equipment must be protected from flooding, available utility power can limit capacity, high demand charge, and usually larger more elaborate structures are required to house electrical equipment. Since electrical equipment is subject to damage from high water, ensure that it is placed above the 500 year (or higher if possible) flood elevation.

Diesel driven pump stations have the advantage of being ideally suited where utility power in unavailable, they have a large capacity, can be permanently mounted pumps with submersible gear drives, can be mounted vertically or angle mounted, can be made trailer mounted to reduce the threat of flooding, and the drive arrangements afford flexibility (direct, belt, hydraulic). Disadvantages to diesel driven pumps are they are noisy to operate, require more routine maintenance, capacity and availability of on-site fuel supply can be restrictive, and are difficult to automate.

i. Equipment Testing. Ensure the contract specifications include testing for all pump station equipment to include pumps, floats, surge protectors, humidity devices, etc. All pump station equipment should be checked, inspected, and verified after installation by the Contractor before finally acceptance.

j. Maintenance. Maintenance of a pump station or well should include project inspections on an annual basis (ideally after the area is drained) in addition to immediately following a high water event. Pump station inspections should be documented using the pump station rating guidelines for continuing eligibility inspections to include the following items as a minimum where applicable:

- structural steel
- structural concrete
- displaced/missing riprap
- electrical lighting/standby generator
- discharge pipe
- sump
- hydraulic pump
- stoplogs

Corrective action should be taken upon discovery of any deficiencies found during the inspection.

k. Case Studies. Constructed HREPs with pump stations and wells are as follows:

Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR
Banner Marsh HREP, LaGrange Pool, IWW RM 138.0-144.0, Fulton Co. and Peoria Co., IL, MVR
Batchtown HREP, Pool 25, UMR RM 242.5-246.0, Calhoun Co., IL, MVS
Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR
Calhoun Point HREP, Pool 26, at the confluence of IWW and UMR RM 220.0, Calhoun Co., IL, MVS
Clarksville Refuge HREP, Pool 24, UMR RM 275.0-275.0, Pike Co., MO, MVS
Cuivre Island HREP, Pool 26, UMR RM 233.0-239.0, Lincoln Co. and St. Charles Co., MO, MVS
Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR
Peoria Lake HREP, Peoria Pool, IWW RM 162.0-181.0, Peoria Co. and Woodford Co., IL, MVR
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Rice Lake HREP, LaGrange Pool, IWW RM 132.0-138.0, Fulton Co., IL, MVR
Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR

Stump Lake HREP, Pool 26, IWW RM 7.0-13.0, Jersey Co., IL, MVS
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS
Trempealeau NWR HREP, Pool 6, UMR RM 718.0-724.0, Trempealeau Co., WI, MVP

MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

l. Photographs. Constructed HREPs with pump stations are shown here.

Photographs 5-4a and b. Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR

Photograph 5-5. Portable Pump-Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR

m. References

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, CECW-ED, 30 Jun 1989

ER 1110-2-100, Engineering and Design - Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, CECW-EP, 15 Feb 1995

3. Stoplog Structures

a. Design Considerations. A general design criterion for this project feature is to construct a structure with operational flexibility that provides the site manager with the capability to meet seasonal and/or annual management goals. Stoplogs can be placed in various types of structures to meet the sizing requirements for raising or lowering water levels. Additionally, the design of the stoplogs themselves can vary widely. Using stoplog structures can be an advantage because they are relatively inexpensive and require low maintenance. Some disadvantages include the following:

- Removing a stoplog can, in some cases, require more than one-person to operate.
- When the head over the stoplogs is high, removal can become nearly impossible.
- Stoplogs with eyes at top are difficult to remove and are often hard to hook, which can also cause problems with sealing properly.

b. Structure Material. Stoplog structures may be constructed of various materials, such as concrete, corrugated metal pipe (CMP), combination concrete and CMP, PVC, or steel.

c. Concrete stoplog structures may have single or multiple bays. The concrete structure may be cast-in-place or precast. Additionally, the structure may or may not have footings. Dewatered versus in the wet construction methods should be considered, especially if control of construction costs are critical.

d. CMP stoplog structures generally consist of a 5-foot diameter riser pipe.

e. PVC stoplog structures have not been used extensively for HREP projects but have proven to be successful on other Corps projects so they should be considered for future HREP projects (http://www.agridrain.com/watercontrolproductsinline.asp). Stoplog structures may also be designed to have a combination of both stoplogs and sluice gates. The ability to resist deflection and warping must be considered. Protection against damage from ultraviolet radiation is important because the breakdown of the outer surface can expose glass fibers.

f. Sheet pile cells may be incorporated into stoplog structures as abutments (Batchtown, Swan Lake and Calhoun Point) or stoplog structures may incorporate internally tied-back Z-shaped sheet pile wing and face walls (Calhoun Point). Concrete footing structures at the top of each abutment support access bridges and stoplog support framing. These footings may be soil-founded (Batchtown) or pile-founded within the retained embankment (Calhoun Point) as local conditions require.

g. Structure Location. Inlet and/or outlet channels from the main channel to the stoplog structures if needed have routinely had sedimentation challenges. To the greatest extent possible, locate stoplog structures adjacent to the river or as close to the river as possible to minimize side channel lengths. Soil borings are recommended at the proposed location of structures to include groundwater elevations. The soils should be evaluated to determine if they are suitable for the structure foundation and if not, what kind of working platform is needed. Ground water elevations can help identify the need for a cofferdam and/or dewatering system during construction.

h. Structure Height. Structures can vary in height to meet customer requirements. At Swan Lake, a number of both one-foot-high and six-foot-high stoplogs are being provided for flexibility in operation. At Calhoun Point, one-foot-high stoplogs that can be ganged together in the field are being provided. In general, the structure should be located and designed to allow for appropriate drainage or flooding of the site, and to ensure that there is adequate height to maintain water levels upstream of the structure.

i. Structure Top Width. For larger structures, if vehicular access across a structure is required, the weight and width of the equipment must be considered.

j. Structure Safety. If operator access is required, appropriate safety measures for guardrails, steps, etc. must be included. Additionally, operator safety should be considered in developing structure features. Non-skid grating and guardrails should be provided on catwalks, etc. Safety features for access to the smaller structures must be considered such as locking devices for hinged hatches.

k. Structure Protection. Ensure that sufficient riprap/bank stabilization is placed around inlet/outlet of gated structures, even if erosion is not a concern. This will prevent wildlife from burrowing next to the structure, which has been a maintenance issue at a few constructed projects. The tendency is to keep the stabilization to a minimum when going for the maximum is usually the better approach.

l. Stoplog Material

Aluminum stoplogs generally weigh less but cost more. While the material weight for aluminum stoplogs is less than wood, hollow stoplogs can accumulate internal silt and thus additional lifting weight over time. Aluminum stoplogs have been designed to have rubber stripping along the bottom and sides to provide a tighter seal. Options for aluminum stoplogs include extruded cross-sections (for individual 1-foot stoplogs) or fabricated cross sections of skin plates and connecting members (for 1-foot or higher stoplogs). Aluminum stoplogs are also subject to being stolen when aluminum recycling costs are high.

Wood stoplogs are buoyant and require ballasting or some type of mechanism to prevent from floating. Wood stoplogs may have a tendency to seal better as wood will swell when saturated. To help with sealing, wood stoplogs have been designed to have grooves so that they “interlock;” when installed, however, this is not always the case, such as at Swan Lake.

m. Stoplog Bay Widths. A stoplog structure can involve a series of bays. The stoplog bay width depends on local user requirements. In Rock Island District, a five foot bay is often used. At Batchtown (in St. Louis District), several structures are across channels where duck blind access is required. A clear width in each bay of ten feet between stoplog supports, and head clearance of five feet between the maximum water level and the low surface of the access bridge, is provided. At Swan Lake, where such access is not required, the clear opening in each bay is only four feet. If a number of similar structures are anticipated at a project site, using similar bay widths, and therefore similar stoplogs throughout, can provide interoperability.

n. Stoplog Storage. Stoplogs may be stored either off site or on-site, such as in a pump house. If stored on-site, keep stoplogs at the highest elevation possible. It is important to establish storage capabilities of the site managers during the design process.

o. Stoplog Protection. Stoplog structures need to be protected from vandalism, theft, and unauthorized use. This can be accomplished through use of padlocks and locking bars. The safety of stoplog structures can be provided through use of inlet/outlet guards, ladders, guardrails, and other such devices.

p. Stoplog Lifting Devices. A stoplog lifting hook is typically furnished for the installation and removal of the stoplogs. Lifting devices should be designed for easy transportation and use, especially during high flows. Stop log hoists may be used to manipulate the structure. Lifting devices can be manual or power-assisted. Electric or hydraulic hoists can be used for raising and lowering stoplogs. The lifting equipment can be supported on a trolley beam running across all bays or on a jib crane. The support requirements for a trolley beam or job crane will determine to some extent the layout of the supporting structures at the sides of the channel to be controlled. Jib crane manufacturers can provide anchor bolt patterns and minimum footing requirements to be used in support structure layout. The design of the lifting device should take into consideration the equipment and/or machinery that the owner has on hand or is readily available to them. Keep in mind when designing a stoplog structure that some site managers may prefer a one-person operation when installing and removing stoplogs. This can become difficult when the head is too high over the stoplogs, the stoplogs are too heavy, and/or the lifting devices are too bulky.

q. Operation. Stoplog structures should be operated so that when the MSMU is in use or the river water levels are expected to rise, the stoplogs should be installed and are to remain in place until one of the following occurs:

- flood waters recedes,
- project no longer in use, or
- overtopping of the exterior berm is anticipated

r. Maintenance. Maintenance of stoplog structures should include project inspections on an annual basis (ideally after the area is drained) in addition to immediately following a high water event. Project inspections should ensure the following:

- stoplogs, slots, keepers, staff gages, and lifting hooks are in good condition
- steel rails, posts, grating, and fasteners are in good condition
- concrete is in good condition
- inlet and outlet channels are open
- trash, debris, and sediment are not accumulating in and around the structure
- erosion, seepage, and encroachments are not occurring adjacent to the structure which might endanger its function
- riprap is not displaced or missing

Corrective action should be taken upon discovery of any adverse conditions at the structures.

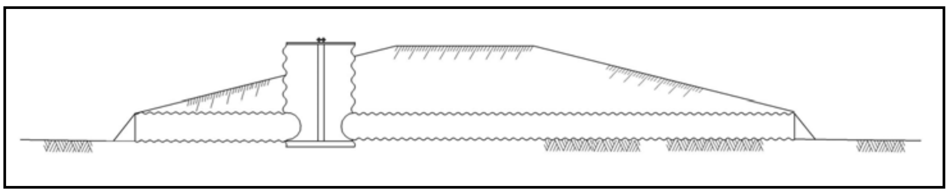
s. Case Studies. Constructed HREPs with stoplog include the following:

Ambrough Slough HREP, Pool 10, UMR, Crawford Co., WI, MVP
Banner Marsh HREP, LaGrange Pool, IWW RM 138.0-144.0, Fulton Co. and Peoria Co., IL, MVR
Batchtown HREP, Pool 25, UMR RM 242.5-246.0, Calhoun Co., IL, MVS
Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR
Calhoun Point HREP, Pool 26, UMR RM 221.0-221.0, Calhoun Co., IL, MVS
Cuivre Island HREP, Pool 26, UMR RM 233.0-239.0, Lincoln Co. and St. Charles Co., MO, MVS
Fox Island HREP, Pool 20, UMR RM 353.5-358.5, Clark Co., MO, MVR
Guttenberg Waterfowl Ponds HREP, Pool 11, UMR RM 614.0-615.0, Grant Co., WI, MVP
Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR
Long Meadow Lake HREP, Minnesota River, Hennepin Co., MN, MVP
Peoria Lake HREP, Peoria Pool, IWW RM 162.0-181.0, Peoria Co. and Woodford Co., IL, MVR
Pleasant Creek HREP, Pool 13, UMR RM 548.7-552.8, Jackson Co., IA, MVR
Pool Slough HREP, Pool 9, UMR RM 673.0-673.0, Allamakee Co., IA MVP
Potters Marsh HREP, Pool 13, UMR RM 522.5-526.0, Carroll Co. and Whiteside Co., IL, MVR
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Rice Lake HREP, LaGrange Pool, IWW RM 132.0-138.0, Fulton Co., IL, MVR
Rice Lake HREP, Minnesota River RM 15.0-17.5, Scott Co. and Hennepin Co., MN, MVP
Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR
Stump Lake HREP, Alton Pool, IWW RM 7.2-12.7, Jersey Co., IL, MVS
Swan Lake HREP, Pool 26, IWW RM 5.0-13.0, Calhoun Co., IL, MVS

MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

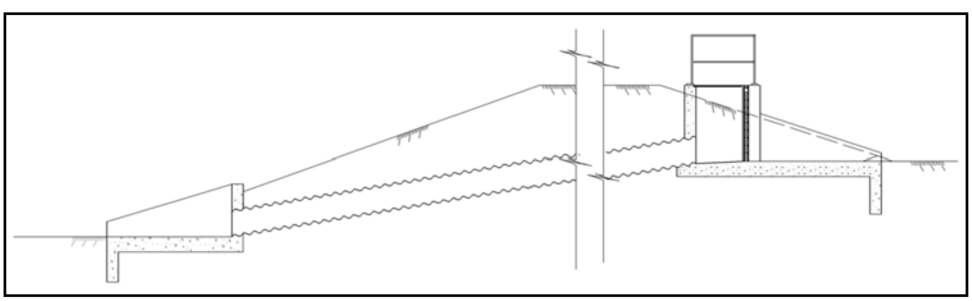
t. Photographs and Figures. Constructed HREPs with stoplog structures are shown in the following photographs:





Photographs 5-6a, b, and c. Banner Marsh HREP, LaGrange Pool, IWW RM 138.0-144.0, Fulton and Peoria Counties, IL, MVR





Photographs 5-7a, b, and c. Potters Marsh HREP, Pool 13, UMR RM 522.5-526.0, Carroll and Whiteside Counties, IL, MVR

Photographs 5-8a and b. Bay Island HREP, Pool 22, UMR RM 311.0-312.0, Marion Co., MO, MVR

Photographs 5-9a and b. Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR

Photographs 5-10a and b. Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR

u. References

EM 1110-2-2705, Engineering and Design - Structural Design of Closure Structures for Local Flood Protection Projects, CECW-ED, 31 Mar 1994

Agri Drain Corporation, Inline Water Level Control Structures, http://wwwagridraincom/watercontrolproductsinlineasp

Agri Drain Corporation, Inlet Water Level Control Structures, http://wwwagridraincom/watercontrolproductsinletasp

EM 385-1-1, Safety – Safety and Health Requirements, CESO-ZA, 03 Nov 2003

EM 1110-2-2100, Stability Analysis of Concrete Structures, CECW-CE, 01 Dec 2005

EM 1110-2-2102, Engineering and Design – Waterstops and Other Preformed Joint Materials for Civil Works Structures, CECW-EG, 30 Sep 2005

EM 1110-2-2104, Engineering and Design – Strength Design for Reinforced Concrete Hydraulic Structures, CECW-ED, 30 Jun 1992 (original), 20 Aug 2003 (Change 1)

EM 1110-2-2105, Engineering and Design – Design of Hydraulic Steel Structures, CECW-ED, 31 Mar 1993 (Original), 31 May 1994 (Change 1)

EM 1110-2-2503, Engineering and Design – Design of Sheet Pile Cellular Structures, Cofferdams and Retaining Structures, CECW-EP, 20 Sep 1989 (Original), 11 Jun 1990 (Errata sheet)

EM 1110-2-2504, Engineering and Design – Design of Sheet Pile Walls, CECW-ED, 31 Mar 1994

EM 1110-2-2906, Engineering and Design – Design of Pile Foundations, CECW-ED, 15 Jan 1991

4. Gated Structures

a. Design Considerations. The primary purpose of a gated structure is to provide gravity drainage from the MSMU. It may be desirable to have at least one gated structure installed within each cell. A gated structure may also be used to enhance MSMU filling operations. If high water events were to occur during the late summer and fall, the gated structure could be opened to help capture water, thereby decreasing the pumping requirements. In addition, the gated structure may serve as an additional opening for water to enter the MSMU prior to overtopping events.

A secondary goal of a gated structure may be to increase dissolved oxygen (DO) levels. Gated structures can be used to help control and maintain water quality in backwaters. If increased DO levels are desired, the size of the gated structure should consider the amount of water needed to provide adequate dissolved oxygen during critical times of the year.

Concrete gated structures may be cast-in-place or precast with the piping being precast reinforced concrete pipe. In some cases, this might be specified as the Contractor’s option. Weight and size limitations might restrict this choice. Gated structures may be constructed of CMP. The inverts may be reinforced with riprap. Desired level of durability and dewatering requirements during construction will influence the choice of structure. It is important to consider the expected life of a CMP structure when designing this type of feature. In addition to material type, another factor to consider in the design of a gated structure is whether or not fish passage is desired.
The type of gate that may be installed depends on the type of structure. Sluice gates requiring a flat back for installation require a concrete structure. Other types of gates (for example, gates which can be installed on the end of a pipe) are not as dependent upon the type of structure. The structure must provide an operating platform from which the gate may be manipulated and which supports any equipment required to do so. This platform can be steel or fiberglass grating. Guardrails should be provided where required by the safety manual. In addition, even if erosion is not a concern, sufficient riprap/bank stabilization will need to be placed around the inlet/outlet of a gated structure. This will prevent wildlife from burrowing next to the structure, which has been an issue at a few constructed projects. The tendency is to keep the stabilization to a minimum when actually, the maximum is usually the better approach.

Inlet and/or outlet channels from the main channel to the gated structures have routinely raised sedimentation challenges. To the greatest extent possible, locate gated structures adjacent to the river, or as close as possible, to minimize side channel lengths. Soil borings are recommended at locations of structures with groundwater elevations. The soils should be evaluated to determine if they are suitable for the structure foundation and if not, determine what kind of working platform is needed. Ground water elevations can help identify the need for a cofferdam and/or dewatering system. Controlling and maintaining debris is a primary consideration in designing the inlet to these structures. Trash racks, flap gates, wooden piles, sheep and cattle fencing, and a number of other techniques have been used to prevent debris from plugging these structures. Debris can be large (trees and logs) or small (floating vegetation). In some situations small debris can be flushed from the conduit entrance or outlet by increasing discharge levels and velocities in the system.

b. Case Studies. Constructed HREPs with gated structures are listed below.

Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR
Batchtown HREP, Pool 25, UMR RM 242.5-246.0, Calhoun Co., IL, MVS
Brown's Lake HREP, Pool 13, UMR RM 545.8, Jackson Co., IA, MVR
Bussey Lake HREP, Pool 10, UMR, Clayton Co., IA, MVP
Calhoun Point HREP, Pool 26, UMR RM 221.0-221.0, Calhoun Co., IL, MVS
Clarksville Refuge HREP, Pool 24, UMR RM 275.0-275.0, Pike Co., MO, MVS
Cuivre Island HREP Pool 26, UMR RM 233.0-239.0, Lincoln Co. and St. Charles Co., MO., MVS
Dresser Island HREP, Pool 26, UMR RM 206.0-209.0, St. Charles Co., MO, MVS
Finger Lakes HREP, Pool 5, UMR, Wabasha Co., MN, MVP
Guttenberg Waterfowl Ponds HREP, Pool 11, UMR RM 614.0-615.0, Grant Co., WI, MVP
Island 42 HREP, Pool 5, UMR, Wabasha Co., MN, MVP
Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Lake Odessa HREP, Pools 17-18, UMR RM 435.0-440.0, Louisa Co., IA, MVR
Long Lake HREP, Pool 7, UMR, Trempealeau Co. and La Crosse Co., WI, MVP
Long Meadow Lake HREP, Minnesota River, Hennepin Co., MN, MVP
Pharrs Island HREP, Pool 24, UMR, Pike Co., MO, MVS
Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR
Spring Lake HREP, Pool 13, UMR RM 532.5-536.0, Carroll Co., IL, MVR
Stump Lake HREP, Alton Pool, IWW RM 7.2-12.7, Jersey Co., IL, MVS
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS
Trempealeau NWR HREP, Pool 6, UMR RM 718.0-724.0, Trempealeau Co., WI, MVP

c. Photographs. Constructed HREPs with gated structures are shown below.

Photograph 5-11. Andalusia Refuge HREP, Pool 16, UMR RM 462.0-463.0, Rock Island Co., IL, MVR

Photograph 5-12. Princeton Refuge HREP, Pool 14, UMR RM 504.0-506.4, Scott Co., IA, MVR

Photograph 5-13. Guttenberg Waterfowl Ponds HREP, Pool 11, UMR RM 614.0-615.0, Grant Co., WI, MVP

d. Reference

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, Appendix C, CECW-ED, 30 Jun 1989

5. Sheet Pile Cells

a. Design Considerations. Sheet pile cells are fabricated from flat PS-series steel sheets. The number of sheets required for a particular radius cell is standard for a particular width sheet and can be ascertained from manufacturers' handbooks. A cutoff wall of Z-shaped steel sheet piles is driven between the two cells and capped with a sill beam (cast-in-place or precast and grouted onto the cells). Fabricated piles are used to create the connection between the cells and the cutoff wall.

Because the Government is required to purchase American steel, the sources for sheet piling and cross-section profiles allowed are limited. This requirement must be considered in the design stage of a project so the correct cross-sections can be included in the Plans and Specifications. PS- and Z-profile sheets are rolled in this country by Chaparral Steel (http://www.chapusa.com/), which distributes through L.B. Foster (http://www.lbfoster.com/). Additional information on these products is available at http://www.sheet-piling.com/main. Another American supplier of these products is Nucor-Yamato steel (http://www.nucoryamato.com/).

Where sheet pile cells are used as abutments for water control structures, the cells are assumed to be stable within a plane parallel to the axis of the berm (i.e., if the end of the berm is stable in itself, a cell situated within the end of the berm will be stable). Stability in a plane transverse to the axis of the berm is checked, based on the depth of the sheet piling and the internal pressures and external pressures on the cell. The internal pressures will be influenced by the method with which the cell fill is placed.

The need for dewatering of the site prior to placement of the cells must also be considered, because it affects means of construction as well as cost.

Developing a clearly-defined construction sequence is critical for proper installation of the cells. Placement of the cells relative to each other in the field should consider the "bulge" the cells may experience after fill is placed. The resulting clear distance between cells must be considered with regard to installation of footings on top of the cells and stoplog support appurtenances.

Special connection details (e.g., bent plates above the sill analogous to the cutoff wall fabricated piles below the sill) are necessary to provide watertight closure between the cells and the stoplog supports. Selecting steel details that will accommodate the final disposition of the cells, and allowing extra distance between the driven cells to account for bulge, can assist in successful erection of appurtenant details.

Sheet pile cells have provided an opportunity for recycling steel sheet piling originally used for temporary purposes (e.g., sheet piling that had been used in the Melvin Price Locks and Dam cofferdam has since been utilized in cell abutments at EMP projects). If recycled sheet piling is being considered, the condition of the piling needs to be evaluated to include a inspection of the interlocks and tips as well as damage to the sheeting itself.

Concrete footings installed on top of the cells support structural/mechanical features such as access bridges, jib cranes, etc. The sheet piling can be used as part of the formwork for these footings. The footings may be supported on the cell fill alone or on foundation piles driven through the fill, as conditions warrant.

Placement of a concrete slab on top of the cell will prevent loss of cell fill in the event a cell is overtopped. Provision of plugged holes in the slab will allow grouting beneath the slab if excessive fill settlement should occur.

Guardrail should be installed around the tops of cells in accordance with the safety manual. In lieu of installing a toeboard, the sheet piling may be cut off four inches above the top of the cell fill/slab. Fiberglass-reinforced plastic guardrails have been used at some locations (Swan Lake); however, because of ultraviolet deterioration and difficulty in making repairs should these items be damaged during floods, wire rope guardrails are an appropriate alternative (Batchtown, replacement of guardrails at Swan Lake).

b. Case Studies. Constructed HREPs with sheet pile cells include the following:

Lake Chautauqua HREP, LaGrange Pool, IWW RM 124.0-129.5, Mason Co., IL, MVR
Swan Lake HREP, Alton Pool, IWW RM 5.0-13.0, Calhoun Co., IL, MVS

MVR – Rock Island District; MVS – St. Louis District; MVP – St. Paul District

c. References

EM 385-1-1, Safety – Safety and Health Requirements, CESO-ZA, 03 Nov 2003

EM 1110-2-2100, Stability Analysis of Concrete Structures, CECW-CE, 01 Dec 2005

EM 1110-2-2104, Engineering and Design – Strength Design for Reinforced Concrete Hydraulic Structures, CECW-ED, 30 Jun 1992 (original), 20 Aug 2003 (Change 1)

E. LESSONS LEARNED (location is in the MVR unless otherwise specified)

Topic	Location	Lesson Learned
Botulism	Lake Chautauqua	Chautauqua experienced botulism deaths of many migratory waterfowl (waterfowl mortalities in 1997 through 2000 were 8,000, 2,500, 250 and 900). Sick birds generally appear in late August when there are low water levels (2 to 10"), low precipitation, and high temperatures for extended periods. These conditions set the stage for the botulism organisms to start reproducing. Birds pick up the toxin and die. Flies lay eggs on the carcasses and the maggots concentrate the toxin to the point where only 3 maggots will kill a duck. The botulism problem usually subsides after the first killing frost. Drying the lake bottom would force the birds to go elsewhere and therefore, avoid the botulism toxins. Therefore, the lower lake dewatering channels were extended from the pump station to the stoplog structure. This required dredging a shallow channel 35' wide and approximately 11,000' long. The extended channel allows the area to be dewatered completely. This removes the habitat for waterfowl and shorebird use and allows the Site Manager to do complete searches of any remaining small wet areas. If dewatered early enough, the area will produce moist soil plant foods that can be used by waterfowl and other wildlife when re-flooded in the fall. It will also allow the bottom to dry to the point where equipment can be brought into the area to control invasive vegetation such as willow.
Cell Operation	Andalusia Refuge	For HREPs with water control structures requiring operation during inclement weather, granular surfacing should be provided along the perimeter levee to strengthen the surface under adverse conditions.
Cell Operation	Bay Island	The MSMU was not designed to allow independent operation of the cells. The existing water supply berm was raised and a new gatewell structure was installed in the water supply berm. This added height to the water supply berm in combination with the new gatewell structure now allows independent operation of the cells.
Cell Operation	Princeton Refuge	The concrete stoplog structure did not allow for complete drainage of the north cell into the south cell. As a result, 2 CMP stoplog structures were installed along the cross dike to provide water level management between the cells at lower elevations by gravity flow.
Contract Changes	Lake Chautauqua	The first contract (Stage I) was typical low bid and was below the government estimate. The contractor started on the access road. The contract measured fill only for payment. The first problem was the material disappeared into a large soft spot. Following the first problem, the 1993 weather pattern kept river water levels high and delayed the project more than a year. Following the initial flood, there were several follow-on floods that overtopped levees and caused flood related damages and time extensions. As a result, the contractor got into a routine of not doing very much when the weather and river was cooperating. He did collect flood damages and time extensions after several flood events. The contractor was not used to working in the flood plain and had equipment that was not suitable to the material. In 1996, the Government terminated the contract and developed Stage II. Designers formulated the Stage II contract so that the work could be done quickly, under flood conditions, and at minimal risk to the government. Incentives to speed up work included a shorter contract duration, intermediate completion dates, and structured payment clauses so that payment was not made until a feature was stable. For example, levees had to be constructed in sections and progress payments not made until they were seeded and mulched. In addition, the contractor was responsible for incomplete and exposed work and the contract defined a flood as being water above a certain elevation. Everything below that level would not result in a time extension.

Topic	Location	Lesson Learned
Erosion Protection: Levees	Bay Island	Severe erosion along the northwestern edge of the perimeter levee was evident after the Flood of 1993. Approximately 1,070' of the perimeter levee toe eroded due to Clear Creek. Clear Creek is a meandering stream that runs along this portion of the levee. The erosion created a 2 to 3-ft vertical cut into the levee toe. The levee slope was re-graded and riprap was placed from the base of the levee toe to 6' from the edge of the levee crown.
Erosion Protection: Levees	Peoria Lake	The erosion control mats and seeding for erosion control along the levees of Cells B and C were not successful with water level fluctuations, resulting in bank erosion. Traditional riprap was installed in place of these mats at various locations.
Erosion Protection: Pump Station	Andalusia Refuge	Riprap was found to be missing in several areas at the water control structure. However, it was determined that the lack of riprap was not causing any problems.
Erosion Protection: Pump Station	Peoria Lake	Erosion occurred around the concrete pad at the pump station outlet. The Site Manager installed riprap around the concrete pad to help reduce the erosive effects around the pump station outlet.
Erosion Protection: Wells	Potters Marsh	The well outlet was provided with a splash pad; however, following testing of the well, it was evident that additional erosion protection would be necessary. To remedy the erosion, a mixture of slush concrete and riprap was placed around the splash pad.
Gatewell	Spring Lake	The gate position was difficult to read. The Site Manager painted the top of the gate stem bright orange to make its position easier to read. Stoplogs are used in the gated inlet structure during maintenance of the structure. The stoplogs are difficult to remove with a high head against them. To ease removal of the stoplogs, the gate is closed temporarily to allow water levels to equalize on either side of the stoplogs.
Gated Structures	Finger Lakes (St. Paul District)	Design for a wide range of flow conditions if increasing dissolved oxygen levels is desired. The gated conduits that were used at this site were sized to provide up to 50 cubic feet per second (cfs) to each of the downstream Finger Lakes. A Biological Response study that was conducted after the project was constructed indicated that the required winter flow was on the order of 5 cfs or less, about 1/10th the capacity of the conduits. However, recommended summer discharges are on the order of 40 cfs, which is near the maximum flow of the conduit. Furthermore, the Fish and Wildlife Service often flushes the pipes by using their full capacity to clear out small debris from the entrance and outlet channels.
Gated Structure	Lake Chautauqua	Ensure the contract specifications address the responsibility of structure operation during construction. At Chautauqua, nobody (owner/sponsor, USACE or contractor) wanted to take responsibility for gate openings on a water control structure from the ILWW to the upper lake and eventually that indecision was at least in part cause to a complete loss of that existing structure and construction of a new structure.
Guardrails	Swan Lake (St. Paul District)	Fiberglass-reinforced plastic guardrails have been used at some locations (Swan Lake); however, because of ultraviolet deterioration and difficulty in making repairs should these items be damaged during floods, wire rope guardrails are an appropriate alternative (Batchtown, replacement of guardrails at Swan Lake).
High Water Action Plan	Banner Marsh and Lake Chautauqua	Since HREPs are constructed in typically wet and potentially flooded areas, ensure that the hydraulic conditions at the site are clear in the contract specifications so that bidders are fully aware of "normal" conditions. Ensure that the contract specifications include a submittal for a detailed high water action plan. The plan should include procedures for rising high water and for dewatering after a high water event.

Topic	Location	Lesson Learned
Levee Construction	Swan Lake St. Louis District	The perimeter levee was constructed 1995 and 1996 with large (8 cy) clamshell bucket using lake bottom silts and clays. Portions of the berm have settled more than expected, especially in areas were the berm alignment was across lower elevational areas, such as sloughs. A 5 to 10% design overbuild of berms were to account for anticipated settlement. Some of these areas have now settled below the overflow spillway grade, now making them the low point in the system. The project has experienced overtopping at these low areas and has resulted in higher maintenance caused by washing road stone off of the top of the berm. The low spots of the berms are expected to be brought back up to grade in 2006, subject to funding availability.
Levees: Rodent and ATV Control	Andalusia Refuge	Settlement of the levee was discovered due to animal burrowing, unauthorized vehicle use, and scouring and erosion. Trapping has resolved the settlement due to burrowing animals. Unauthorized vehicle use from ATVs and snowmobiles no longer seems to be a problem. The settlement from scouring and erosion also appeared to be corrected.
Levees: Rodents	Spring Lake	Since construction has been completed, muskrat burrowing has caused severe erosion on the side slopes and large sinkholes on the levee crown. As a result, water is flowing between the units. This has caused the refuge manger to be unable to manipulate water levels within individual cells as desired. The problem has also become a safety hazard to vehicles traveling on the levee crowns. Annual inspection and maintenance will continue to assess the muskrat damage. One possible solution would be to lay chain link fence fabric on the levee slope, providing a physical barrier to the muskrats. Another possible solution would be to establish an aggressive eradication program, such as trapping. Some site managers claim that having flatter side slopes, such as 10:1 vertical to horizontal, can help prevent muskrat burrowing.
Level of Protection	Bay Island	The perimeter levee provides a 2-year level of protection. This level of protection should be used only at sites where impacts of frequent flooding are acceptable for project O&M. It was recommended that perimeter levees provide at least a 5-year level of protection. A higher level of protection will decrease the rate of sedimentation within the MSMU, increase controlled management opportunities, and decrease the risk of prolonged flooding when trying to establish desired vegetation.
Level of Protection	Spring Lake	A 2-year level of protection, as provided by the interior levees (or cross dikes) in Upper Spring Lake, should only be used at HREPs where impacts of frequent flooding are acceptable for project operation and maintenance. Flooding in the spring of 1997 caused damage to some of the embankment materials. The 50-year perimeter levee was not overtopped during the floods of 1997, 1999, or 2001, and is considered an appropriate level of protection.
Pump Cavitation	Banner Marsh	The existing pump station structure was modified as part of the HREP to install a new 48” submersible pump. The existing sump was modified and an anti-vortexing plate was installed prior to pump installation. The pump was factory tested but not to the low sump elevation level as specified. After installation, the pump developed a cavitation noise in the sump level operating range during operation of the pump, which has led to complete failure. As a result, heavy rains have caused localized flooding within the MSMU. It may also cause accelerated wear of pump components, thus shortening the expected service life of the pump. The pump was pulled for inspection and measurements with no conclusive findings. The pump was reinstalled with the cavitation noise present and a spare impeller was purchased for replacement in the future. The recommendation has been to continue using the pump as normal. Under normal operation, the 48” submersible pump is a backup that only turns on when the 24” service pump is unable to keep up. The 24” service pump can handle about 90% of the annual MSMU pumping requirements.
Pump Controller Valve	Banner Marsh	The 48” pump controller failed twice. The first failure was due to condensation in the pump controller cabinet, which caused a component in the soft start drive to fail. The condensation was caused when the power was turned off to the entire pump station by opening the main breaker. This made it impossible for the pump controller cabinet heater to function and condensation resulted. The Site Manager was instructed to not turn off the main breaker anymore. No O&M Manual was available at the time to provide instruction for pump operation. The second failure was a different component in the soft start drive, which is believed to have failed due to stress caused from the first failure. Both problems were corrected by replacing the faulty components. If further components of the soft start drive fail, it has been recommended replacing the entire drive, which is only one part of the pump controller.

Topic	Location	Lesson Learned
Pump Inspections	Spring Lake	Since the project did not include a system for pump removal, the Site Manager had to add a jib hoist and crane to the pump station to facilitate removal of the pumps for inspections.
Pump Operation	Banner Marsh	A light was installed on the outside of the pump building so that the Site Manager can verify that the pump is running from his house rather than having to drive out to the pump station.
Pump Size and O&M	Lake Chautauqua	Configuration: Lake Chautauqua pump station is a single submersible turbine that pumps from a lower level pump station to the upper level. It is located at the junction of 2 lakes and the river. It is gate controlled and capable of pumping into or out of any of the 3 water bodies or is capable of gravity flow into or out of any of the 3 water bodies. This configuration greatly increases its versatility and also simplifies pump controls. Pump Size: When the pump station was designed, the pump criterion was to dewater the lower lake in 30 days (allows sufficient time for moist soil production). This resulted in a 41,000 GPM pump. Multiple smaller pumps were ruled out as being too expensive. The design criteria were flawed in the following respect: The pump station has never been used to dewater the entire lake within the 30 day timeframe. The cost to run the pump and pay the demand charges is too costly. The FWS refuge staff would rather wait for the river to drop before dewatering mostly by gravity. In fact, waiting is usually faster. (The pump can pump down a full lake by about 0.10' per day). The pump is more than adequate to pump remnants out of the lake and to maintain the lake in a dewatered condition. For these purposes a smaller pump would also work. It would have resulted in less demand and electric charges as well as less submergence requirement and a less expensive pump station. Maintenance and/or repair of pump station components requires the dewatering of the pump station sump area. Pump station component maintenance and repair should be examined for user friendliness.
Pump Station	Andalusia Refuge	When the pump was turned on in the fall of 1994 to fill the MSMU, the trash rack clogged with vegetation and cut off the water supply. Subsequently, a chain link fence was installed 6' from the pump intake, and an outer mesh fence was installed 100' from the pump intake. The outer mesh fence was subjected to damage from ice during the winter of 1995 to 1996. The Site Manager stated that the fences were not working as intended and had been destroyed by ice, and that the vegetation had filled back in from shore to shore. The trash rack fence system had been designed for those years when there was an excess of floating (or dead) vegetation, river levels were low, and fall pumping was required, which didn't meet the needs of the site manager. It was decided that the outer mesh fence could be removed, leaving the posts in place, and re-installed when needed. Otherwise, if the outer mesh fence remains in place, annual maintenance would be necessary prior to ice-over of the refuge.
Pump Station	Swan Lake (lower compartment); Calhoun Point and Stump Lake - MVS	There are permanent pump stations in which the pump is installed in a slanted intake tube supported in the water on the supply side by a system of piles and cross-beams. The discharge pipe passes through the berm (an embankment created between parallel rows of cross-tied sheet piles) and discharges through a duckbill. The pile support system for the pump allows installation without creating a dewatered location for building a sump. The pump support system must accommodate removal of the pump for maintenance.
Pump Station in Cold Weather	Banner Marsh	The pump floatation system would freeze up, so the Site Manager purchased a bubbler system to prevent floats from freezing.
Pump Station Inlet	Princeton Refuge	The river grating on the pump station inlet box has been a challenge. It will plug with debris and create a vortex during pumping operations. It is recommended that a secondary fence be installed between the ends of the wingwalls. This fence would then extend along the top of the wingwalls up to the top of the inlet box to keep debris out during flood events.
Pump Station Inlet	Princeton Refuge	The grating on top of the pump station inlet box is heavy and removing and replacing it for maintenance is dangerous to the operator and hazardous to the public if left off. The grating on top of the pump station inlet box was designed to be heavy for safety reasons and to prevent vandalism. If the grating is replaced with a lighter, hinged section, a padlock should be installed.
Pump Station Location	Princeton Refuge	During construction, the existing pump station was relocated from the downstream end to the middle of the perimeter levee. However, the existing pump station only consisted of a single pump. As a result, a portable pump with a diesel engine mounted on a highway trailer was supplied following construction.

Topic	Location	Lesson Learned
Pump Station Materials	Spring Lake	The door to the pump station rusted on the inside due to moisture. All metal should be galvanized to help prevent rust damage.
Pump Station Siltation	Bay Island	The pump station had a continuous problem with the pumping chamber and intake structure filling in with 2 to 3' of silt. The silt enveloped the pump impellers, thus making the pump station inoperable until the pumping chamber was cleaned out. In addition, removal of the silt in the pumping chamber had been labor intensive and difficult to complete without easy access to the pumping chamber and intake structure. Silt accumulation in the pumping chamber and around the pump impellers created different power demands on the pump motor. Fluctuation in the pump motor loads or possibly incoming power supply had been throwing the phase converter out of balance. The services of an electrical contractor to recalibrate the phase converter had been needed about twice annually since the pump station had been in service. A sluice gate was installed on the outside of the pump station intake structure and that a platform structure was constructed in the pumping chamber. The sluice gate was placed at the intake of the pump station near the existing trash rack. This gate is closed during non-pumping times to prevent the buildup of silt in the pumping chamber. A platform structure with a ladder was installed to facilitate cleaning out of any silt that collects inside the pumping chamber.
Pump Station Stoplogs	Andalusia Refuge	The pump station stop logs would not seal due to the presence of construction debris in the channels. Therefore, the stop log channels had to be cleaned out. Additionally, the stop logs were difficult to remove because of their close proximity to the trash rack. As a result, the pump station trash rack was relocated and a hoist installed.
Pumps and Fishing Lines	Princeton Refuge	Fishing line has been a challenge with the seals around the pump impeller head. A trash rack cleaning apparatus could be utilized to help with the fishing line. This apparatus would have to be used on a regular basis and could be stored in the pump station engine building.
Sheetpile Cells	Lake Chautauqua	The project constructed 4 each 74-ft diameter sheet pile cells. The sheet pile was driven to bedrock and filled with stone. The 4 large cells were connected with arc cells to a lower elevation that would allow complete dewatering of the lake. The arc cells were filled with stone and capped with an H pile supported concrete cap that supported a flood wall and a 10-ft by 10-ft heavy duty sluice gate. The main cells included bridges to span the arc cells and provide access to open and close the gates. The bridge abutments were supported on H-piles driven within the main cells. The gates had back-up bulkheads and aluminum stop logs. **BACKGROUND:** The upper lake at Lake Chautauqua had a 60 year old water control structure consisting or 4 radial gates 12' wide. The gate had not been used for over 30 years. During a flood event, the structure washed out, leaving a large scour hole in the levee system. A flood damage report analyzed various closure alternatives to allow rapid inflow before an over-top event could damage the levee. Other desirable design features were maintaining a consistent water level and increasing the ability to dewater the lake. Analysis showed that another gated concrete structure would be very expensive. Other alternatives included spillways, fuse plug spillway, culverts with gate control, and the selected alternative described below. This design worked well to close the breach in the levee, meet all functional purposes, minimize maintenance, and ease operation. Downstream scour is not a concern and the cost of a stilling basin was eliminated. Used sheet pile was utilized from St Louis District saving additional money. Hydraulics developed an operating plan for when to open the gates. To date the gate plan has worked well and has been used twice. During construction, Engineering used State Plane Coordinates to locate the next main cell after the first cell was constructed and surveyed. Cell spacing was critical so that the gates and floodwall would fit properly. During the gate construction contract, the contractor was required to work up to a designated flood level. He was able to do this by leaving the arc cells extended to the flood elevation and providing interior supports. This worked well and allowed construction within the arc cells during relatively high river levels.
Spillway	Princeton Refuge	During the Flood of 2001, the granular surfacing along the overflow spillway was washed to the downstream slope and the geotextile fabric beneath the granular surfacing had been shifted to the downstream shoulder. Despite the disturbance to the granular surfacing and geotextile fabric, the overflow spillway slopes were still intact with most of the vegetation remaining. It appeared that the geotextile fabric had acted as a slippage plane during the flood event for the granular surfacing to "peel" off the overflow spillway. Therefore, the geotextile fabric was not replaced when the overflow spillway was lowered 8".

Topic	Location	Lesson Learned
Spillway	Princeton Refuge	The design for the overflow spillway was to be 2' lower than the north perimeter levee to allow for rapid filling of the MSMU interior water surfaces prior to overtopping of the perimeter levee. The as-built construction drawings show the final grade of the north perimeter levee at elevation 582.3' msl and the overflow spillway at elevation 580.3' msl, which provides the required 2-ft difference. However, 8" (minimum) of granular surfacing was then placed on the overflow spillway. This would place the top of the overflow spillway at approximately elevation 581' msl. A land survey verified that this was indeed the case. The average top elevation of the north perimeter levee was found to be 582.45' msl, while the overflow spillway showed an average top elevation of 581.05' msl. The result was a 1.4-ft difference between the 2 ends rather than the required 2-ft difference. This discrepancy may have contributed to a large breach in the north perimeter levee during the Flood of 2001. During the flood event, the Site Manager observed that the north perimeter levee and overflow spillway overtopped at the same time, rather than the latter first. As a result, the overflow spillway was lowered 8".
Spillway	Stump Lake St. Louis District	The exterior perimeter berm (levee) was designed with a 200 ft long overflow spillway on the downstream portion of the project. The riprap stone was graded stone C (400 lb top size). Severe erosion to the spillway and adjacent berm occurred during an overtopping event in 1997. In 1998, the spillway capacity was reanalyzed and redesigned with larger riprap stone (1,200 lb top size) and 500' additional length. To date the spillway has been overtopped numerous times and has maintained its integrity.
Spillway vs Stoplogs	Bay Island	Overflow spillways were constructed within each cell to allow the MSMU to flood at a set elevation. The overflow spillways help remove the burden of constantly monitoring the river for rising elevations and the need to access the site for removal of all the stoplogs. After the overflow spillways were installed, it was noted that the transition from the perimeter levee crest down to the overflow spillway crest, a 1-ft vertical drop, may be too abrupt at a 10% slope.
Stoplog Materials	Banner Marsh	One of the stoplog structures is starting to rust due to the high acidity of the water in the project area or it may be a natural occurrence. The Site Manager may need to repaint this structure.
Stoplog Operation	Banner Marsh	The stoplog structures have been difficult to operate. The Site Manager has recommended that the stoplog structures have a sluice gate installed to stop flow. This would facilitate placement and removal of stoplogs.
Stoplog Operation	Banner Marsh	In the other stoplog structure, the stoplogs have a tendency to float. The Site Manager has wedged objects between the C-frame and the end of the stoplogs as a remedial effort to keep the stoplogs from floating. It has been recommended that the stoplog structures have locking mechanisms installed to prevent the stoplogs from floating or the procedure for installing the stoplogs needs to be changed.
Stoplog Operation	Bay Island	The water control structures were designed and constructed with the intention of one person removing and replacing the stoplogs. Stoplogs were constructed out of pressure treated Spruce-Pine with a dimensional size of 5'-2½" x 5½" x 2½". However, removal of the wood stoplogs has proven to be more than a one person operation and can often be a struggle for two persons. It was recommended that the wood stoplogs be replaced with aluminum stoplogs, which are lighter. It was also recommended that one of the bays at each structure be converted to a sluice gate, thereby eliminating some of the stoplogs.
Stoplog Operation	Peoria Lake	The Site Manager has expressed the inability to independently operate the 3 cells, which is undesirable. In addition, there have been challenges in operating the stoplog structures due to the weight of the wood stoplogs. Using solid plates or aluminum stoplogs in lieu of wood stoplogs has been discussed.
Stoplog Operation	Spring Lake	Removal of the stoplogs underwater had been difficult. Locating the lifting lugs with the lifting device was a hit-and-miss operation. Therefore, the stoplog lifting device was modified by the Site Manager to make locating the lifting lugs easier. In addition, the stoplogs do not seal well, allowing seepage between cells. The stoplogs will eventually seal after several days due to fine sediment build-up between the gaps. It has been recommended that the stoplog settings not be changed frequently to avoid breaking this seal. If a more immediate seal is needed, it has been suggested to utilize cinders on the upstream side of the stoplogs.

Topic	Location	Lesson Learned
Vegetation Control (interior)	Andalusia Refuge	An abundance of woody vegetation was also reported on several islands in the MSMU. In 1996, the ILDNR Site Manager aerially sprayed the MSMU to control bulrush, lotus, and willow growth. The islands were also burned in 1997 and 1998 to control undesirable vegetation. A beaver dam was found across the main channel. A continual problem in the MSMU is the erosion of the island banks.
Vegetation Control (levees)	Andalusia Refuge	In 1997 and 1998, thick woody vegetation was noted as growing among the riprap on the perimeter of the levee. The vegetation was removed and the riprap was sprayed with Round-Up. This process has since been repeated several times.
Vegetation Response on Berms	Andalusia Refuge	The perimeter levee was originally seeded with a mixture which was predominantly Indian grass. Initial establishment was successful, however, there was no post-Flood of 1993 re-establishment of the Indian grass on the side slopes of the perimeter levee, nor was the perimeter levee re-seeded. Reed canary grass is now the predominant species. As reed canary grass is very invasive, spraying or controlled burns in the MSMU may be necessary to limit it to the perimeter levee only.
Wells	Fox Island	Test bore holes for new well construction failed to identify large cobble and rocks at approximately the 30-ft depth at both new well locations approximately 1 RM apart. Cost and time escalation was realized and well installation methods were changed dramatically upon the discovery of the cobble.