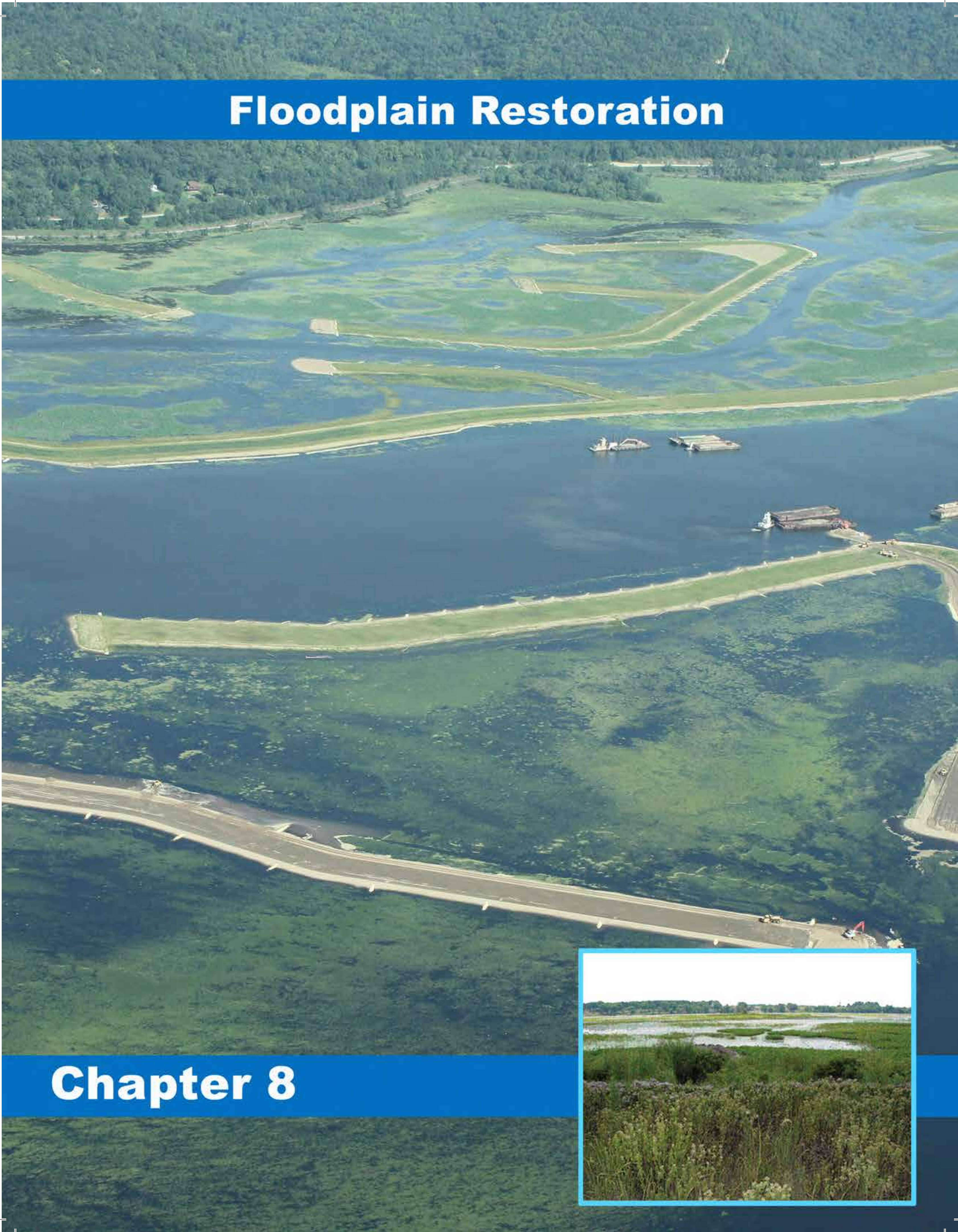
Floodplain Restoration



Chapter 8

UPPER MISSISSIPPI RIVER RESTORATION ENVIRONMENTAL MANAGEMENT PROGRAM ENVIRONMENTAL DESIGN HANDBOOK

CHAPTER 8

FLOODPLAIN RESTORATION

Floodplain Forest, Photo by MDC

Donaldson Point, Photo by MDC

Thompson Bend, Photo by USACE

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CHAPTER 8

FLOODPLAIN RESTORATION

A. RESOURCE PROBLEM

Floodplain habitats are integral components of the large river ecosystems because of the seasonal flood pulse that inundates them and connects them to the river. River floodplain ecosystems support a wide variety of species, which are distributed along a flood frequency gradient from low elevation areas which are frequently inundated to areas of higher elevation infrequently inundated (figure 8-1).

Large floodplain rivers are dynamic, and disturbance is the key driver in maintaining the floodplain diversity. Flooding, droughts, sedimentation, channel migration, sediment re-suspension, fire, ice shear, tree wind-throw, log jams, and ecosystem engineers (e.g., beavers) are some of the natural disturbances that shape floodplains (USACE 2000). Man-made disturbances also have affected river habitats on the Upper Mississippi River System (UMRS). These include impoundment, water level regulation, dredging and dredge disposal, channel training structures, boat generated waves, levee construction, agriculture, nutrient enrichment, logging, urban development, and contaminants (USACE 2000). Navigation dams converted the free-flowing river to a series of shallow impoundments. Portions of the floodplain were permanently flooded by the dams and backwaters area increased significantly in the some northern reaches of the UMRS. Since impoundment, sedimentation of backwaters, island loss, and loss of secondary channels have greatly modified the river floodplain. Much of the southern reaches of the UMRS floodplain have been isolated by levees and the majority of the floodplain is in agricultural production. Additionally, forested reaches of the UMRS floodplain have experienced significant habitat degradation due to logging and subsequent conversion of land to agriculture. Deforestation and agricultural conversion throughout the basin has resulted in increased sediment delivery to the mainstem river.

Floodplain restoration in the northern reaches of the UMRS focuses primarily on constructing islands, dredging, and water level management. In the southern river reaches, floodplain restoration includes a mixture of water level management, connecting isolated backwater sloughs and lakes to the river, levee setbacks, and restoration of agricultural areas to aquatic, wetland, floodplain forest, bottomland hardwoods, and prairie habitats. The majority of floodplain restoration has occurred on public lands since privately-owned floodplain areas requires landowner cooperation or acquisition of real estate interested from willing sellers and donors.

Some floodplain restoration management actions include:

- Topographic Diversity (Ridge and swale; environmental dredging)
- Depressional Wetlands
- Reforestation
- Wetland Species Plantings (grasses, sedges, rushes, forbs)
- Levee Setbacks

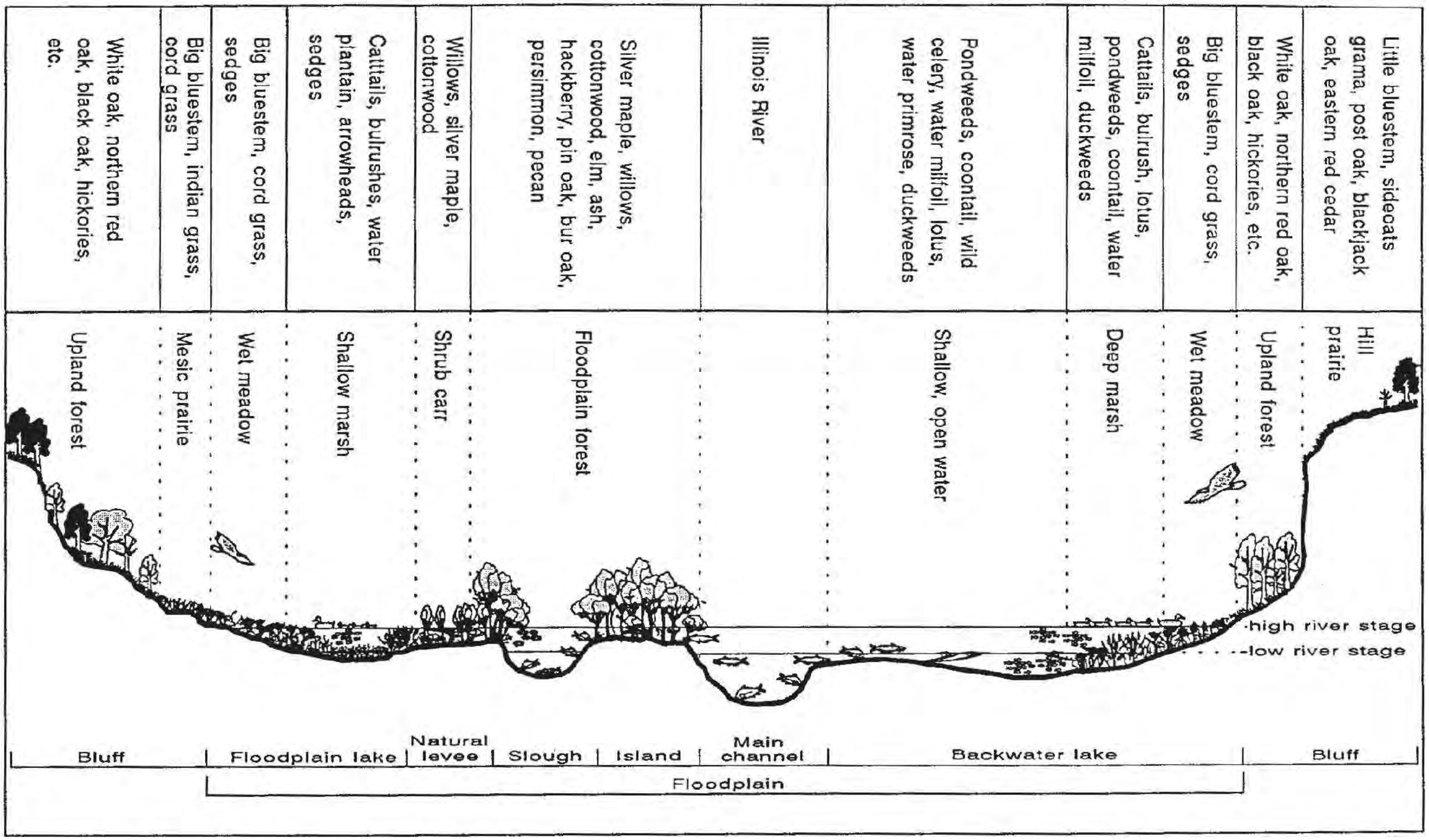


Figure 8-1. Cross-section of Habitat Types Typical of the Upper Mississippi River System (Sparks 1993)

B. MODELS

Conceptual models can be useful in visualizing how management actions link to project objectives as well as UMR system objectives. Figure 8-2 illustrates one example of how the management actions taken on the floodplain relate to system-, reach-, and project-specific biota objectives in terms of restoring UMR forest communities. In addition, management actions directly affecting hydrology and hydraulics and geomorphology can indirectly influence the biota objective.

The Ecosystem Functions Model (HEC-EFM) is a relatively new model designed to assist planning teams in determining ecosystem responses to changes in the flow regime of a river or connected wetland. The Rock Island District's Huron Island Habitat Rehabilitation and Enhancement Project (HREP) is currently using this model to design restoration features. HEC-EFM analysis involves 1) statistical analyses of relationships between hydrology and ecology; 2) hydraulic modeling; and 3) use of Geographic Information Systems to display results and other relevant spatial data. Through the analysis, planning teams should be able to visualize and define existing conditions, highlight potential restoration sites, and assess and rank alternatives according to predicted changes in different aspects of the ecosystem. Further model information and downloading instructions are available at: http://www.hec.usace.army.mil/software/hec-efm/.

C. TOPOGRAPHIC DIVERSITY

Topographic diversity refers to the ridge and swale pattern that forms in a natural floodplain. The process of sediment erosion and deposition form ridge and swale topography, which is an alternating sequence of narrow sandy ridges and low wetland swales that parallels the river. The ridges provide areas for flood intolerant tree species to become established. However, human modification (e.g., impoundment, leveling the floodplain for agriculture) to the floodplain has greatly reduced topographic diversity. Impoundment has elevated the water table leading to a loss of dry root zone and ultimately these flood intolerant tree species are eliminated for the forest community. Agriculture has leveled many areas changing hydrologic conditions, i.e., exposing sand lenses and draining areas ultimately altering that habitat that can be restored in these areas. Topographic diversity is essential for maintaining species diversity on floodplains, where relatively small differences in land elevation result in large differences in annual inundation and soil moisture regimes. These differences regulate plant distribution and abundance (Sparks 1992). Most topographic diversity restoration within the UMRS has occurred in conjunction with dredging. Material dredged from the main channel has been used to simulate ridges on the floodplain or as well as in island construction (See Chapter 9, *Island Design*, for more information). The newly elevated land area may then be planted with flood intolerant tree species (e.g., oaks and other hard mast tree).

1. Design Methodology

a. Potential Environmental Benefits. As proposed, this measure could be achieved through either the modification of existing geomorphic surfaces or through the creation of new ones. Increased topographic diversity in turn, would increase habitat diversity and benefit targeted species. Topographic diversity could also potentially serve to improve conditions for the recruitment and development of floodplain vegetation. Improving floodplain topographic diversity would benefit wildlife that is dependent on a diverse floodplain plant community.

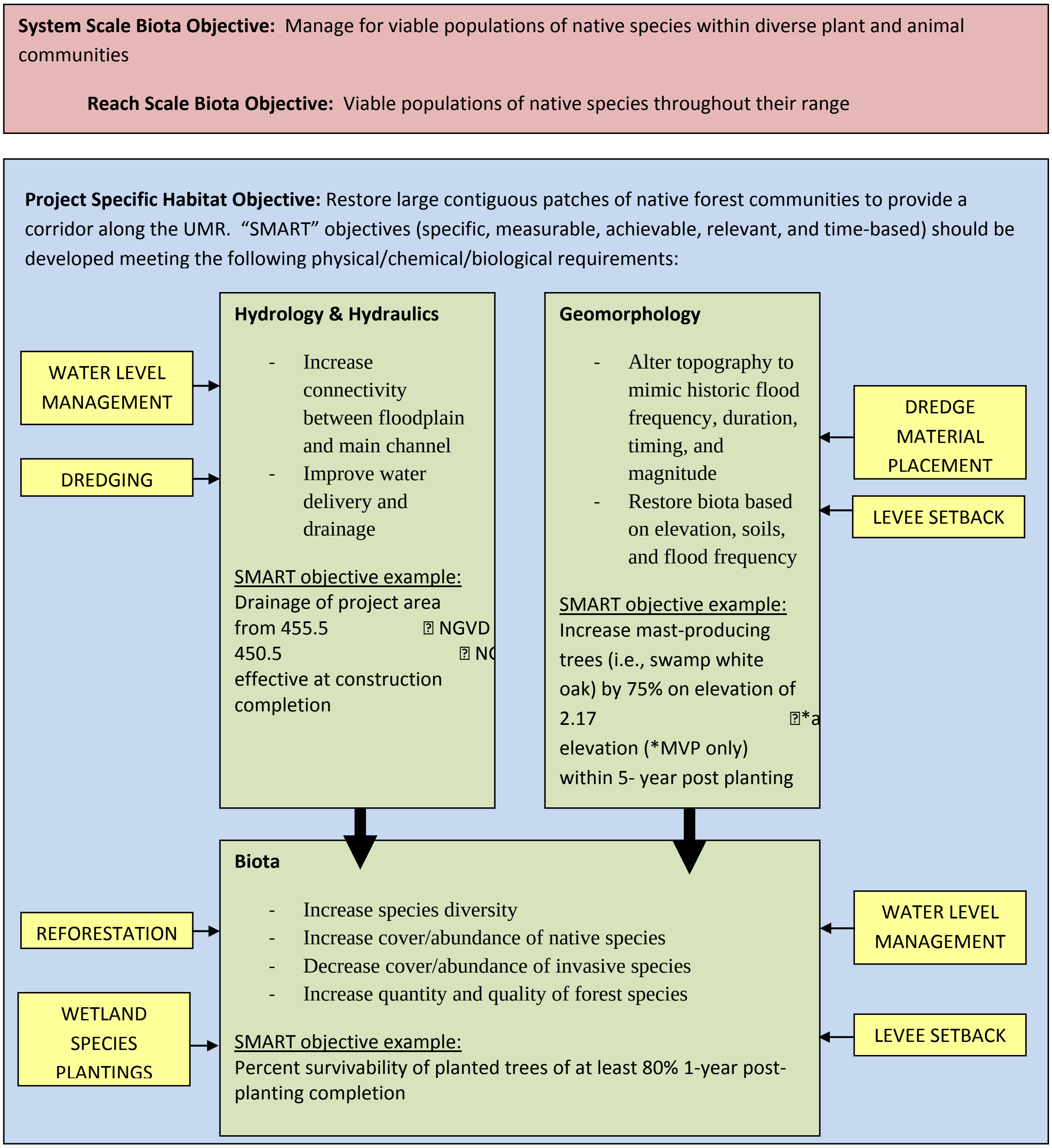


Figure 8-2. Conceptual Model for Reforestation
(Management actions are depicted in yellow.)

b. Potential Constraints. During the summer months flows are relatively high due to impoundment caused by the locks and dams. Thus, the modified flow regime does not resemble the historic (pre-impoundment) flow regime in timing, magnitude, or duration of peak flows. This has implications for both the design and possible functioning of floodplain surfaces that could be restored.

The principle constraints to effectiveness of restoring floodplain diversity will be existing flow regime and existing soil conditions. Unless the management of existing flow regime is altered to more closely mimic the historic flow regime, any effort to restore topographic diversity will not be sustainable in the long-term because the processes that create topographic diversity (scour and deposition) have not been restored. Secondly, the existing soil conditions on the site may also be limiting factor due alterations in the soil profile (e.g., permeability, type, loss of seed bank, compaction, sand lenses, etc.). Secondary constraints include the availability of substrate to restore the ridges, and the potential short-term water quality impacts of in-channel construction.

2. Design Considerations and Evaluation. It is assumed that topographic diversity (i.e., ridges) would be constructed at elevation corresponding to different magnitudes of flow, simulating a natural floodplain setting. It is conceivable that stage-discharge relationships corresponding to pre-impoundment flood flows could be developed and used to design topographic restoration. However, the existing flow regime does not often mimic the pre-impoundment hydrograph. If the restored ridges and flow regime approximated pre-impoundment conditions, it would most likely represent a scaled-down version of the historic alluvial system. That is, the restored system would be an alluvial system within the entrenched channel operating on a modified flow regime. Although not difficult to envision, designing a self-regulating system would prove to be difficult due to challenges with altering the existing flow regime. If new ridges are created or floodplain surfaces are modified, they may require bank protection to prevent erosion. Bank protection could be accomplished through the addition of rock (e.g., rip rap) imported from outside the area or with bioengineering approaches (e.g., willow mattresses, ground cover, etc.). Additionally, any topographic restoration must take into account existing soil conditions and what types of plant communities these soils can sustain. Furthermore, topographic restoration should include planting or establishing floodplain vegetation on the ridges that are able to survive and thrive on the existing soils otherwise soil enrichment may be required. It is assumed that the vegetation on the ridges would simulate a natural floodplain successional pattern. The vegetation on different topographic surfaces would correspond to flood frequency. Additional items to consider include erosion control, desired future floodplain vegetation, control of exotic species, and relationships between flow and vegetation.

Additionally, another design consideration would be how the topographic restoration measure would response to extreme peak flow events. During events of magnitude, massive erosion on the restored topographic surfaces could occur. Measures of effectiveness could include mapping of restored surfaces and associated vegetation. The primary uncertainties with restoring topographic diversity include the flow regime requirements, substrate availability for construction, effects of restored topographic features on channel behavior, and the effects of peak flows on the restored topographic features.

The effects of restoring topographic diversity on downstream and upstream geomorphic processes would need to be evaluated. If the emphasis were on modifying topographic surfaces that already exist, then the potential effects would probably be relatively insignificant. If entirely new topographic surfaces were restored, then they would change flows and geomorphic processes in an already modified system. Therefore, the latter would have higher risk and would require a more detailed evaluation.

Restoring topographic diversity is a conceptually appealing feature but it begs the question of “what is the intent of the restoration?” Is the intent to restore floodplain structure through engineering or is it to restore ecosystem processes and functions allowing the river to be self-sustaining? The former can be done, but the latter is what is needed to achieve true restoration of topographic diversity.

3. Lessons Learned

- When constructing topographic features, it is imperative to mimic the elevations currently in the adjacent area and to consider the natural slop of the river from the main channel to backwaters. In general, higher elevated islands or floodplain features work well next to channels because higher ridges are better able to withstand wave and wind action without being overtopped or eroded. Lower elevated ridges work better further off the main channel and away from high fetch areas.
- Proper placement of topographic features in relation to flow and wave action is important to ensure success. Topographic features that are misplaced relative to the flow may actually increase undesired events such as increased sedimentation in backwaters as the flow may bring in sediment-laden water, thus converting the backwater into a settlement basin.

4. Case Studies

a. Reno Bottoms (NESP Lock and Dam 8 Embankment Modification, Interim Report 2010, St. Paul District). The installation of Lock and Dam 8 and the associated embankment in 1937 permanently altered hydraulic and geomorphic conditions through the project area. It also fragmented habitat. The scope of the study focuses on evaluating project features that would modify the existing embankment to improve hydraulic conditions and natural river processes within Reno Bottoms. The potential actions to improve hydraulics and habitat discussed in the study included use of dredged material for beneficial habitat restoration. For dredging and material placement, the project would consider a combination dredging locations to include dredging in both backwater and side channel habitat. At this time (project suspended due to NESP funding), it is assumed that dredged material placement would be done in a fashion to optimize hydraulic conditions, to include channelizing flow through side channel habitat; and/or separating backwater habitat from side channel habitat. Dredged material would be placed and planted with appropriate herbaceous or woody vegetation covered based on final elevations. If constructed, this project would provide a case study for assessing environmental benefits of restored ridge and swale habitat as well as design methods.

b. Huron Island Complex HREP. The Huron Island Complex HREP is located in Pool 18 between river miles (RM) 421.2 and 425.4 in the Rock Island District). This project is currently in Feasibility. The Complex contains approximately 1,500 acres of floodplain habitat. As a result of constructing Lock and Dam 18, water levels in Pool 18 are generally higher for the entire year, flood pulses are higher, and periods of low flow formerly common during the fall have been eliminated. Consequently, about 99 percent of the Complex is located at or below the 2-year flood elevation. Under this hydrologic regime, forests stands experience prolonged inundation (>50 days) during the growing season, which results in 96 percent of the Complex being dominated by silver maple (De Jager et al. 2012).

The goal of the Huron Island Complex HREP is to increase topographic diversity through the construction of elevated tiered berms and reforestation of flood intolerant hardwood species and scrub/shrub wetland species. HEC-EFM was used to determine optimal berm heights by incorporating the growing season, hydrology, and hardwood inundation duration tolerances. The Project Delivery

Team (PDT) found a berm elevation of 535 feet would result in <25 consecutive days of inundation during a 2-year flood event. Furthermore, a second tiered berm at an elevation of at least 537 feet would provide <25 consecutive days of inundation during a 5-year flood event. These elevations are incorporated into the 2-tier berm design to provide for the greatest survival and sustainability of hard mast trees.

Semi-permanently inundated wetlands are also designed as part of the ridge and swale design. Using the same methods described above (i.e., optimal elevation heights from HEC-EFM), a ridge and swale habitat would be constructed to a minimum elevation of 535 feet using existing soils. The topographic diversity will extend just over 1,000 feet (upstream to downstream) and will be constructed with borrow from the adjacent land. Borrow can be obtained to a depth of 6 feet below surface which results in semi-permanently inundated wetlands. A draft drawing indicating this type of topographic diversity is shown figure 8-3.

c. Fox Island Division HREP. The Fox Island Division HREP is located in Pool 20 between RMs 358.5 and 353.6 in the Rock Island District. This project is currently in construction. The goals of this project include reduce forest fragmentation and enhance forest species diversity (creating topographic diversity to enhance tree plantings), enhance and expand existing wetlands (included channel excavation), and restore native grassland. The material excavated during the channel creation was used to restore topographic diversity by creating a 30-acre area 1.5 feet above existing elevation (figure 8-4). This raised area will be planted with containerized tree plantings (October-November 2012). An additional 240 acres will be planted at existing elevation. Future monitoring of this site will provide additional information on how restoring topographic diversity impacts the success of the tree plantings.

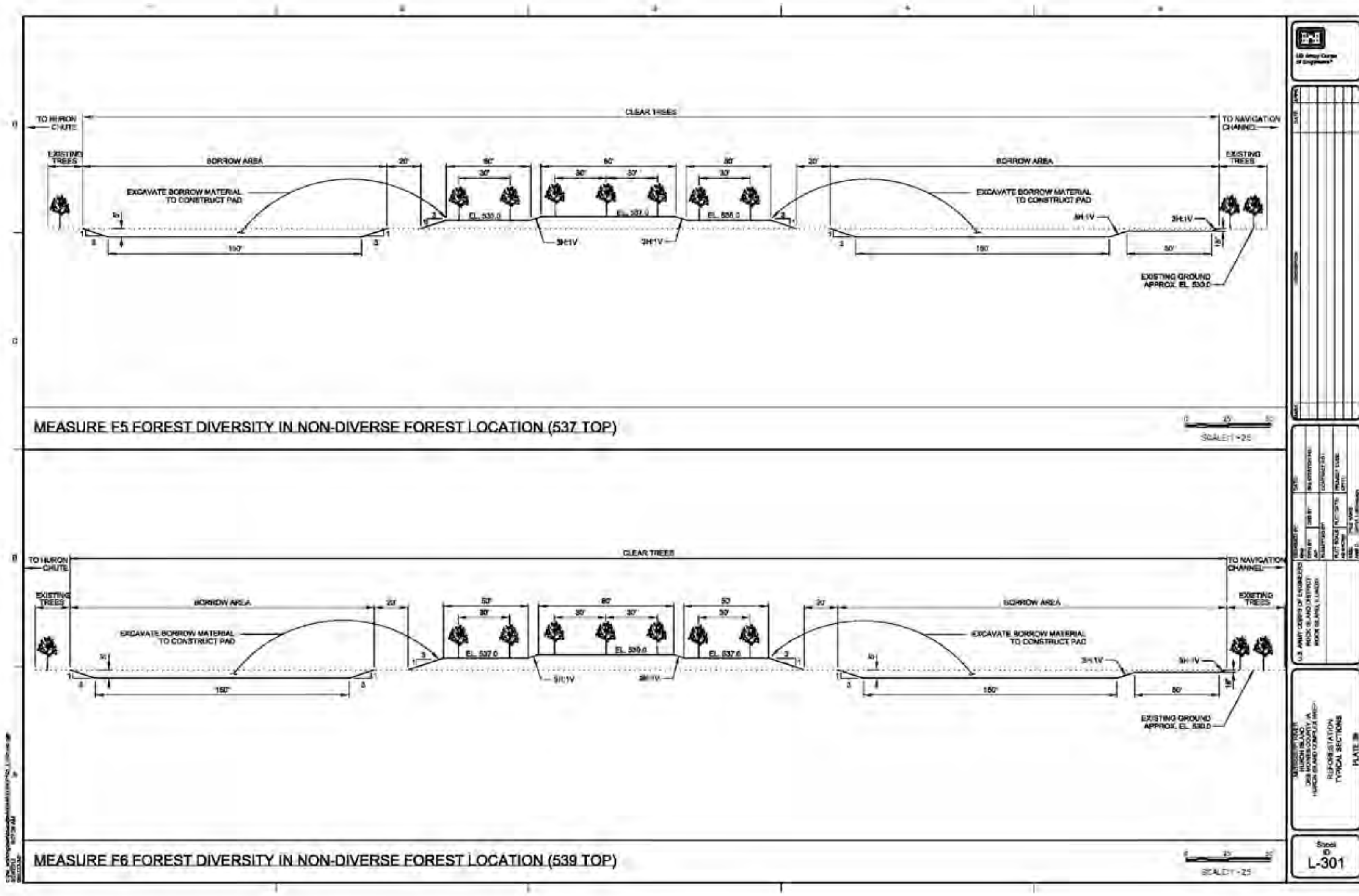


Figure 8-3. Topographic Diversity Proposed at Huron Island, Pool 18

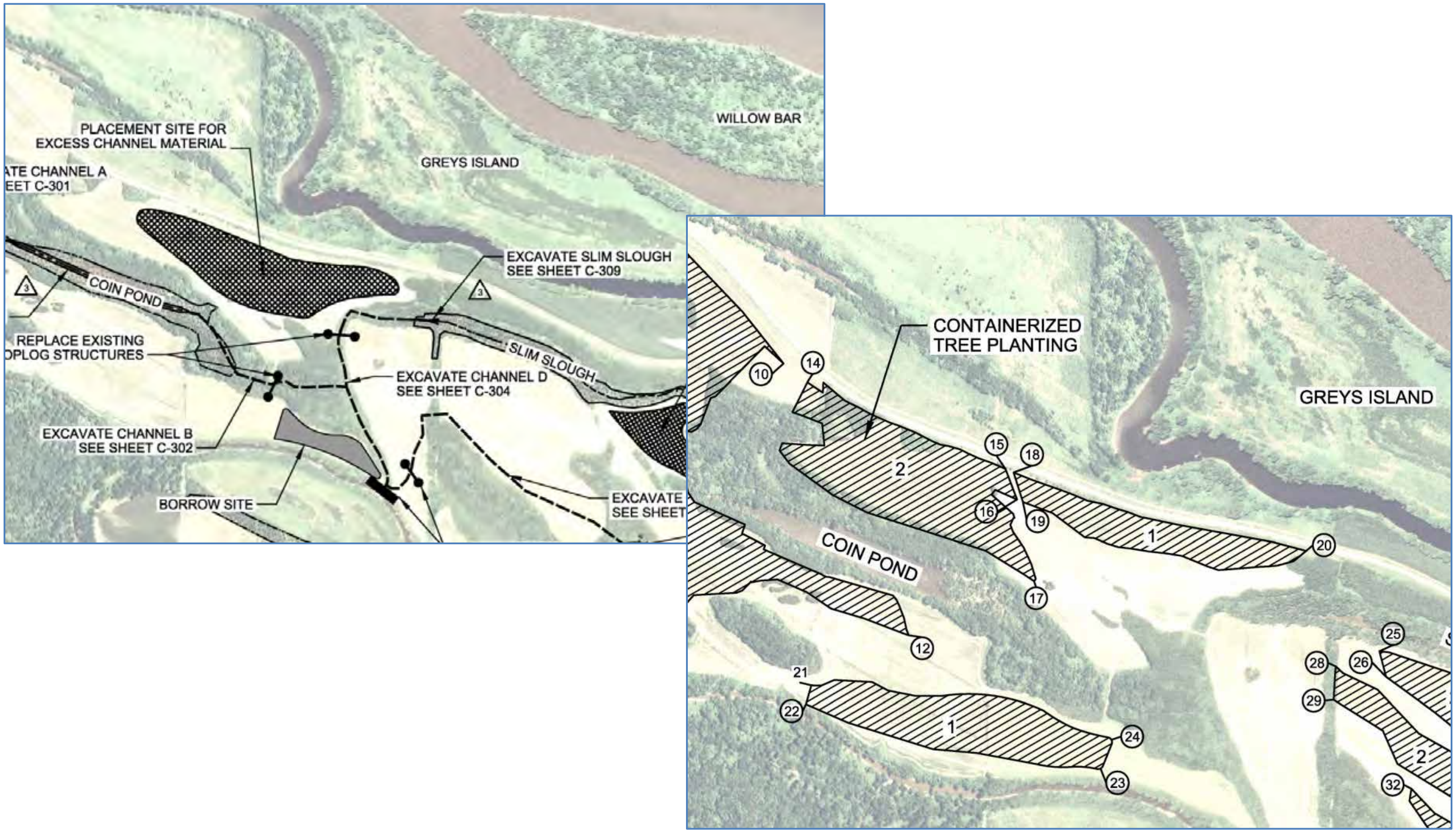


Figure 8-4. Fox Island Division HREP. Upper panel depicts location of placement site for excess channel material from Slim Slough. Lower panel illustrates location of containerized tree plantings.

D. DEPRESSIONAL WETLANDS

Depressional wetlands are constructed to create open water habitat by excavating deeper pockets within a mudflat. These pockets fill with water and allow for growth of submergent aquatic vegetation, drawing in wildlife that utilizes that habitat increasing biotic diversity. The depressional wetland may be considered a perched wetland if little to no interaction with the groundwater occurs. This makes the depressional wetland dependent on surface flows for moisture.

1. Design Methodology. Depressional wetlands can be constructed through mechanical excavation or through the use of explosives. Empirical studies by the Bellevue EMP-LTRM Field Station at Potters Marsh HREP indicate that, if designed properly, there is no difference in usage by waterfowl between the two construction methods. This study indicated that depressional wetland usage was linked to the amount of cover in the immediate vicinity of the depressional wetlands, where depressional wetlands with the best proximate cover saw the most usage by migrating waterfowl and wading birds (Gent 1997).

Additionally, the material excavated to create these wetlands may be used for berm construction or to create topographic diversity (Section C, page 8-3) further enhancing biotic diversity within the project area.

The size of the depressional wetland does matter for wildlife. If the goal of the project is to attract migrating waterfowl, then several smaller wetlands (>0.1 to <0.75 acre each) constructed in close proximity to each other has been shown to be ideal (as observed at Potters Marsh HREP). Larger depressional wetlands (>0.75 acres) appear to be used by amphibians, great blue herons, deer, and turkeys, but not waterfowl (as observed at Cottonwood Island HREP). Smaller, more numerous depressional wetlands may offer more cover since they have more bankline for the volume as compared to larger depressional wetlands. However, depressional wetlands larger than 0.1 acres are needed. Depressional wetlands less than 0.1 acres have shown to be used primarily by predators and are not considered desirable habitat (as observed at Big Timber Refuge).

Depressional wetland side slopes should be gradual, no steeper than 1V:3H; however the slope depends on the type of wetland and vegetation that is desired at the site. A slope upwards of 1V:20H (Confluence Point, St. Louis District) has been used in order to achieve the desired wetland plant community. Steep side slopes should be avoided since they are conducive to predators, but not for brood rearing or other habitat uses.

Depressional wetland depth varies from 3 to 8 feet deep. Depth does not appear to be a limiting factor for usage by migrating waterfowl. Depressional wetlands constructed at 3 to 4 feet have shown to be successfully used by migrating waterfowl at Potters Marsh HREP. If fish habitat is desired from the depressional wetland, depths should be sufficient for overwintering (> 5 feet).

Floodplain soils are very diverse. Prior to constructing a depressional wetland, a detailed soil analysis should be conducted to determine soil type, permeability, and compaction. In order to hold water within the depressional wetland the desired soils are clays (CL or CH), which have the lowest permeability of all soil types. A soil test (Atterberg Limits or Grain Size Analysis) on the material should be performed to determine what it classifies as which will assist in determining its level of permeability. The site will also need good compaction in order to improve the impermeability of the clay. A compaction test (Proctor and drive tubes) should be performed to verify whether the soils have very loose/weak clay or stiff/strong clay. Additionally, the overall site geology should be explored to identify any potential sand lens, which should be avoided to prevent draining the constructed depressional wetland. Additional soil tests and resources to consider include:

- ASTM D 698 Compaction Test (Standard Proctor Test): determines soil compaction
- ASTM D 2487 Unified Soil Classification System: outlines how soils classify and why
- ASTM D 4318 Atterberg Limits: classifies fine grained soils (clays and silts)
- ASTM D 2488 Visual Classification of Soils
- Permeability Test: only perform if a specified level of soil permeability is being used, rather than the soil type

2. Lessons Learned

- If borrow material is needed for a proposed project, designers should consider incorporating depressional wetland designs into the project, thereby gaining habitat benefits through beneficial use of borrow and placement of excavated material.
- Side slopes for depressional wetlands should be gradual. Terracing of the side slopes of larger depressional wetlands does not appear to be a cost effective practice. After a few years, the terraces erode into the wetland, leaving a bowl-shaped depression similar, if not identical, to the shape of depressional wetlands created by excavation or explosives.
- Depressional wetlands experience some sedimentation and should be constructed deeper than needed to account for this. For waterfowl use, depressional wetlands 3 to 5 feet in depth have shown to be sufficient (as observed at Potters Marsh HREP). However, at that depth it is possible that the depressional wetland would freeze to the bottom in the winter. If it is anticipated that fish would be present in the project area over the winter months, depressional wetland should be a minimum of 8 feet or deep to prevent them from freezing solid.
- Explosives regulations are prone to frequent change. It may not be possible to obtain permits to create depressional wetlands through the use of explosives. Designers should check permitting requirements in the early stages of feasibility if explosives are proposed.

3. Case Studies

a. Potters Marsh HREP. Potters Marsh is located in Pool 13 in the Rock Island District. Both mechanical excavation and explosives were used to create depressional wetlands (figure 8-5). for open water depressions within the developing mudflats and higher elevation terrestrial habitat. These holes filled with water and provide secluded open water for migratory waterfowl. Eighteen depressional wetlands were constructed (approximately 8 acres), and based on the 2003 Performance Evaluation Report, the depressional wetlands are experiencing some sloughing, but the interiors seem to be retaining their constructed depth (USACE 1992, 2003).

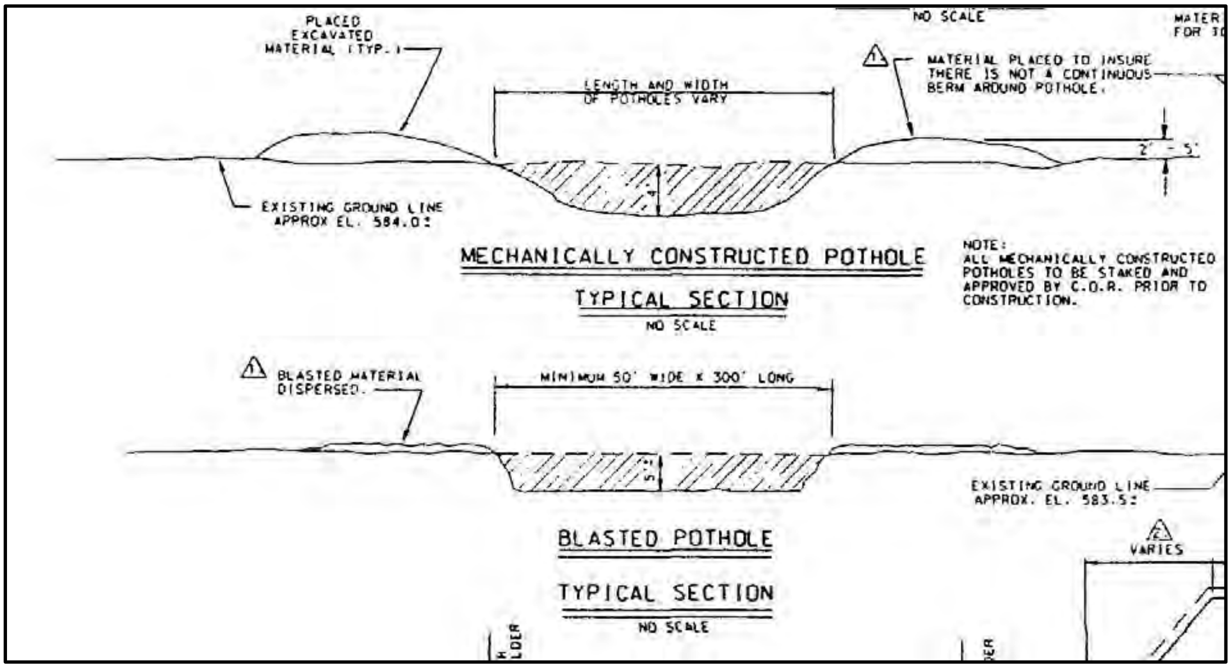


Figure 8-5. Mechanically Constructed Depressional Wetland ("Pothole") Cross Section, Potters Marsh (USACE 1997)

b. Cottonwood Island HREP. Cottonwood Island is located in Pool 21 of the Rock Island District (figure 8-6). Two 1-acre depressional wetlands, one 0.75-acre, and two 0.5-acre depressional wetlands were mechanically excavated to increase food, shelter, and breeding habitat for wildlife (USACE 1996). These are larger depressional wetlands and feature a 20-foot bottom width and final elevation approximately 3 feet below flat pool. The sides of the depressional wetland were terraced. Each terrace was approximately 10 feet wide with a 1-foot rise. The transition slop was 3H:1V. The depressional wetlands filled with water and have been used by deer, herons, amphibians, and fish; however, waterfowl use was not initially observed (USACE 2001).

During a site visit to the Cottonwood Island HREP project site on May 8, 2012, Corps personnel observed a constructed, depressional wetland (photograph 8-1) which is working as designed.

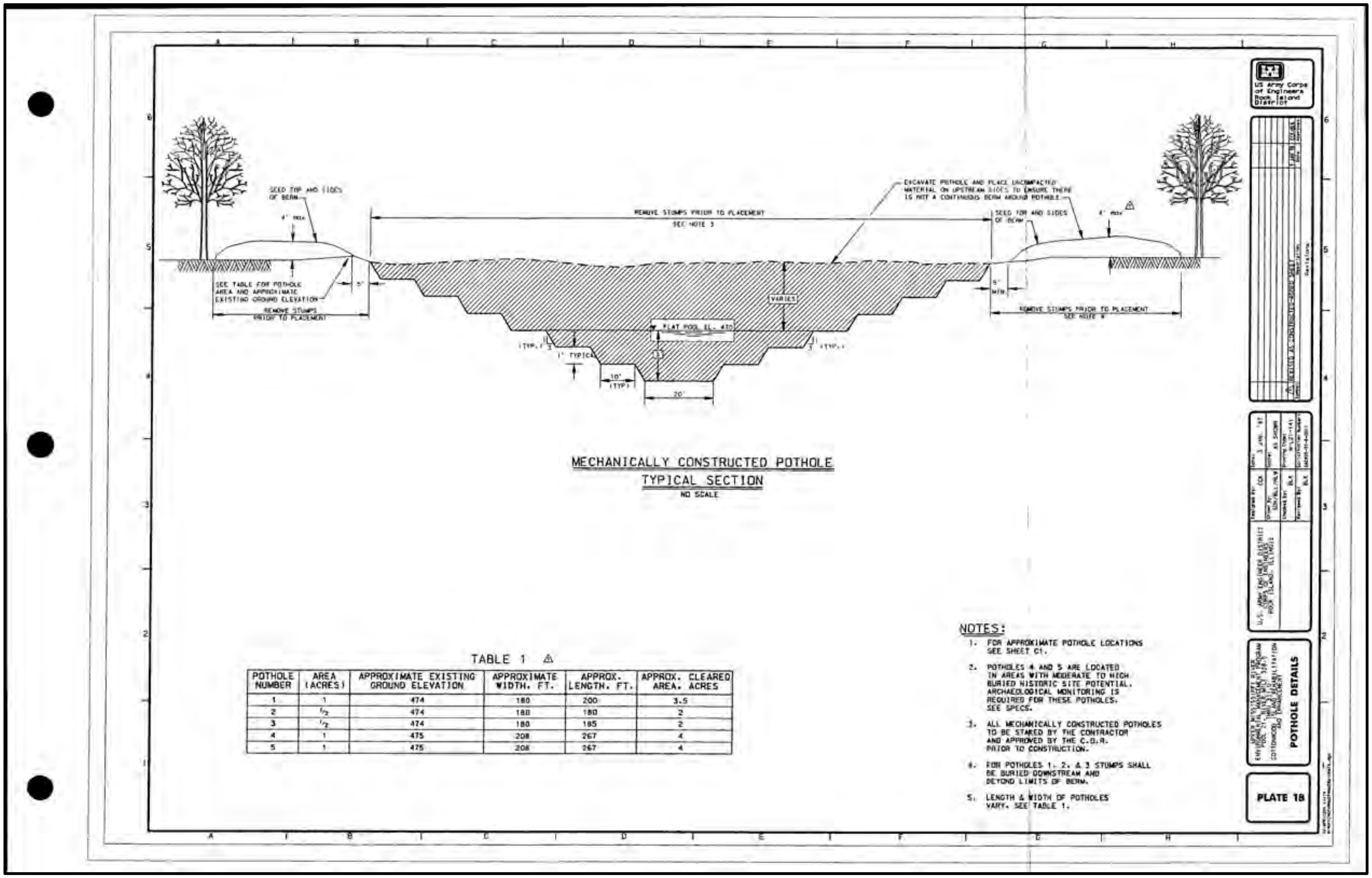


TABLE 1

POTHOLE NUMBER	AREA (ACRES)	APPROXIMATE EXISTING GROUND ELEVATION	APPROXIMATE WIDTH, FT.	APPROX. LENGTH, FT.	APPROX. CLEARED AREA, ACRES
1	1	474	180	200	3.5
2	1/2	474	180	180	2
3	1/2	474	180	185	2
4	1	475	208	267	4
5	1	475	208	267	4

Figure 8-6. Mechanically Constructed Depressional Wetland Cross-Section, Cottonwood Island HREP (USACE 2001)

Photograph 8-1. Cottonwood Island HREP Constructed, Depressional Wetland

c. Big Timber Refuge HREP. Big Timber Refuge is located in Pool 21 in the Rock Island District. Ten depressional wetlands (0.03 to 0.08 in size) were created in mudflats using explosives to provide isolated resting, feeding and brooding areas for migratory waterfowl (figure 8-7; USACE 1989). The depressional wetlands have seen great response from invertebrates, amphibians, and small fish, and well as predators; however with presence of predators these potholes have had limited use as feeding and brooding habitat for waterfowl (USACE 1995).

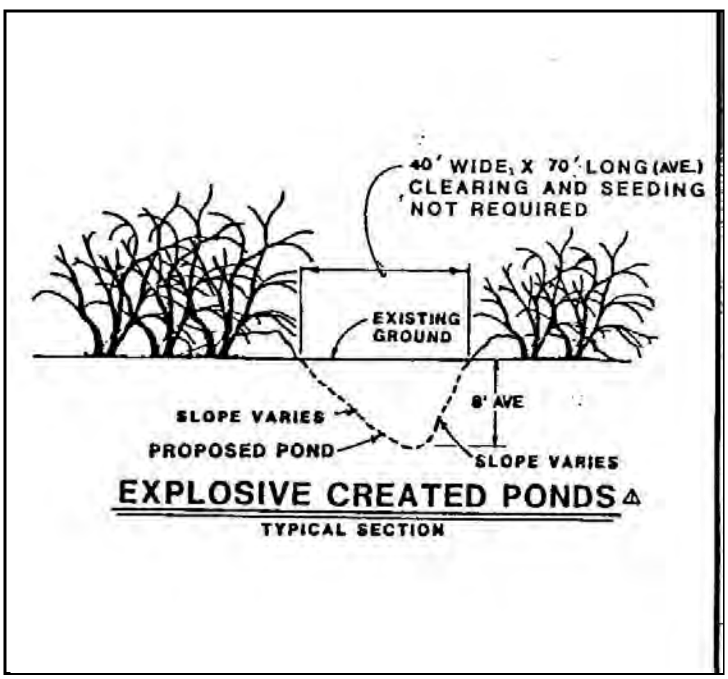
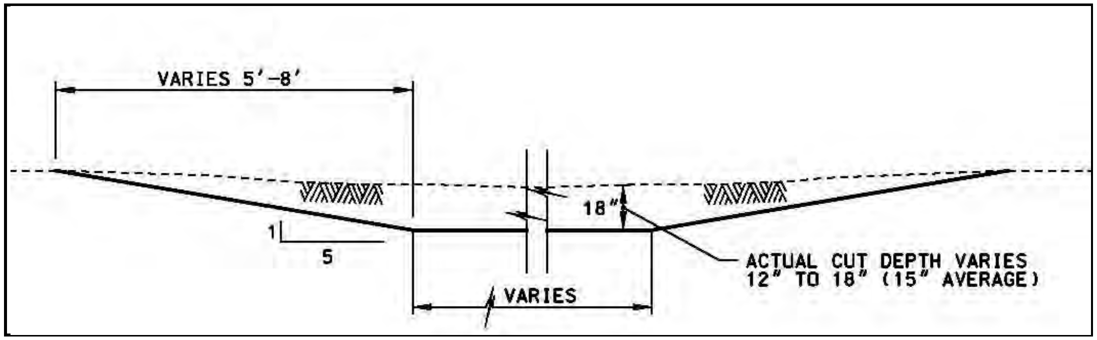


Figure 8-7. Explosive Created Depressional Wetland From Big Timber Refuge HREP (USACE 1989)

d. Lake Odessa HREP. Depressional wetlands, or ephemeral wetland, were mechanically constructed to address concerns with snake habitat loss during the enhancement of levees within the project. The project is still under construction as of May 2012, but according to the project sponsors, these wetlands are being used by various snakes and other reptile and amphibians. The design for this feature is shown in photograph 8-2 and figure 8-8.

Photograph 8-2. Depressional Wetland Constructed at Lake Odessa
Photo Courtesy of Andy Robbins, IA DNR, May 2012.



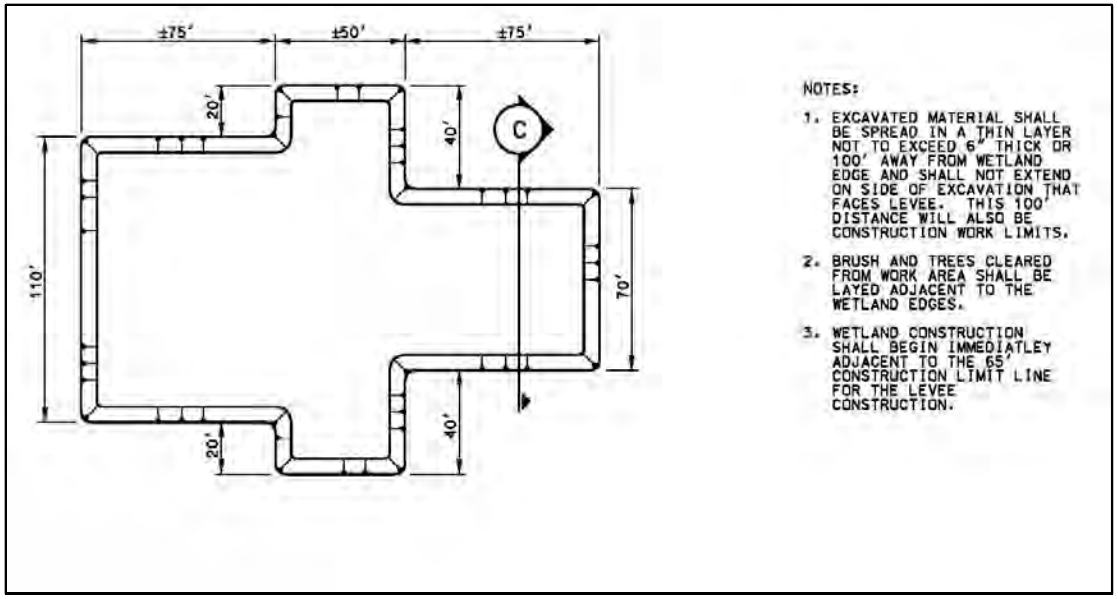


Figure 8-8. Typical Depressional Wetland Plan Used at the Lake Odessa HREP

E. REFORESTATION

The majority of forested land in the Upper Mississippi River (UMR) basin occurs in Minnesota and Wisconsin as well as southwestern Illinois and southeastern Missouri associated with river floodplains. Logging, agriculture, urban development, alterations in hydrological regimes, levees, and river impoundment have resulted in the present floodplain landscape. These changes have adversely affected tree growth on the floodplain, increasing mortality in the less flood tolerant species (e.g., pin oak), and has caused successional shifts in the remnant forest composition to species which are more flood tolerant (Johnson et al. 1974).

Today's UMRS forests represent only a small fraction of pre-European settlement floodplain forest. Seventy to ninety percent of forested floodplain habitats have been lost (Grossman et al. 2003) with the only contiguous forest cover being confined to a relatively narrow strip on the riverward side of agricultural levees (USACE 2004a). Additionally, levees have provided protection for some places to sustain hard-mast species (i.e., nut-producing trees) while other areas hold water longer killing trees. Figure 8-9 illustrates the loss of forest near Cape Girardeau, Missouri.

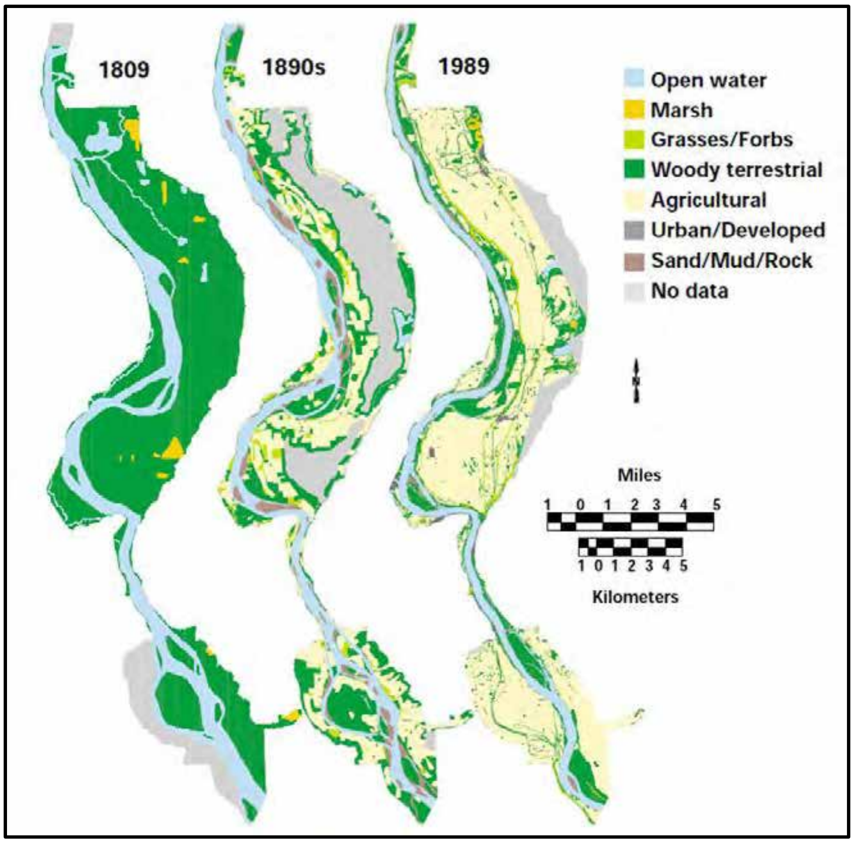


Figure 8-9. Loss of Forested Communities From 1809 to 1989 Near Cape Girardeau, MO (USGS 1999)

The Hydrogeomorphic (HGM) Classification System developed and used by Heitmeyer (2008) for the Middle Mississippi River Regional Corridor study uses hydrogeomorphic data for habitat classifications, including forest types. Forested HGM forest types are riverfront forest, floodplain forest, bottomland hardwood forest, and slope forest (table 8-1).

Table 8-1. HGM Forest Classifications (Heitmeyer 2008)

Forest Type	Location	Soils	Flood Frequency	Dominant Species
Riverfront Forest	Chute & bar surfaces; edges of abandoned channels	Well-drained sands, sandy loams, & silt loams	< 1 year in swales; 1-2 years on ridges	Early successional species: willow & silver maple
Floodplain Forest	Point bar surfaces; along tributaries	Mixed silt loams; ridge & swale topography	1-2 years on swales; 2-5 years on ridges	Successional transition: elm, ash, sweetgum, sugarberry, & box elder
Bottomland Hardwood Forest	Between floodplain forest & bluff	Silty clays	2-5 years	Varies by elevation; from bald cypress-tupelo swamps in low lying areas to oaks and hickories in highest elevations
Slope Forest	Alluvial fans and higher terraces	Erosional sources &alluvium	Rarely	Diverse mix of species common to upland and floodplain communities.

1. Design Methodology. The Corps employs foresters who are responsible for maintaining forested lands owned by the Corps. The following design methods provide a summary of some of the techniques used during reforestation; however, during the planning process the PDT should consult the foresters. Additionally, a set of modeling tools are available to assist in selecting sites, tree species, and tree sizes for successful reforestation. These flood potential models for the Upper Mississippi and Lower Illinois Rivers are available from USGS at http://www.umesc.usgs.gov/reports_publications/psrs/psr_2001_01.html. Additional resources on reforestation techniques and practices include:

- Schweitzer, Callie J.; Stanturf, John A.; Shepard, James P.; Wilkins, Timothy M.; Portwood, C. Jeffery; Dorris, Lamar C., Jr. 1997. Large-scale comparison of reforestation techniques commonly used in the lower Mississippi alluvial valley: first year results. In: Pallardy, Stephen G.; Cecich, Robert A.; Garrett, H. Gene; Johnson, Paul S., eds. Proceedings of the 11th Central Hardwood Forest Conference; Gen. Tech. Rep. NC-188. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 313-320.
- Allen, J.A.; Keeland, B.D.; Stanturf, John A.; Clewell, A.F.; Kennedy, Harvey E.. Jr. 2001. A Guide to Bottomland Hardwood Restoration. Gen. Tech. Rep. SRS-40. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 142 p.\
- Stanturf, J.A., S.H. Schoenholtz, C.J. Schweitzer, J.P. Shepard. 2001. Achieving restoration success: Myths in bottomland hardwood forests. Restoration Ecology. 9(2): 188-200.

Many states in the UMR basin have published forestry best management practices, which provide technical guidelines for implementing forestry practices while protecting forest, soil, and water resources. Links to published forestry best management practices for the five UMRS states are listed below:

- Illinois (IDNR 2000): http://web.extension.illinois.edu/forestry/publications/index.html
- Iowa (IDNR 2004): http://www.iowadnr.gov/forestry/bmps.html
- Minnesota (MFRC 2005): http://www.frc.state.mn.us/initiatives_sitelevel_management.html
- Missouri (MDC 2005): http://mdc4.mdc.mo.gov/Documents/441.pdf
- Wisconsin (WDNR 1995): http://www.dnr.wi.gov/forestry/Usesof/bmp/

The Corps' forest management program has focused on planting larger stock trees to enhance survivability. The annual flood pulse of the Mississippi River often will kill up to 75 percent or more of seedling plantings. Mowing and herbicide can be applied to plantings, but equipment access can be limited.

Reforestation requires an understanding of individual site quality (e.g., soils, water regime, and elevation) and species requirements. During the planning the following need to be taken account 1) species intolerance to flood regimes, 2) light requirements and availability, 3) herbivory, 4) poor seedling quality or seed, and 5) species-species interactions (Henderson et al. 2009). Misunderstandings have the potential to lead to large-scale planting failure.

a. Containerized and Root Production Method®. The RPM® or container grown technique creates large seedlings that may be more conducive to surviving the potentially harsh conditions found on the floodplain. These seedlings have dense fibrous roots (photograph 8-3), and studies have shown that these seedlings have larger initial basal diameter, greater height and survival rates, and produce acorns faster as compared to bare root seedlings, (Lovelace 2002; Dey et al. 2004). However, a study conducted by the Henderson et al. (2009) found no difference in survival between bare root seedlings and RPM®, and relative growth rate of RPM® seedlings was lower than bare root which suggests that even though the seedlings have a head start in terms basal diameter, they do not necessarily grow at significantly higher rates. Cost of RMP® trees is higher, but they are larger trees which can be planted at a wider spacing, potentially saving on overall costs. Consultation with foresters is recommended when selecting planting stock method for a proposed project.

Photograph 8-3. RPM® Root Mass (Left) Compared to Bare Root Mass (Right) (FK Nursery Library, 2012)

b. Soil Mounding . Soil mounding creates small differences in elevation altering the site suitability for tree seedling establishment and growth (Schoenholtz et al. 2005) by improving drainage and increasing the overall height above flood water levels for species less tolerant of flooding (Dey et al. 2008). However, this technique of "soil mounding" has also been shown not to improve tree height, diameter growth, or survivability (as compared to unmounded; Dey et al. 2004; Dey et al. 2008; Henderson et al. 2009).

The soil properties play an important role in determining if soil mounding is needed. Soils that are loamy and fairly well drained may not need mounding (Dey et al. 2004). In the St. Paul District, based on a 2003 survey, the average minimum elevation above mean pool elevation where swamp white oak occurs is 2.17 feet, and for black oak is 3.01 feet. These values provide a rough guideline on appropriate elevations for these species to succeed in this latitude.

c. Tree Species. Selection of trees species is dependent on site conditions (e.g., elevation, flood frequency, and soils). The hard-mast species planted (depending on latitude) may include Bur Oak, Swamp White Oak, Pin Oak, Northern Pecan, Shellbark Hickory, and to a limited extent, Walnut and Northern Red Oak . Other species found on the floodplain include Persimmon, Hackberry, and Green Hawthorne. Other trees with "winged fruit or light-seeded" (Ash, Box Elder, Cottonwood, Silver Maple and/or Sycamore) could invade creating a diverse forest community. Stanturf et al. (2000) suggested wind and flood dispersal of light-seeded species might occur up to 100 m from established sources.

d. Seed Source. It is recommended to collect seeds within a one hundred-mile radius of the planting site, adapted to local weather conditions and flood frequency. It is not recommended to use a seed source from an upland site (USACE, 2012).

e. Competition. Competition from herbaceous plant species may be problematic for planted tree seedlings. Various techniques can be used to reduce competition. Techniques may include placement of degradable ground cover mats or use of herbicides. Ground mats are exclusively used with RPM® stock seedlings, and should not be used with bare root seedlings. Ground cover mats have been used in the past to reduce competition. However, Missouri Department of Conservation has observed that ground cover mats do not work well in areas that flood due to the floodwaters stripping the mats or that mats become entangled and potentially strangling the seedling. Additionally, the Corps foresters are moving away from the use of ground mats due to their ineffectiveness. The Corps foresters recommend the use of herbicides during early tree establishment, but use may be limited by flooding durations. Herbicides can be used with both RPM® and bare root seedlings.

Fertilization after tree seedling establishment would increase survival and enhance growth (USACE, 2012). There is potential for invasive species like reed canary grass to out-compete tree seedlings and form dense monocultures inhibiting tree growth. Active management of reed canary grass may be necessary to increase tree planting success.

f. Herbivory. Herbivory by deer and small mammals poses an additional threat for natural and artificial tree regeneration. Deer browsing can be a primary source of tree seedling mortality. The use of protective measures such as stem guards, ground mats, fencing, tree shelters, and other types of exclosures can limit browse damage in tree plantings. However, voles and other burrowing animals tend to hide in ground cover mats for cover and then their predators ruin the mats trying to get to their prey. This ruins the ground cover mats and any protection they may have initially provided. Tree shelters can be used to protect the seedlings if deer damage is expected to be severe. Tree shelters come in various heights. Four to five foot tubes are good for areas with high deer damage, while shorter tubes (2-3 feet) may be adequate for protection from other animal damage (girdling of lower stems and/or roots from voles and other rodents). Tree wrap and rodent repellants are other options that could be used to reduce herbivory. According to Corps foresters, certain types of tree wraps can be detrimental to long-term tree health by trapping sediment around the base which reduces the basal oxygen exchange. Therefore use of tree wraps should based on site-specific conditions. Rodent repellants must be re-applied every time it rains, leading to increase costs and labor.

2. Lessons Learned

- Tree mortality along the UMR has been positively correlated with flood duration and amplitude. After the 1993 flood, some areas near St. Louis, Missouri experienced between 80 to 100 percent mortality of seedlings. Flood tolerance of trees is species specific therefore in sites that have a high flood potential planting more flood tolerant species is recommended.

- In the St. Paul District, tree plantings have been successfully established in both the spring (mid-April to mid-June) and fall (mid-October to mid-November). Seedling availability from nurseries is usually better in the spring.
- Tree plantings need weed control for a minimum of three years. Ground cover mats are no longer recommended for use. Use of herbicides is needed during early tree establishment.
- Tree shelters require regular maintenance. Environmental factors can damage them. Other vegetation can grow up inside the tube and choke out the tree seedling. Additionally, in low elevation, tree shelters may collect significant amounts of sediment during flood events, potentially causing seedling mortality. Tree shelters should be avoided where prescribed fires is to be used within five years of project completion. Tree shelters must be properly installed so as not to leave a gap at the base of the tree for rodents to enter.
- If possible, avoid row planting of tree seedlings to make the site look more natural and improve aesthetics. Missouri Department of Conservation suggests randomly planting seedlings or plating them at 45 degree angles from the river so that rows are not as evident.
- Quality assurance is very important during contract planting operations to ensure seedling survival and success. Among the critical items to check for is how well the planting stock was protected during storage and handled during planting. The sensitive roots of seedlings must be kept cool, moist, and out of the wind and sun from the moment they are lifted out of the nursery bed until they are covered with soil in the transplant location.
- Quality assurance is also very important in verifying the source of planting materials.
- Fine sediments with a high percentage of clay may be more difficult to establish trees on. This is especially true if there is significant compaction from heavy equipment during construction. One potential solution is the use of power augers during tree plantings to loosen the soil in the planting hole.
- When planting containerized trees in high clay content (>60 percent) hydric soils berms should be used. When a depression is created in these soils (planting a container tree) and a rainfall event occurs water accumulates in these depressional areas and creates a small pond in which the roots are submerged for extended periods of time thus effectively reducing root growth due to the lack of available oxygen. When planting the same container tree in a berm you actually set the container on top of the surface and surround it with soil thus providing more air to the roots more quickly after a flood or rainfall event.
- Do not plant hard mast trees where soil hydrology and pH has to be altered. Hard mast trees grow on well-developed alluvial soils and pioneering tree species (soft mast) colonize newly-developed alluvial soils (near riverfronts and areas of high sediment deposition).
- Hard mast trees colonize elevated areas with herbaceous understory (i.e., grass) in large river floodplains.
- Levees along the Lock and Dams have altered the soil hydrology changing the pH of floodplain soils, which ultimately affect which tree species can be planted.

3. Case Studies

a. Bay Island HREP. Bay Island is located in Pool 22 between RM 311.0 and 312.0 in the Rock Island District. The Bay Island project was constructed to provide high quality, dependable wetland habitat for migratory waterfowl. Water level management capabilities were achieved through constructing a levee system, pump station, and water control structures. Approximately 30 acres within the two created wetland management units were planted with mast trees (figure 8-10).

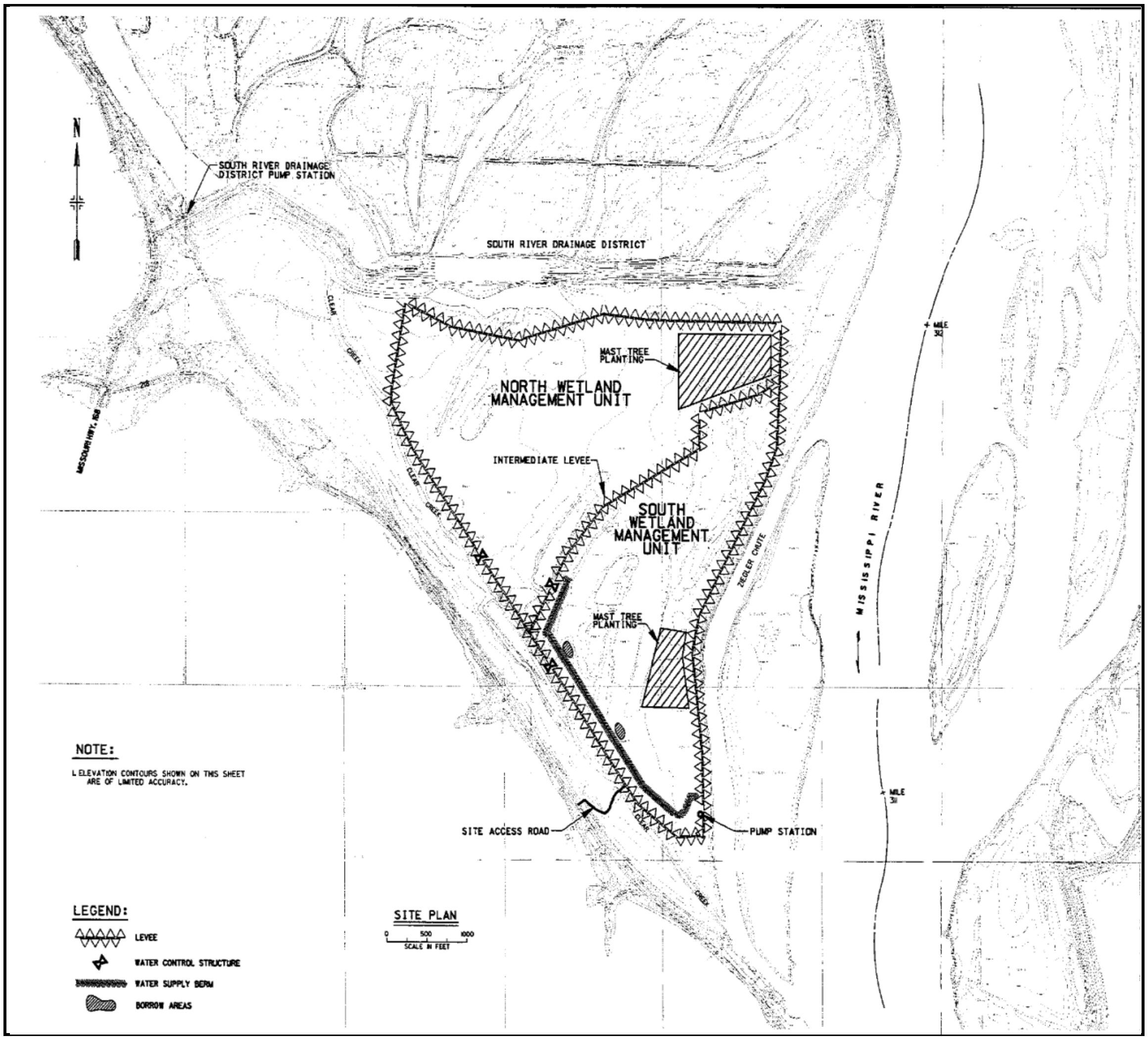


Figure 8-10. Location of Tree Plantings for the Bay Island HREP (USACE 1999a)

In 1994, pin oaks were planted in a unique design to test alternative methods for establishment of mast trees on Mississippi River bottomland sites. Four planting techniques were tested: (1) planting container-grown tree stock; (2) planting bare-root tree seedlings with tree shelter protection; (3) planting bare-root seedlings without shelter; and (4) planting acorns. Immediately after tree planting was complete, 1/100 hectare permanent monitoring plots were established within each reforestation area. The permanent sampling plots were recovered and remeasured in October 1995.

The first year results (1995) showed that even with an overtopping flood, by October 1995, overall survival of the 450 container grown trees planted on the 4-acre plots was 99.3 percent. Acorn survival from sample plots was 45.7 percent, yielding 944 seedlings per hectare. Survival of bare-root seedlings, both sheltered and non-sheltered, was 84.2 percent with 978 trees per hectare. Due to the flood, most of the tree shelters (63 percent of the sheltered trees) were washed away. Trees that initially had shelters for the first 6 months and then had the shelters washed away by flood waters had only 70.3 percent survival rate (USACE 1999a). The initial performance evaluation report recommended pursuing more mast tree plantings that consist of container-grown or balled and burlapped trees. If seedlings or acorns are used, the layout should be coordinated with the local sponsor who will be maintaining the site to ensure that trees are clearly marked and appropriately spaced for the mowing equipment to be used at the site (USACE 1999a).

By 2002, flooding events hampered overall success of mast-tree plantings (USACE 2002a). Only about a dozen trees were still growing from the original plantings that included approximately 7,500 acorns and seedlings in a 10-acre area. In 2000, the Missouri Department of Conservation planted new trees to do a direct comparison between RPM® and bare-root trees. Tree berms in the south wetland management unit were planted with RPM® trees, alongside 100 two-year old bare root stock seedlings (USACE 2002a).

b. Thompson Bend Riparian Corridor Project. The Thompson Bend Riparian Corridor Project is located between Mississippi River RM 30.to 5.0 in the St. Louis District. In this stretch of the Mississippi River flows in a broad sweeping reverse curve just above the confluence with the Ohio River (figure 8-11). This area has been susceptible to severe flooding and there is high risk that the Mississippi River will create a channel cut-off and form a new, shorter, steeper, high velocity channel with resultant changes upstream and downstream. In the early 1980s, the Corps and an organization of local landowners developed a plan using traditional (e.g., riprap) and innovative measures to minimize scour and erosion. The innovative design included successive lines of vegetative perpendicular to the flow-line across the neck of the curve and in, January 1986, began plantings of different species of trees and shrubs that eventually totaled over 125 acres (on private lands). The theory was flood velocities would decrease at each successive tree line, thus limiting scour and erosion and encouraging deposition. The Flood of 1993, however, destroyed much of the project. Trees 60 to 70 feet tall were bent over and completely submerged for months. The trees died but remained rooted in place preventing erosion. Even though damage occurred, the estimate following this flood was more net gain of soil due to deposition than loss due to scour. Flow measurements showed velocities were decreased by almost half by each successive tree line. The Corps purchased easements from landowners to restore and enhance the destroyed tree lines and is responsible for both planting and initial maintenance of the trees.

In 2011, continued plantings occurred using a mix of cottonwood, sycamore, and overcup oak. Pre-tree planting efforts included summer mowing, herbiciding, and planting a cover crop of redtop (*Agrostis gigantean*), Virginia wild rye (*Elymus virginicus*), and partridge pea (*Chamaecrista fasiculata)*. In the fall, bareroot sycamore seedlings (n = 5,101) and cottonwood cuttings (n = 5,101) on 10 x 10 foot staggered spacing were planted. Overcup oak seedlings (n = 1,134) were interplanted throughout the area to obtain an even distribution. Total planting area was 26 acres. In 2012, follow-up application of a pre-emergent/post-emergent herbicide will occur within tree rows.

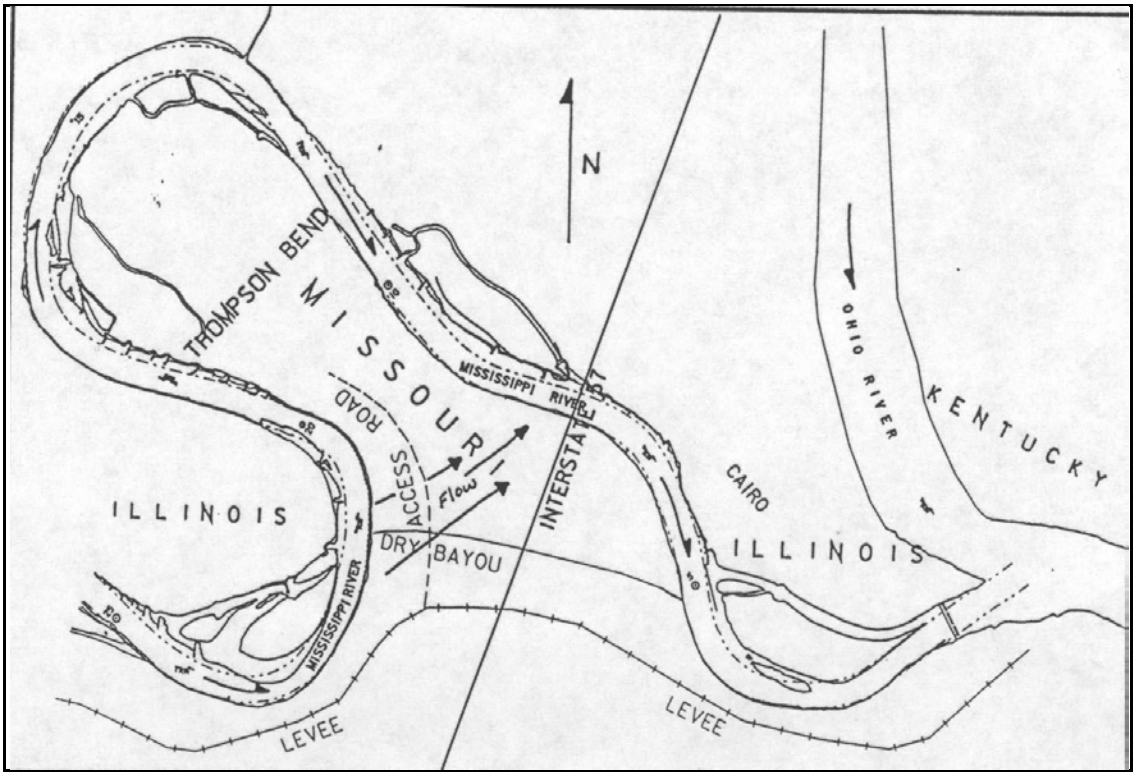


Figure 8-11. Thompson Bend Riparian Corridor Project Location.

c. Brown's Lake. Brown's Lake is located in Pool 13 in the Rock Island District between RMs 544.0 and 546.0. One feature of this project involved placement of dredged material into a terrestrial site to depths of 6 to 8 feet and re-planting with mast production trees. One of the project goals was to establish bottomland hardwood.

In May, 1990 a 150 foot wide strip immediately adjacent to the upstream dredge material containment levee was direct seeded with pin oak acorns. Approximately 25,000 acorns were dropped by helicopter onto this 150 foot wide strip. On May 20, 1991 a strip survey of this area was conducted by the Corps. Strips three feet wide and fifteen feet apart were surveyed for pin oak seedlings. Based on this survey it is estimated that 1200 pin oak seedlings were growing on the site at this time. The pin oak seeding immediately adjacent to the upstream containment levee was somewhat successful. Approximately 5 percent of the acorns dropped produced seedlings after the first year.

These seedlings have since died from extended inundation in 1992 and 1993. This site was re-planted with mast producing hardwoods in June 1992. No planting of trees within the placement site was successful before this time due to consolidation and drainage problems. Future projects which consider dredged material placement sites for reforestation should include design of a drainage system for the placement site.

In addition to the objective of increasing bottomland hardwood diversity this project has the secondary objective of developing valuable data regarding the planting of mast production trees on dredged material deposits. Iowa State University has been contracted to plant the trees and monitor their survival with the following objectives in mind:

- evaluate species suitability based on growth survival,
- evaluate the use of nurse crop species on early growth survival of trees,
- evaluate the use of different kinds of seedling stock types on early growth and survival of trees, and
- evaluate the use of applications of sewage sludge and fertilizer on early growth and survival of trees

Only species native to the region were selected for planting. Species known for their value as wildlife food were given priority for planting. Two kinds of plots have been established on the study site. The first consists of smaller 16-tree plots that will test the suitability of 13 different mast producing species for planting on this site. The second kind of plot is large and in total covers most of the area. These plots were planted with 3 mast-producing species (Black Walnut or Shellbark Hickory, Red Oak and Bur Oak). Nested within these plots are subplots to test the use of sludge as an organic amendment, the use of nurse crops to control competition, and the use of fertilizer to increase growth rates.

Conclusions. The technique of aerial pin oak seeding immediately adjacent to the upstream containment levee was somewhat successful. While creation of the dredged material containment area did succeed in raising the elevation of the placement site, much of this area remains too poorly drained to be suitable for regeneration of mast-producing tree species. Mast trees planted as part of the ISU revegetation study are growing on sites in the containment area that are relatively higher in elevation and better drained than the surrounding ground. This mast tree component currently occupies only a small percentage of the replanted area. Persistent poor drainage in much of the containment area limits the likelihood that further active mast tree revegetation efforts would be successful. Natural revegetation of the area by wet-soil adapted tree species such as willow and cottonwood appears to be underway. Over time, further consolidation of the dredged material may provide more favorable conditions for mast tree production. Although some mortality of the mast trees currently established on the site will continue to occur, those that survive to maturity could provide a future seed source for natural mast tree regeneration in the long term.

d. Long Island Division (Gardner Division). Long Island Division is located in Pool 21 in the Rock Island District between RMs 332.5 and 340.2. Two of the project objectives were to; reduce forest fragmentation, and to increase bottomland hardwood diversity. The project area also has one of the last high quality stands of bottomland forest in the middle reaches of the UMR. In order to meet the objectives it was decided to plant 67 acres of mast-producing trees on the dredged material placement site located on Long Island’s eastern agricultural field.

Completion of mast tree planting on the 67 acres of Long Island’s 184-acre eastern agricultural field with the highest elevation was in 2004. This planting area is where the dredge disposal from O’Dell Chute channel dredging was deposited and incorporated into the soil. Trees specified to be planted included 1005 pin oaks, 670 swamp white oaks, 670 bur oaks, 670 northern pecans, and 536 sycamores for a total of 3,551 trees. The trees were planted at 30-foot intervals on berms parallel to O'Dell Chute. The berms were 30 feet apart. All trees were to receive weed barrier mats and the trees were at least 5/8-inch caliper and 5 feet high.

A meeting was held on 12 November 2003 at the reforestation site on Long Island to inspect the mast tree plantings and assess the success and condition of the previous two plantings. The team had concerns about tree survival due to the abundant weed growth. The tree plantings appeared to have good survivability, but were stressed by the amount and height of weeds around them. The tall weeds have the potential to lay over the tree plantings stunting their growth or killing them. It was decided to use herbicide and seeding options to aid in the tree's survival. It was suggested that in future mast tree plantings, that berms be seeded as well as the rows between the berms.

During a later inspection, District foresters felt that the flooding helped manage the weeds around the mast trees and will give the trees a better survival rate. In 2006, Missouri Department of Conservation personnel visited the site and could not find any of the seedlings due to competition. Common ragweed at the time of the visit was approximately 12 feet tall.

The Long Island HREP project site was re-visited on May 8, 2012 by Corps and FWS personnel. The site visited included walking to several areas of planting. Some success of direct planting was noted at the site, with trees planted on lower elevations having a higher success rate. The plastic used to protect the roots and lower trunk of the planted trees has not deteriorated at all in the 8 years since the original planting. The growth of some of the trees has been stunted by the plastic as shown by visible ridges where the plastic cuts in to the trees. Figures 8-12 and 8-13 and photographs 8-4a, 8-4b, 8-4c, and 8-5 illustrate plans and photos for the site.

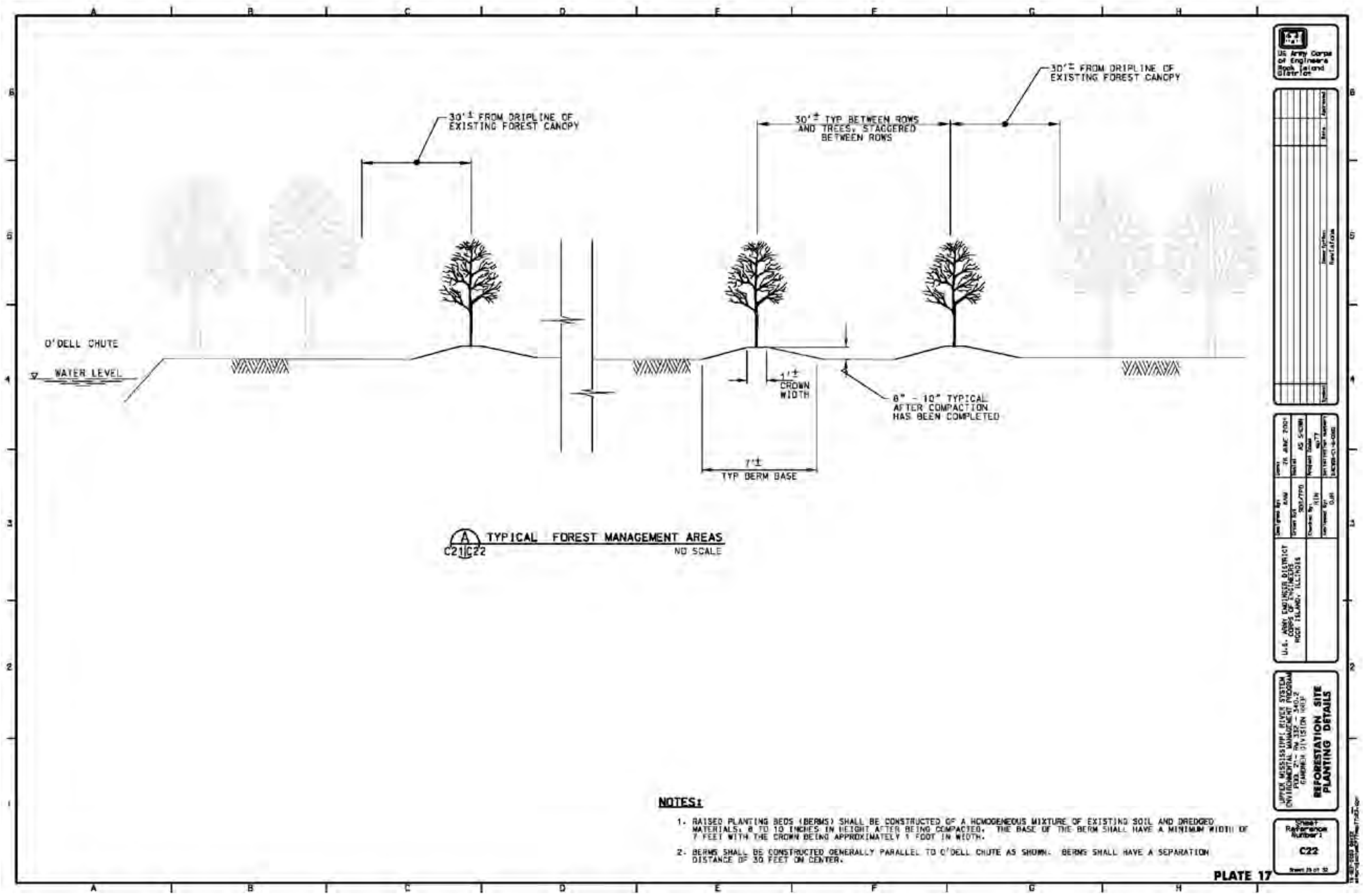
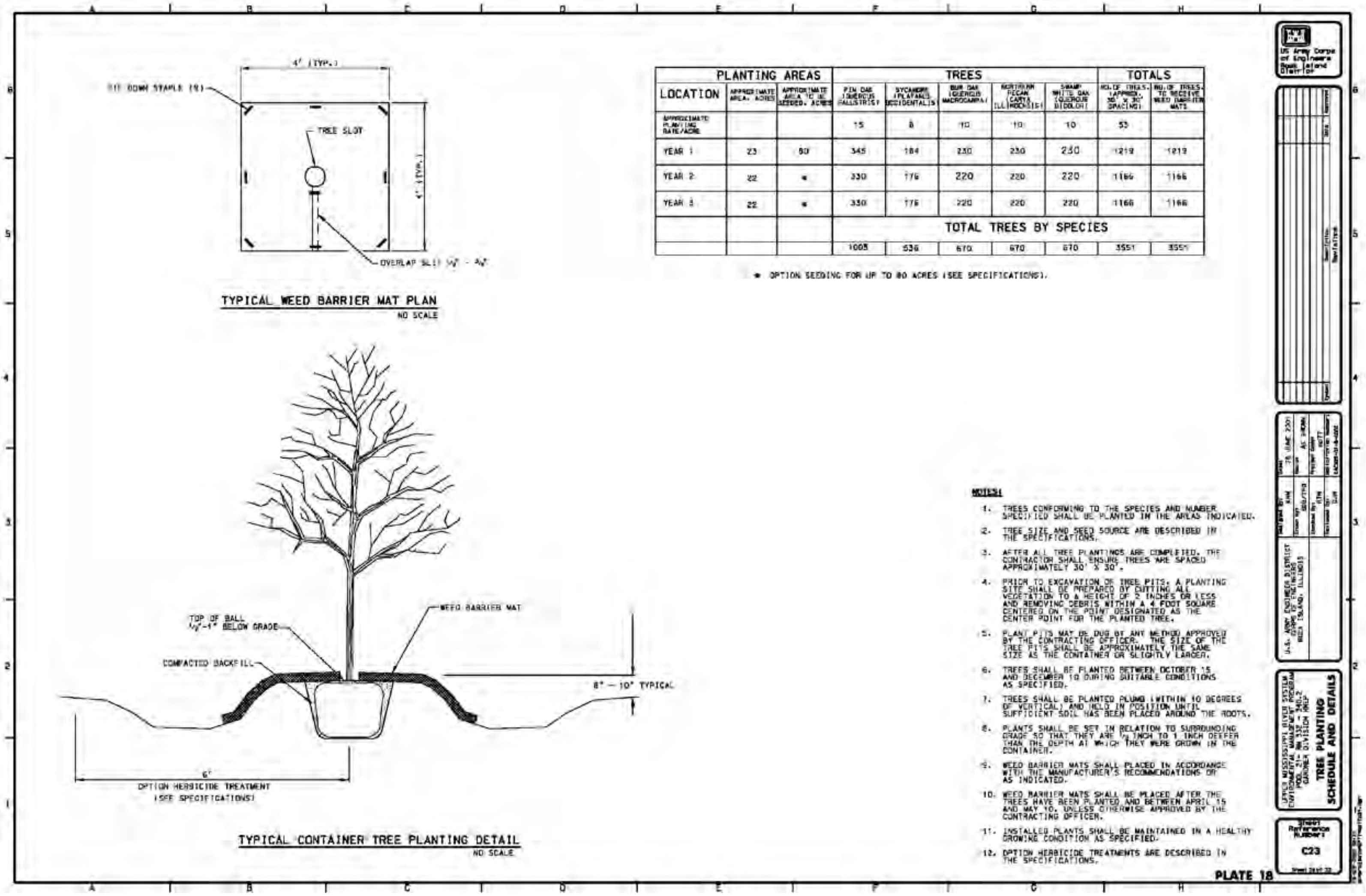


Figure 8-12. Tree Planting Design for the Long Island Gardner Division HREP



PLANTING AREAS			TREES					TOTALS	
LOCATION	APPROXIMATE AREA, ACRES	APPROXIMATE AREA TO BE SEEDED, ACRES	PIN OAK (QUERCUS PALUSTRIS)	SYCAMORE (PLATANUS OCCIDENTALIS)	BUR OAK (QUERCUS MACROCARPA)	NORTHERN PECAN (CARYA ILLINOENSIS)	SWAMP WHITE OAK (QUERCUS BICOLOR)	NO. OF TREES (APPROX. 30' X 30' SPACING)	NO. OF TREES TO RECEIVE WEED BARRIER MATS
APPROXIMATE PLANTING RATE/ACRE			15	8	10	10	10	53	
YEAR 1	23	80	345	184	230	230	230	1219	1219
YEAR 2	22	*	330	176	220	220	220	1166	1166
YEAR 3	22	*	330	176	220	220	220	1166	1166
			TOTAL TREES BY SPECIES						
			1005	536	670	670	670	3551	3551

* OPTION SEEDING FOR UP TO 80 ACRES (SEE SPECIFICATIONS).

NOTES:

1. TREES CONFORMING TO THE SPECIES AND NUMBER SPECIFIED SHALL BE PLANTED IN THE AREAS INDICATED.
2. TREE SIZE AND SEED SOURCE ARE DESCRIBED IN THE SPECIFICATIONS.
3. AFTER ALL TREE PLANTINGS ARE COMPLETED, THE CONTRACTOR SHALL ENSURE TREES ARE SPACED APPROXIMATELY 30' X 30'.
4. PRIOR TO EXCAVATION OF TREE PITS, A PLANTING SITE SHALL BE PREPARED BY CUTTING ALL VEGETATION TO A HEIGHT OF 2 INCHES OR LESS AND REMOVING DEBRIS WITHIN A 4 FOOT SQUARE CENTERED ON THE POINT DESIGNATED AS THE CENTER POINT FOR THE PLANTED TREE.
5. PLANT PITS MAY BE DUG BY ANY METHOD APPROVED BY THE CONTRACTING OFFICER. THE SIZE OF THE TREE PITS SHALL BE APPROXIMATELY THE SAME SIZE AS THE CONTAINER OR SLIGHTLY LARGER.
6. TREES SHALL BE PLANTED BETWEEN OCTOBER 15 AND DECEMBER 10 DURING SUITABLE CONDITIONS AS SPECIFIED.
7. TREES SHALL BE PLANTED PLUMB (WITHIN 10 DEGREES OF VERTICAL) AND HELD IN POSITION UNTIL SUFFICIENT SOIL HAS BEEN PLACED AROUND THE ROOTS.
8. PLANTS SHALL BE SET IN RELATION TO SURROUNDING GRADE SO THAT THEY ARE ½ INCH TO 1 INCH DEEPER THAN THE DEPTH AT WHICH THEY WERE GROWN IN THE CONTAINER.
9. WEED BARRIER MATS SHALL PLACED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS OR AS INDICATED.
10. WEED BARRIER MATS SHALL BE PLACED AFTER THE TREES HAVE BEEN PLANTED AND BETWEEN APRIL 15 AND MAY 10, UNLESS OTHERWISE APPROVED BY THE CONTRACTING OFFICER.
11. INSTALLED PLANTS SHALL BE MAINTAINED IN A HEALTHY GROWING CONDITION AS SPECIFIED.
12. OPTION HERBICIDE TREATMENTS ARE DESCRIBED IN THE SPECIFICATIONS.

Figure 8-13. Tree Planting Design for the Long Island Gardner Division HREP

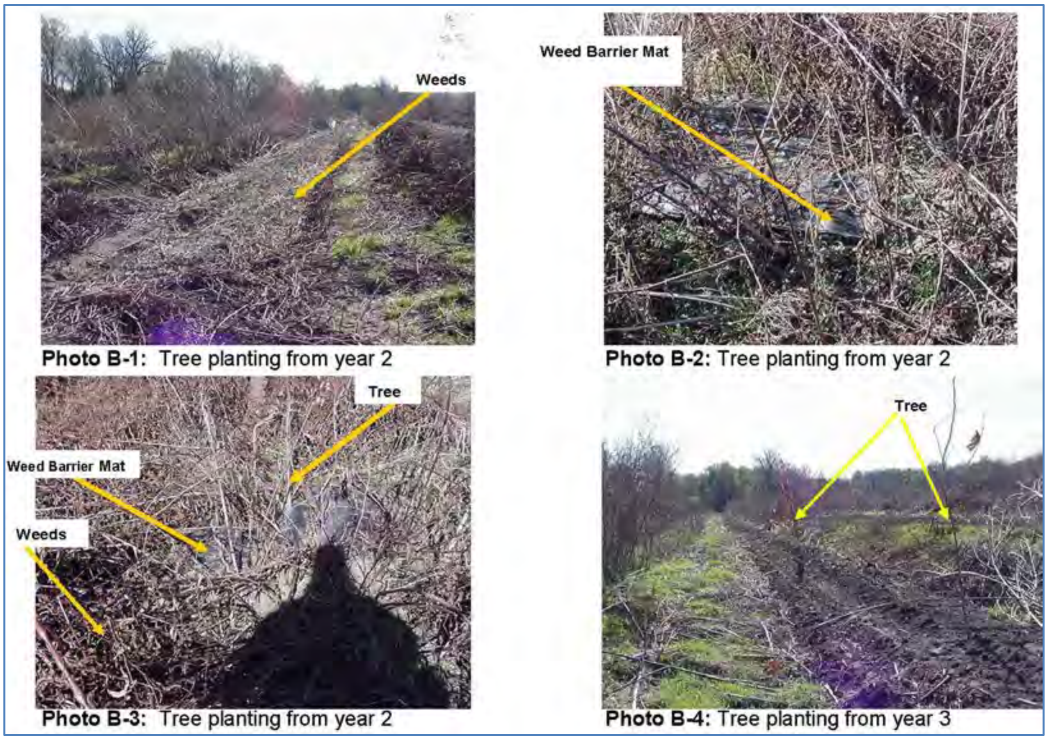


Photo B-1: Tree planting from year 2
Photo B-2: Tree planting from year 2
Photo B-3: Tree planting from year 2
Photo B-4: Tree planting from year 3

8-4a

8-4b

8-4c

Photograph 8-4. Long Island Gardner Division HREP Tree Plantings

Photograph 8-5. Plastic “Burlap” Placed Around Base of Tree

e. Cottonwood Island. Cottonwood Island is located in Pool 21 between RMs 328.5 and 331.0 in the Rock Island District (figures 8-14, 8-15, and 8-16). One of the project objectives was to increase bottomland hardwood diversity and quality. The features used to obtain this objective were the planting and attempted establishment of trees in existing management/crop areas and on elevated ridges. Several sites were been selected for planting throughout the project area. Restoration of a mast-producing tree component to these areas would provide wildlife with an additional winter food source for a period of up to 100 years. Pin oak, swamp white oak, bur oak, pecan, and sycamore would be planted on 30-foot spacing. species would be intermixed at each site to avoid solid blocks of individual species.

Large stock seedlings greater than 4 feet high would be planted to introduce a component of mast-producing trees to the project area. The tree plantings would be spaced and distributed to allow for a natural appearance. This enrichment planting technique differs from a plantation tree culture, where the objective would be to make mast-producing trees the dominant species. Instead, enrichment plantings are designed to introduce a component of mast-producing trees to create a mixed forest stand.

Pin Oak, Sycamore, Bur Oak, Northern Pecan, and Swamp White Oak were planted at designated locations at each planting site. Ground disturbance for mast tree planting occurring on previously harvested forest management areas consisted of cutting and removing all woody vegetation within 6 feet of the center point for the planted tree and then excavating a planting hole 2 feet in depth and 3 feet in diameter. Tree planting operations within the agricultural field involved disking to a depth of 4 inches, this was followed by excavation of planting holes. The forest management areas maintained a natural appearance throughout the establishment process, as only the vegetation directly surrounding the seedling was controlled. On the dredged placement site, soil disturbance for tree planting was limited to the newly placed material only. A cover crop of red top grass and annual grains was to be established in the tree planting sites to help control unwanted weed species. Herbicides were used to control any competing vegetation. After a 3-year establishment period, the surrounding ground in all planting areas was allowed to assume natural regrowth.

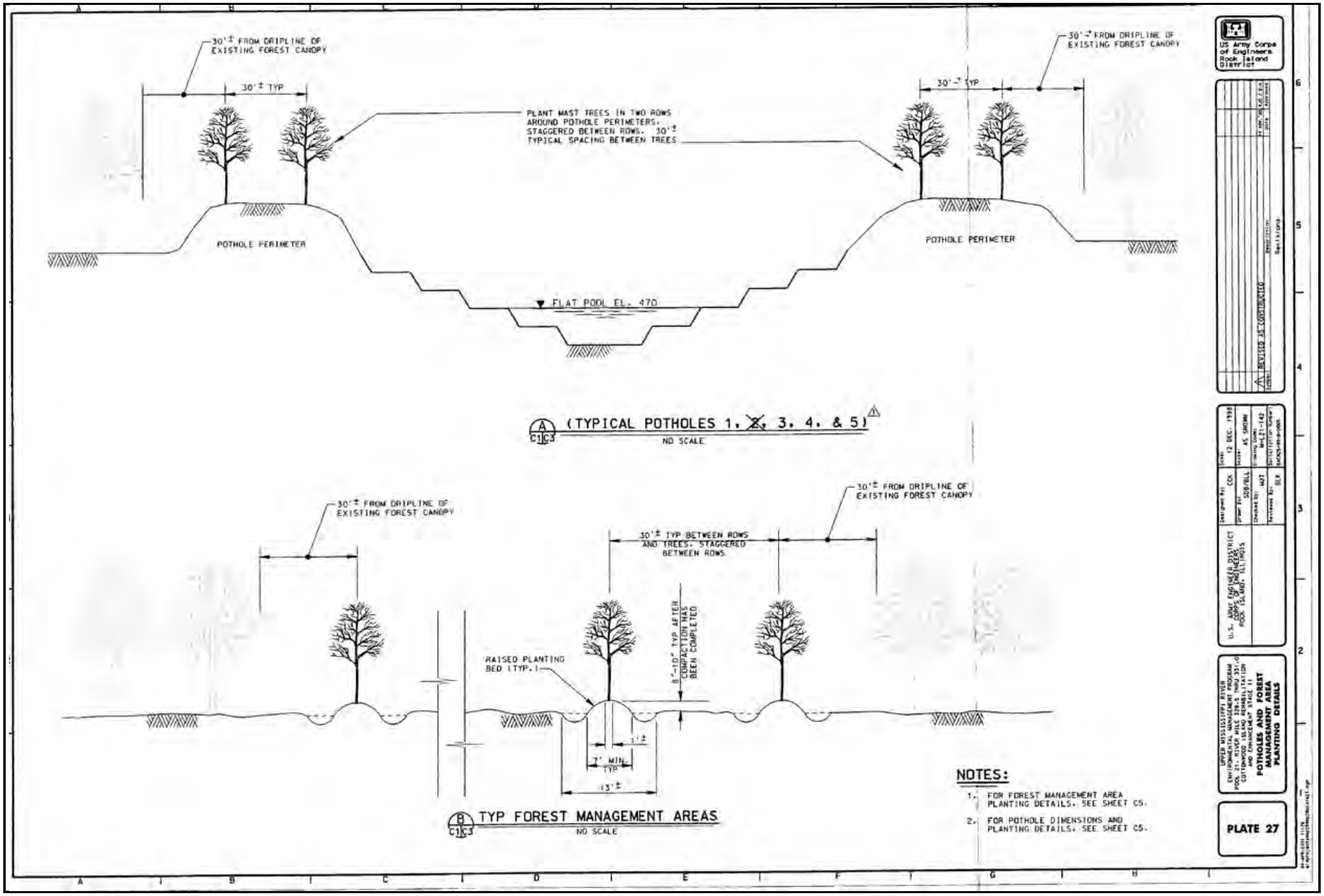


Figure 8-14. Forest Plans for Cottonwood Island

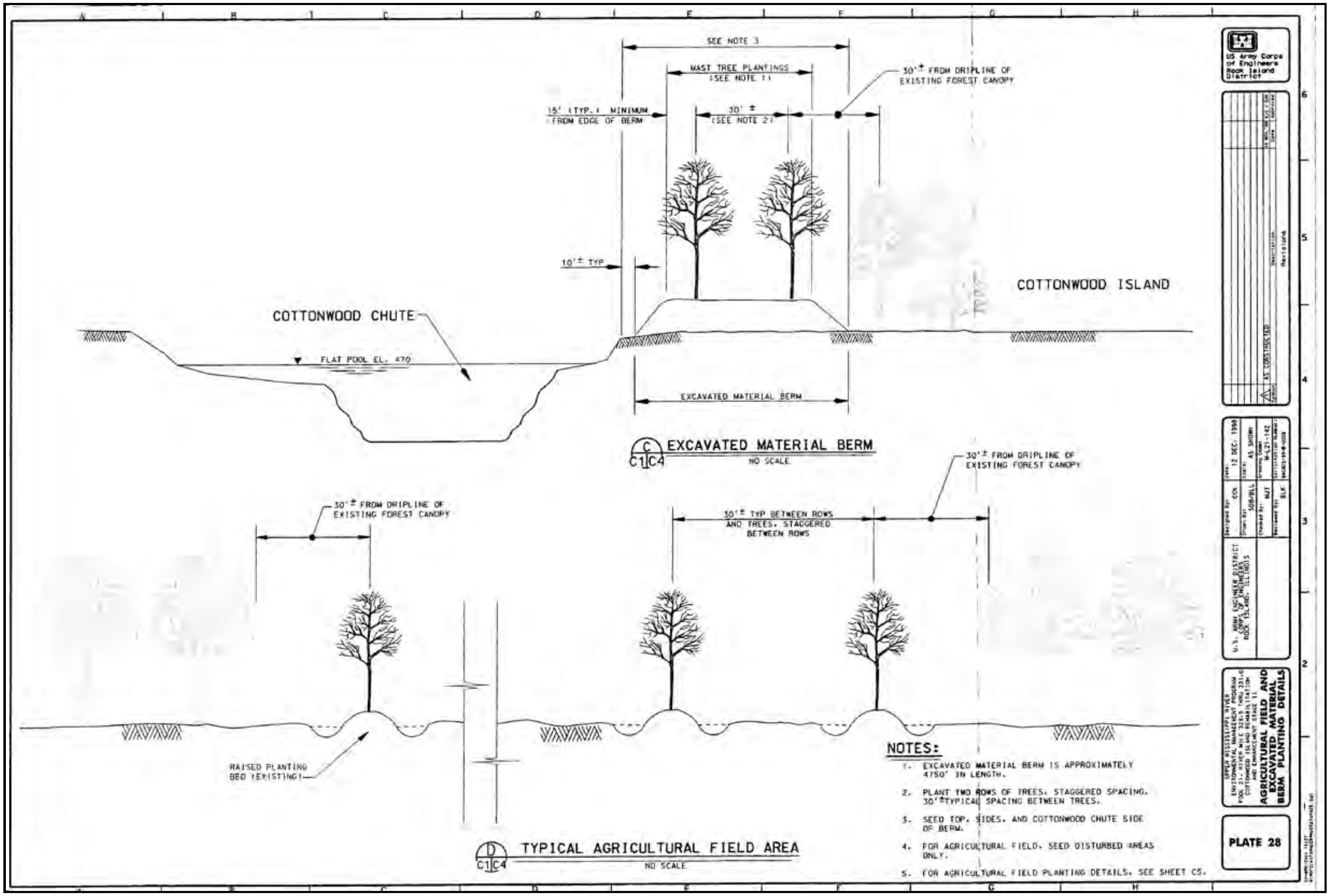
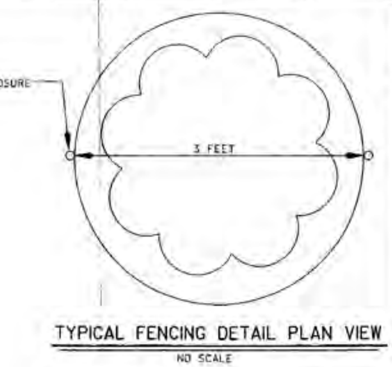
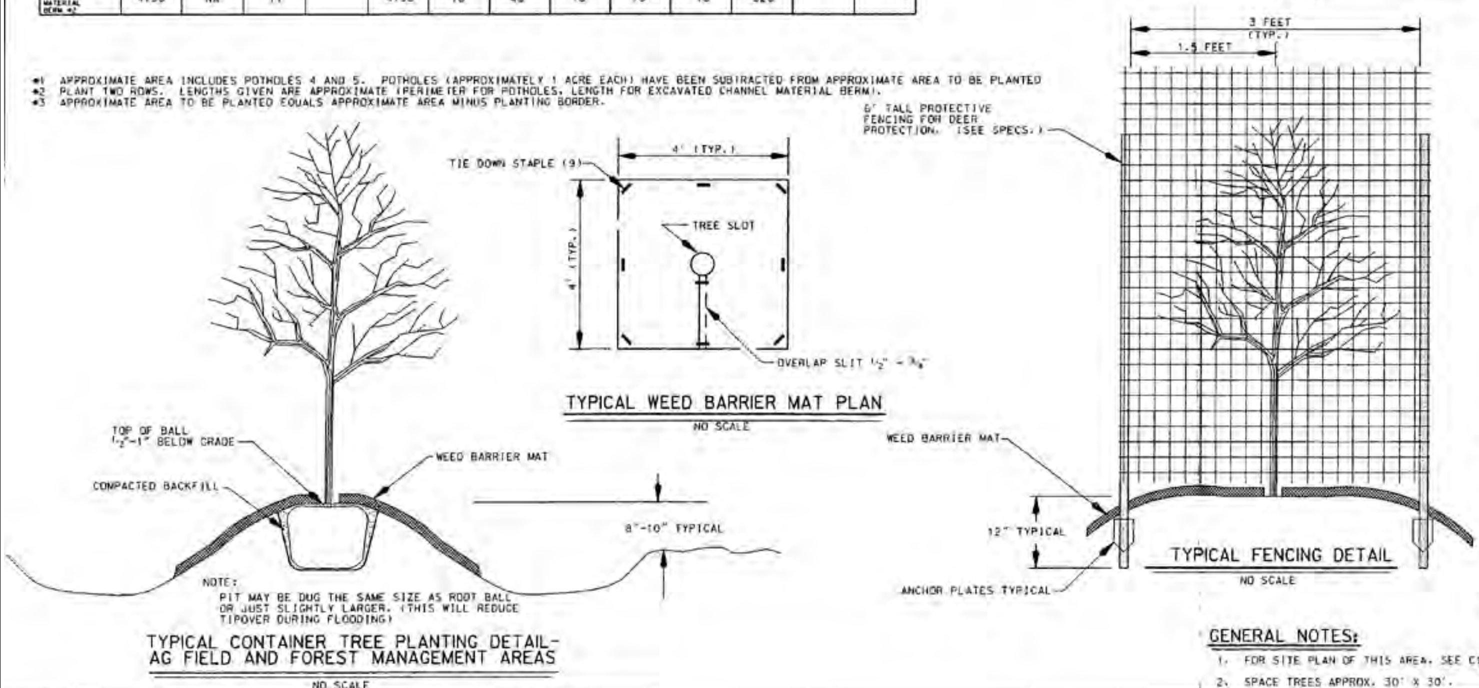


Figure 8-15. Forest Plans for Cottonwood Island

PLANTING AREAS						TREES					TOTALS		
LOCATION	APPROXIMATE AREA, ACRES		APPROXIMATE AREA TO BE SEEDED, ACRES	APPROXIMATE PLANTING BORDER, ACRES	APPROXIMATE PLANTING ACRES *1	PIN OAK (QUERCUS PALUSTRIS)	SYCAMORE (PLATANUS OCCIDENTALIS)	BUR OAK (QUERCUS MACROCARPA)	NORTHERN PECAN (CARYA ILLINOENSIS)	SWAMP WHITE OAK (QUERCUS BICOLOR)	NO. OF TREES (APPROX. 30' x 30' SPACING	NO. OF TREES TO RECEIVE PROTECTION FENCING	NO. OF TREES TO RECEIVE DEER REPELLENT
APPROXIMATE PLANTING RATE/ACRE						11	6	11	11	11	50		
1. FOREST MANAGEMENT SEGMENT 5	8.0		8.0	1.5	6.5	75	45	75	75	70	340	25 △1	25 △1
2. FOREST MANAGEMENT SEGMENT 6	9.8		9.8	2.1	7.8	85	45	85	85	85	385	25 △1	25 △1
3. FOREST MANAGEMENT SEGMENT 7	5.8		5.8	1.4	4.4	50	25	50	50	50	225		
4. AGRICULTURAL FIELD *1	33.0		33 △1	7.6	23.4	260	140	260	260	260	1180	25 △1	25 △1
5. POTHOLES *2	LENGTH, FT	WIDTH, FT			LENGTH TO BE PLANTED/ROW FT (PLANT TWO ROWS)								
*1	200	180	NA		760	12 △1	6 △1	12 △1	12 △1	18 △1	60 △1		
~~*2~~ △1	[illegible] △1	[illegible] △1	[illegible] △1		[illegible] △1	[illegible] △1	[illegible] △1	[illegible] △1	[illegible] △1	[illegible] △1	[illegible] △1		
*3	185 △1	180	NA △1		730	6 △1	3 △1	6 △1	6 △1	9 △1	30 △1		
*4 △1			NA △1			6 △1	3 △1	6 △1	6 △1	9 △1	30 △1		
*5 △1			NA △1			6 △1	3 △1	6 △1	6 △1	9 △1	30 △1		
						TOTAL TREES BY SPECIES: (ITEMS 1-5)					TOTAL TREES: (ITEMS 1-5)	TOTAL PROTECTION FENCING	TOTAL DEER REPELLENT
						511	276	511	511	521	2330	75	75
6. EXCAVATED CHANNEL MATERIAL BERM *2	4750	NA	11		4750	70	40	70	70	70	320		

*1 APPROXIMATE AREA INCLUDES POTHOLES 4 AND 5. POTHOLES (APPROXIMATELY 1 ACRE EACH) HAVE BEEN SUBTRACTED FROM APPROXIMATE AREA TO BE PLANTED
*2 PLANT TWO ROWS. LENGTHS GIVEN ARE APPROXIMATE (PERIMETER FOR POTHOLES, LENGTH FOR EXCAVATED CHANNEL MATERIAL BERM).
*3 APPROXIMATE AREA TO BE PLANTED EQUALS APPROXIMATE AREA MINUS PLANTING BORDER.





GENERAL NOTES:
1. FOR SITE PLAN OF THIS AREA, SEE C1.
2. SPACE TREES APPROX. 30' X 30'.

US Army Corps of Engineers Rock Island District
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ROCK ISLAND, ILLINOIS
TREE PLANTING SCHEDULE AND DETAILS
PLATE 29

Figure 8-16. Forest Plans for Cottonwood Island

Better than 95 percent of the Mast trees planted in the Agricultural field have survived with most thriving. Some of the Sycamore trees planted in this area are over 20 feet tall with the trunks of some of the Oak trees over 8 inches in diameter. It is not known why the trees in this area are doing so much better than the others areas. It was noted that the trees were container grown when planted and the mats placed around the trees at the time of planting are present for nearly every tree in the Agricultural field. The additional size of the plantings and the removal of competition for nutrients and other benefits gained by the securely placed mats seem to have been of great benefit.

f. Ted Shanks Conservation Area HREP. Ted Shanks Conservation Area is located in Pool 24 between RMs 284 and 291 in the St. Louis District. Following the prolonged Mississippi River flood in 1993, much of the bottomland hardwood and floodplain forest at the site died and reed canary grass invaded these areas. Prior to the HREP project, Missouri Department of Conservation planted 300 acres of hard mast RPM® trees on higher elevations in 2002. However, in 2008, the exterior berm at the site was overtopped and the prolonged inundation killed over 80 percent of these trees. To restore the forest community at the site, the HREP will construct a setback levee and will plant approximately 300 acres of floodplain forest on lower elevations and 50 acres of hard mast trees on higher elevation. Construction for the project started in 2011. A monitoring plan which includes pre-construction (Fall 2011) and post-construction sampling will track tree survivability, tree height and basal diameter, and relative growth rate (USACE 2011).

g. Spring Lake Islands HREP. Spring Lake Islands is in lower Pool 5 between RMs 740 and 743.5 in the St. Paul District. As part of the EMP project the La Crescent Natural Resource Project office was asked to make planting recommendations for the proposed islands. It was decided that the best way to determine the suitability for mast-producing trees on these islands would be to sample various locations of existing mast-tree stands and determine at what elevation above average pool elevation these trees are most likely to be found. The results of this study show that swamp white oak occur on average at an elevation of 2.17 feet above average pool elevation. One black oak was found at an elevation of 3.01 feet. Elevations range from 0.57 to 3.17 feet above average pool elevation. Sample sites were selected with the initial expectation that water levels would be most controlled close to the dam and the most upstream sites would have a hydrology that most closely mimics the natural, free-flowing river. That data indicates that the distance from a dam may be an important consideration when designing a planting plan for an EMP project or when attempting to reforest an established island. In pools with mid-pool control points, proportionally even higher elevations above average pool elevation may be required upstream of the dam in order to support mast-producing trees. This could affect the design of the EMP projects where establishing mast-producing trees is an objective.

h. Huron Island Complex HREP. The Huron Island Complex is located in Pool 18 between RMs 421.2 and 425.4 in the Rock Island District. Due to the altered hydrologic regime after constructing Lock and Dam 18, about 99 percent of the Complex is located at or below the 2-year flood elevation. The forest now experiences prolonged water inundation (>50 days) during the growing season. The primary goal of the project which is currently in feasibility is to increase topographic diversity (Section C, page 8-3) through construction of elevated tiered berms (figure 8-17). Reforestation on the tiers will be accomplished through the planting of 15 mast tree species (i.e., river birch, bitternut hickory, northern pecan, shellbark hickory, common persimmon, honey locust, Kentucky coffeetree, black walnut, American sycamore, swamp white oak, bur oak, pin oak, American basswood, and overcup oak) in three RPM® sizes (i.e., #3, #5, and #15) to determine the efficiency and survival of planting larger trees (table 8-2). Tree monitoring is incorporated in the post-construction monitoring plan.

Table 8-2. Proposed Tree Planting at Varying RPM® -Sized Trees

Location	Planting Rate Per ½ Acre for Each of the 15 Species Planted
Plot 1	
RPM® #3	4
RPM® #5	0
RPM® #15	1
Plot 2	
RPM® #3	4
RPM® #5	2
RPM® #15	0
Plot 3	
RPM® #3	0
RPM® #5	2
RPM® #15	1

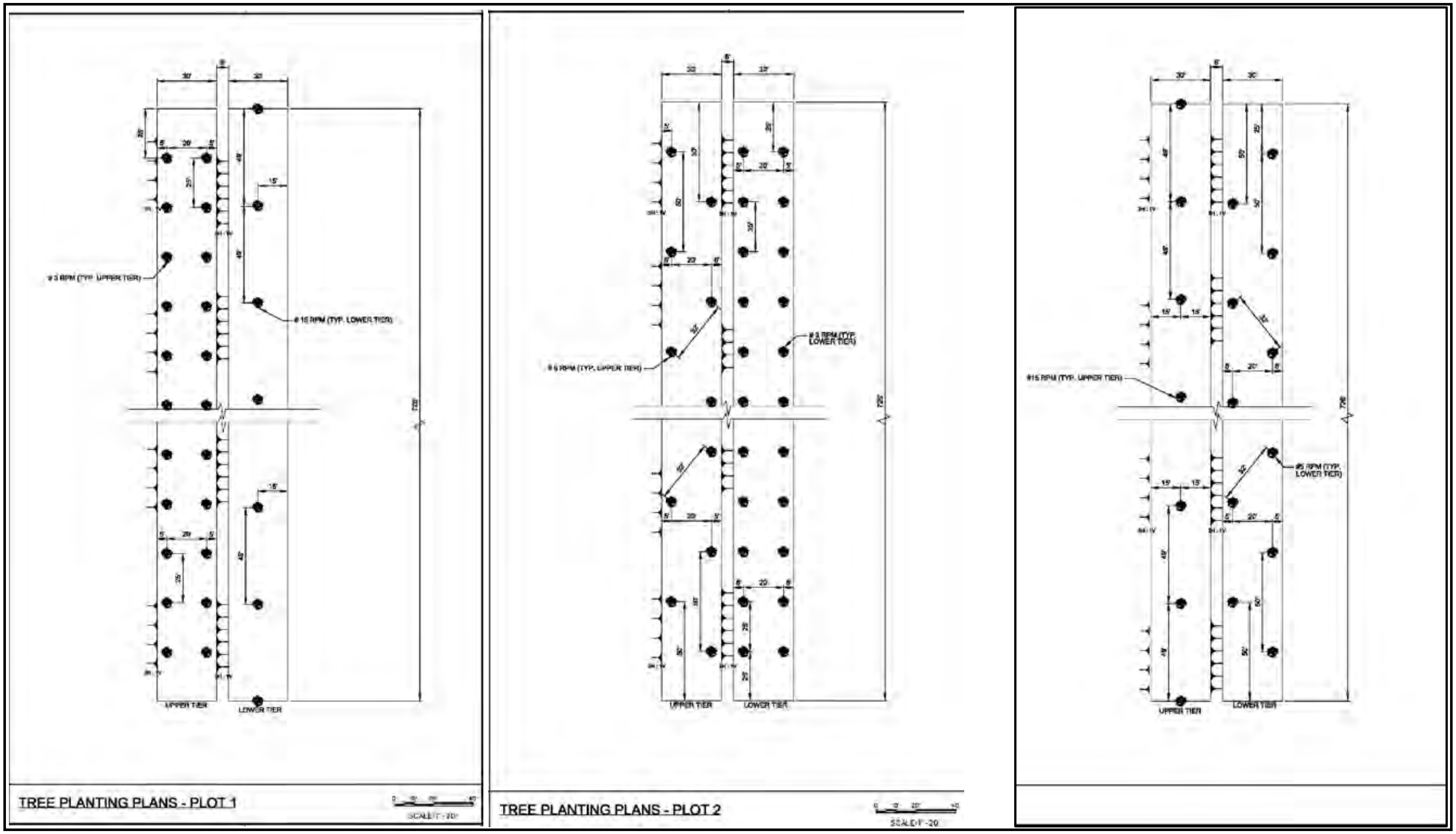


Figure 8-17. Proposed Tree Planting Plots for Huron Island

F. WETLAND SPECIES PLANTINGS (GRASSES, SEDGES, RUSHES, & FORBS)

Several wetland plant communities are dominated by herbaceous vegetation are comprised of grasses, sedges, rushes, and forbs. These wetland communities include wet prairie, sedge meadows, and fens. The UMR Basin contained extensive wet prairie along the river and on islands. The pre-settlement maps for portions of the UMRS indicate that the dominant plant community type on the floodplain was prairie (figure 8-18). These native plants provide habitat, cover, and food sources for wildlife and also help reduce site erosion and improve aesthetic appearance. However, much of these herbaceous wetland communities have been lost due to conversion to agriculture, urban development, fire suppression, and increased nutrients. Restoring native grasses, sedges, rushes, and forbs reestablishes these lost plant communities.

1. Design Methodology. Before restoring native plants into a site, it is important to ensure that the site conditions are what the plants need to grow and survive. Soil compaction, soil moisture, light availability, nutrient availability, and presence of invasive species need to be considered in order for successful establishment of a self-maintaining native plant community.

a. Seed Source. It is recommended to collect seeds within a one hundred-mile radius of the planting site, adapted to local weather conditions and flood frequency. This will also preserve the genetic integrity of the local population (IDNR 1997).

b. Seeding Rates. The seeding rates may vary according to the planting objectives (table 8-3). If a pure stand of grass is desired, then a seeding rate of 8 to 14 pounds pure live seed per acre should be sufficient depending on seedbed conditions (www.mdc.mo.gov). If a diverse mix of grasses and forbs are desired, then the amount of grass seed grass should be reduced to 2 to 4 pounds pure live seed per acre. Increase the amount of forb seeds until the mixture is 60 percent grass and 40 percent forbs by weight (Rock 1977). It is also possible to reduce the volume of grass by utilizing a process known as "debearding." In this procedure, the grass seeds are processed in a machine that removes the awns or "beards." The removal permits the seeds to pass through seeding devices more easily. If the seed has been debearded, then reduce the amount listed by one-fourth. The ratio of grass to forb seed will often be a matter of personal preference, seed availability, and cost.

Table 8-3. Seeding Rates for Native Warm-Season Grasses [1]

	Pounds of Pure Live Seed/Acre			
Grass species	**Good Seedbeds**	**Fair[2] Seedbeds**	**Savanna/Glade/ Prairie Mixture**	**Grassland Nesting Bird Mixture**
Big Bluestem	8.0	12.0	0.4	0
Indiangrass	7.8	11.7	0.4	0
Little Bluestem	6.4	7.8	2.8	2.6
Side-oats Grama	7.5	11.2	0	1.9
Eastern Gama Grass	8.0	12.0	1.0	1.0
Switchgrass (forage)	4.7	7.0	0	0.5
Switchgrass (levees, flood areas, erosion control)	7.0	14.0	0	0
Canada or Virginia wild rye	15.0	22.5	0.4	3.0
Native Prairie forbs	3.0	4.5	3.0	3.0

[1] Rates are pounds per Pure Live Seed (PLS)/acre. Available online at http://mdc.mo.gov/landwater-care/plant-management/native-plants/establishing-native-warm-season-grasses. Accessed 03 April 2012.
[2] Fair is for very coarse seedbeds or broadcast seeding

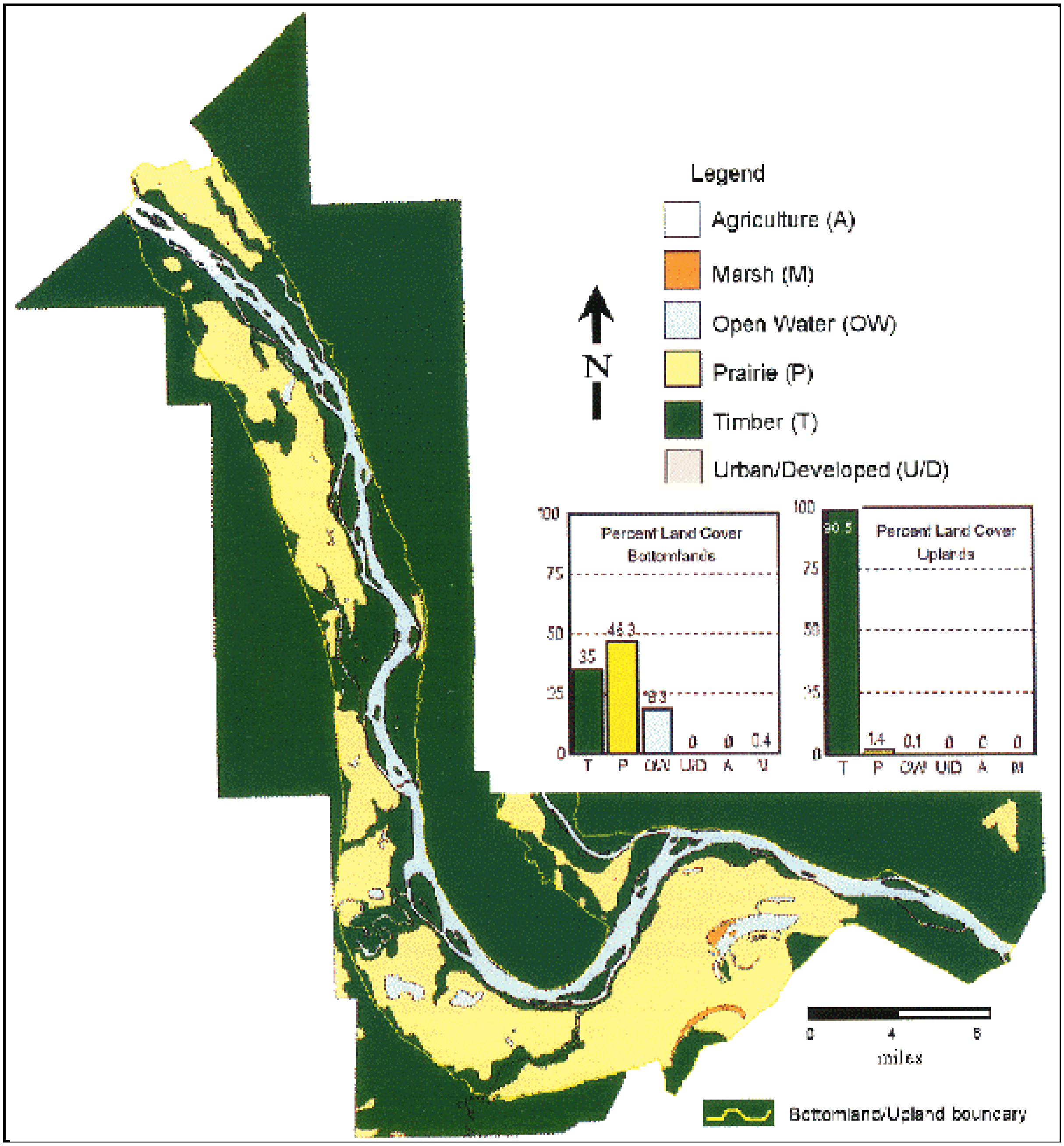


Figure 8-18. Geographic Information System Map Showing Pre-Settlement (1816) Land Cover Along Navigation Reaches 25 and 26 of the UMR. The graphs show percent land cover for timber, prairie, open water, urban/developed, agriculture, and marsh for the upland and bottomland regions (Nelson et al. 1998).

c. Planting Method. Seeds can be planted by a variety of methods, including drills, rotary spreaders, or hydraulic mulchers. Any large scale planting which does not drill the seed into the ground will require the use of a harrow to "set" the seed. The use of no till prairie seed drill has increased dramatically. Using no till planters reduces the cost, saves time, and prevents disruption of the soil that could be experienced with traditional methods of planting. If the conditions are suitable, and the seed viable, then germination should occur within 2 to 3 weeks post planting. Do not expect substantial growth of prairie plants one year post planting because during the first year the plants focus their energy on establishing their root systems. After two or three years, if survival is good, the plants should be well established.

d. Time of Planting. The ideal spring planting date varies with location and climate but generally includes a two-month period from April 15 to June 15, with the earliest planting being made in the southern reaches. Plantings made after the middle of June run the risk of encountering hot, dry weather which will reduce seed germination and seedling survival. It is also possible to plant during the late fall, thus allowing seeds to stratify naturally in the soil. If planting in the fall, be sure to plant late enough to allow seeds to germinate the following spring. The freezing temperatures could kill the seedlings if planted too early in the fall (IDNR 1997).

e. Plant Species. The key is to have a diverse mix of grasses, sedges, rushes, and forbs adapted to conditions of the project site. Several resources are available for selecting appropriate wetland species including the following resources:

- U.S. Department of Agriculture Natural Resources Conservation Services "Minnesota Wetland Restoration Plant Identification Guide Plant List" (available online: http://www.mn.nrcs.usda.gov/programs/wrp/plantid/plants.html; Accessed 09 May 2012).
- National Park Service "An introduction to using native plants in restoration projects" (http://www.nps.gov/plants/restore/pubs/intronatplant/intronatplant.pdf; Accessed 09 May 2012).

f. Invasive Plants. Invasive plants are a common problem in disturbed areas, including wetland restoration sites. Invasive plants need to be managed in order for successful establishment of native plants. The greater the amount of weeds that can be removed prior to native planting, the greater the chance the restoration site will succeed. Various removal techniques can be used depending on the invasive species. Typical methods for invasive plant removal include:

- physical removal (pulling, mowing, burning, tilling)
- smothering (mulching, cover crop)
- chemical control (pre- or post-emergent herbicides; Aqua Master ®)
- ecological control (flooding, fire, alter disturbance pattern, change nutrient availability, change soil pH, alter light availability)

g. Hydrology. When restoring wetland plant communities, restoring hydrology is critical. Many wetland plants are adapted to specific degrees of soil saturation, water depth, and flood frequency and duration. If the current hydrology of the site does not provide the conditions necessary for the desired plan species, it will need to be altered. Altering hydrology can be done through reshaping contours of the site with gently slopes or through reconnecting flow from a river or stream back through the wetland. For more intensive projects, water level management may be needed. See Chapter 5, *Localized Water Level Management*.

- Wetlands designed for waterfowl should be managed so that at least 50 percent of the surface area is less than 18 inches deep. This will enable emergent vegetation such as cattails to become established and grow vigorously. The other half of the wetland can range from 2 to 6 feet deep, but 3 to 4 feet of water is all that is necessary to assure water for duck broods.
- Where water quality improvement is the primary goal, water depths should be less than 3 feet with vegetation over 75 percent of the wetland.
- Water control structures can be used to periodically drain water off wetlands to enhance plant germination and otherwise manage wetland plants. The control structure can also be used to increase water depths to create open water areas.
- Slow drawdowns ultimately result in more food and habitat for waterfowl and shorebirds. The drawdowns must be timed carefully to avoid adversely affecting invertebrates and amphibians, however.

h. Role of Disturbance. The use of disturbance is important in managing herbaceous wetland communities. The use of fire can be useful in maintaining the native herbaceous plants while discouraging growth of invasive and woody plant encroachment. If fire is not a feasible method, mowing and raking the mulch off may be used to achieve a similar effect. If fire is used n conjunction with herbicide treatment to control invasive plants prior to planting, fire should follow the herbicide treatments to remove the large amounts of dead biomass .

i. Nutrients. Efforts should be made to reduce the exposure of the wetland plantings to nutrient-rich runoff. Certain invasive species, e.g., reed canary grass, are highly nutrient tolerant. The introduction of nutrient-rich runoff favors these invasive species and may reduce the likelihood of success in native wetland plantings.

j. Soils. Efforts should be made to select species that can survive with the soils found on the project site. If the soil cannot support the vegetation then the plantings will be most likely be unsuccessful. Consider making changes to the physical soil properties by increasing or decreasing saturated hydraulic connectivity by mechanical compaction or tillage, as appropriate; incorporate soil amendments; and consider the effects of construction equipment on soil density, infiltration, and structure. To change the soil bio-geochemical properties consider increasing the soil organic carbon by incorporating compost; or increasing or decreasing soil pH with lime, gypsum, or other compounds. (USDA 2010)

2. Lessons Learned

a. Soils

- A higher percentage of seeded species were dominant on sites with more than 1 foot of fine material (68 percent) than on sites with less fine material (56 percent).

- Fine material sites with more than 35 percent silt/clay had a higher average percent cover than sites with lesser amounts; however, at least 15 percent fines in the topsoil is sufficient to establish vegetation.
- Fine material increased the density of vegetation (both planted and naturally occurring).
- Six inches of fine material should be the minimum used for capping.
- The percent cover is highest on vegetation sites that were capped with more than 1 foot of fine material. A thicker cap of fine material with a higher percentage of fines may encourage a dense growth of woody and herbaceous cover.
- The fine material should contain sufficient coarse material to allow for aeration and water infiltration. This should be included in the specifications for the project.
- Fine material placement techniques that have worked successfully include: mechanical dredging in backwaters with placement using front-end loaders; hydraulic dredging in backwaters using containment cells for placement on the site and follow-up spreading and incorporation with heavy equipment; use of an irrigation sprayer to apply fine material dredged from a backwater using a small hydraulic dredge; and use of dump trucks to deliver topsoil where the project site is accessible by land.
- Ideally, fine material and soil amendments should be incorporated into the base material. Six inches of soil depth is often suitable for planting grass and forbs, with dry prairie species possibly requiring a bit less.
- Coarse, sandy dredged material is a poor medium for plant growth. It is important to incorporate some form of organic material with the sand to provide a suitable environment for seed germination, plant establishment and survival. To date, UMR revegetation projects have generally utilized fine sediments dredged from backwaters for topsoil. This has worked well. Sewage sludge and compost are other options being explored on a limited basis.
- To help promote long-term survival and health of vegetation plantings, project sponsors should be encouraged to monitor soil nutrient levels at reasonable intervals after the project is completed. Color and condition of foliage plus plant size may be used as an initial indicator. If a problem is suspected, a soil test will confirm the nutrient levels and can be arranged through local extension offices. Follow-up action may include application of fertilizer.
- Soil erosion can be very effectively controlled using vegetation. However, soil-holding capabilities vary between plant type and species. It is important to consult a vegetation specialist during the planning and design phase to help with plant selection.

b. Elevation

- Even within the floodplain, the flood tolerance of different plant species varies considerably. Elevation differences of 6 inches or less can determine whether a site will support certain types of plants. Therefore, it is very important to match plant species to elevations. A good general reference is Whitlow, T. H., and Harris, R. W. (1979). *Flood tolerance in Plants: A State-of-the-Art Review*, Technical Report E-78-

2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS., NTIS No. AD A075 938.

- Post-construction flooding on low elevation islands usually results in establishment of new plant species from seed that is washed onto the site. Sometimes this new vegetation can significantly change the original composition and density of plants, and often includes undesirable species, such as vetch, purple loosestrife, reed canary grass and others. Therefore, it is recommended that simple, relatively inexpensive planting mix be used on these lower areas.
- Islands have the potential to support diverse stands of vegetation that can then provide benefits such as wildlife habitat, visual barriers, and protection from wind. Vegetation types include bottomland forest, grassland, and shrubby woody vegetation. Designing islands with diverse topographic relief provides managers with a greater number of vegetative options.

c. Grass and Forbs

- Recommend using a diverse mix of native grass and forbs to ensure good overall survival. Wildflowers can enhance the appearance of the site.
- On projects where mulch is utilized, planners should consider weed-free certified mulch. The Minnesota Department of Transportation has such a program and vendors are listed on their website. By using this mulch, the risk of infesting your island with an invasive plant species is much reduced.
- Studies have shown that it is not necessary to plant any wetland plants in the wetland itself. Simply returning water to the area results in aquatic vegetation developing within 2 years.
- The aquatic plants that will likely grow include prairie cordgrass, arrowhead, cattails, sedges, marsh milkweed, water smartweed, and bulrushes (*Better Wetlands*).

3. Case Studies

a. Huron Island Complex HREP. Huron Island Complex is located in Pool 18 between RMs 421.2 to 425.4 in the Rock Island District. Due to the altered hydrologic regime after constructing Lock and Dam 18, about 99 percent of the Complex is located at or below the 2-year flood elevation. The forest now experiences prolonged water inundation (>50 days) during the growing season. The primary goal of the project which is currently in feasibility is to increase topographic diversity (Section C, page 8-3) through construction of elevated tiered berms. The design of the berm slopes incorporates the planting of a mix of wetland species transitioning from submerged to emergent aquatic vegetation to a mix of seasonally inundated emergent and scrub/shrub wetland species (table 8-4). The aquatic vegetation plantings will be accomplished through an experimental design incorporating planting at multiple elevations, utilizing exclosures, growth from the seed bank, and planting tubers, bareroot stock, and potted plants (figure 8-19). Comparisons between the planting treatments will determine optimal aquatic vegetation planting designs for future HREP projects

Table 8-4. Huron Island Complex Vegetative Planting Design

Permanently Inundated Aquatic Vegetation (EL. 426-529 ft) **Seeding Rate = 500 total plants per ½ acre**					
Plant Size	**Illinois Pondweed**	**Sago Pondweed**	**American Wild Celery**	**Coontail**	**American Elodea**
Potted plant	100	100	100	100	100
Bareroot	100	100	100	100	100
Root Tuber or Rhizome	100	100	100	100	100

Intermittently Exposed to Semi-Permanently Inundated Aquatic Bed (EL. 529 – 532 ft) **Seeding Rate = 500 total plants per ½ acre**				
Plant Size	**Waterwillow**	**Arrowhead**	**Pickerelweed**	**Smartweed**
Potted plant	125	125	125	125
Bareroot	125	125	125	125
Root Tuber or Rhizome	125	125	125	125

Seasonally Inundated Emergent Wetland (EL. 531 – 534 ft) **Seeding Rate = 500 total plants per ½ acre**				
Plant Size	**Sedges**	**Bulrush**	**Blue Flag Iris**	**Sweet Flag**
Potted plant	125	125	125	125
Bareroot	125	125	125	125
Root Tuber or Rhizome	125	125	125	125
Seed Mix (10 pounds per acre overall)[1]				

Seasonally Inundated Emergent Wetland (EL. 533 – 535 ft) **Seeding Rate = 25 total trees per ½ acre**					
Plant Size	**Hibiscus**	**Common Elderberry**	**Buttonbush**	**Dogwood**	**Sandbar Willow**
#3 RPM®	5	5	5	5	5

[1] Seed mix for tiers (under trees and scrub plantings) consists of Virginia wild rye, Canada wild rye, partridge pea, buttonbush, rice cut grass, cardinal flower, and sneezeweed

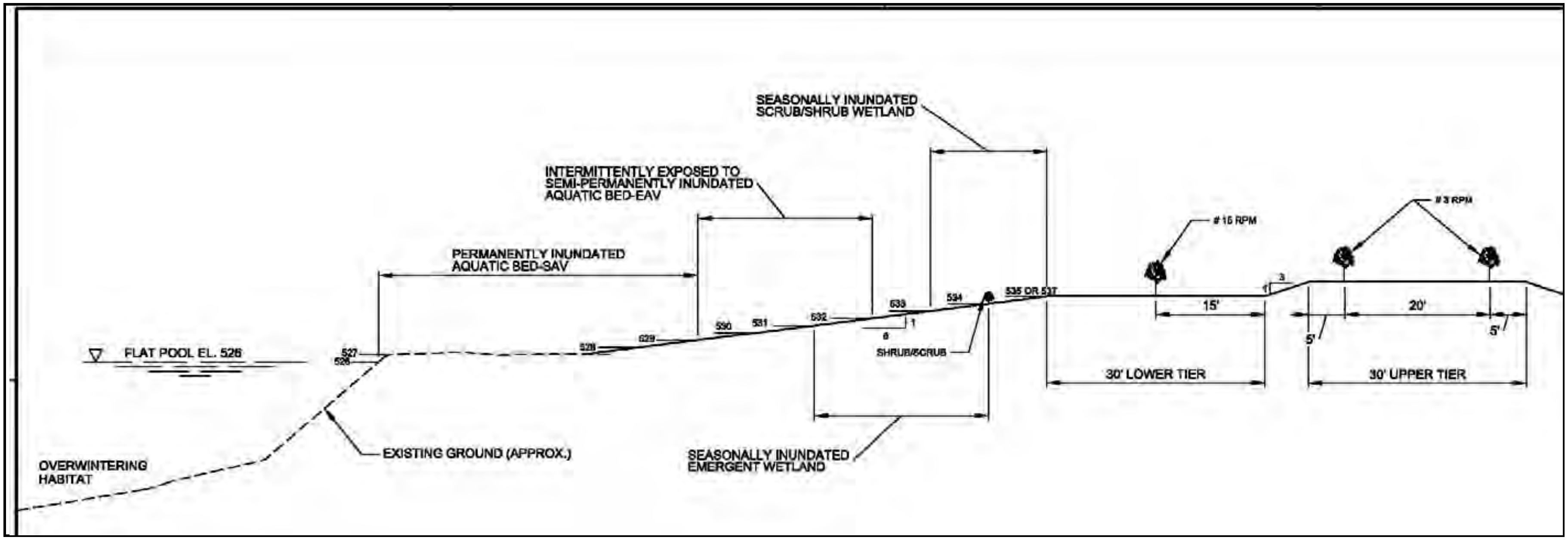


Figure 8-19. Proposed Plantings at Huron Island

b. Potters Marsh. Potters Marsh is located in Pool 13 between RMs 522.5 to 526.0 in the Rock Island District. One of the project features was to develop grassland on a confined placement site (CPS), with the objective of enhancing habitat for migratory birds by increasing feeding or resting areas by increasing suitability. Seven acres were designed for this feature.

The grassland area was constructed after initial settlement of dredged material. The area was seeded with selected grasses. This grassland area helped compensate for any lost vegetation due to the CPS construction and further enhanced the habitat values on the site. This grassland provides habitat for dabbling ducks as well as non-game species like the dickcissel and the indigo bunting. These improvements would provide an enhanced aesthetic environment for recreationists hunting or fishing within the complex boundaries.

The Refuge Manager reported that during the spring of 1997 several pairs of Canadian geese had nested in the interior of the CPS and mallards had nested on the associated berm and grassland areas. Small numbers of sandhill cranes visit the Savanna District each year. During 1995, a sandhill crane nest located near the containment site successfully hatched two young. This was the first documented sandhill crane nest in northwestern Illinois since 1872. Refuge staff observed nesting activity by sandhill cranes on or around the CPS grassland and berm in the spring of 1997, although actual nests or hatching success were not confirmed.

A third site visit to the CPS by Corps staff on October 2, 1997, showed cover crop rye grasses were still dominant on the berm and grassland. This third inspection revealed an increased presence of warm season grasses and forbs. Several species encountered, such as little bluestem, sideoats grama, and blue grama, were included in the seed mixture specified for the CPS. Other species, such as New England aster, Indian grass, and big bluestem, were not included in seeding specifications, but could either be natural components of the seed bank in the area or incidental inclusions in the seed mixtures applied after construction of the CPS.

During the October 2, 1997, site visit, Corps staff encountered a plant specimen tentatively identified in the field as the federally listed threatened species decurrent false aster (*Boltonia decurrens*). This identification was confirmed the following day by the endangered species coordinator at the Rock Island Field Office of the USFWS. The known range for this species in Illinois is limited to floodplains of the Illinois River and of the UMR downstream of the confluence with the Illinois. This species is not recorded as occurring in Carroll or Whiteside Counties, and the reason for its presence on the CPS feature at Potters Marsh is not known. There is a possibility that seeds of this species may have been accidentally transported to the site in seeding mixtures or through some other construction-related activity.

The initial vegetation response and observed waterfowl use of the area since construction indicates a positive response to the HREP and suggests that the project is providing benefits to migratory bird species. Establishment of a plant community dominated by warm season native grasses and forbs typically requires at least 3 to 4 years to fully develop, with periodic maintenance activity such as controlled burning to control less desirable vegetation (e.g., cottonwood seedlings). Continued monitoring of vegetation changes and migratory bird use within and around the CPS will help to determine the long-term performance of this feature.

On April 1, 1998, USFWS refuge staff conducted a maintenance bum of the berm and grassland areas of the CPS. Site visits conducted by Corps staff on May 22 and July 15, 1998, revealed an increased dominance of warm season grasses and forbs, as well as an increase in the number of species present. These initial observations suggest that the grassland community responded well to the initial maintenance bum.

Burning should be applied to the grassland and containment berm annually or biennially when possible. Mowing may also be beneficial where encroachment is initiating or when burning is not practicable.

The managed marsh continues to be submerged year round in order to control the encroachment of willow and cottonwood trees by keeping the marsh too wet for the trees to thrive. The project has been operated in this manner since June 2000. The strategy of flooding the marshland has been somewhat successful in killing undesirable vegetation, but encroachment remains a problem and would most likely worsen if the managed marshland were operated as a moist soil unit (moist soil units are drawn down in the summer months). Encroachment continues to be worse in the grassland area where the land is higher and flooding is not possible. Grassland and forb species were especially threatened by the encroachment.

The grasslands planted met the project objective of enhancing wildlife habitat.

c. West Newton Beneficial Use Site near Kellogg, MN. The scope of work for this project was to establish and maintain native prairie vegetation on 130.77 acres located near Kellogg, MN on lands owned by the Corps of Engineers, St. Paul District. Approximately 1.3 million cubic yards of dredged coarse-grained sands were hydraulically placed on the site to depths of up to 20 feet and then contoured to resemble sand dunes in 2002. The seed used for this project (tables 8-5, 8-6, and 8-7) was harvested from The Nature Conservancy lands within the Weaver Dunes complex just south of the project site. Seeding was conducted between May 1 and June 15, 2005. A cover crop of oats was planted during the 2004 growing season and crop residue remains at the site. Seed was drilled wherever possible, but inaccessible areas were broadcast seeded. The seeding density was defined as a minimum average of 70 plants per 100 square feet. Plant diversity was comprised of a minimum of 50 percent of grass species and 25 percent of forb species. Mowing was used to control pioneering non-native plant species during the first growing season (before the general height is 12 inches or when the non-native begin to flower, whichever is earlier). Mowing occurred before the non-native set seed. Mowing was set at a height of 4 inches.

Table 8-5. Species, Seed Rates, and Acres Planted at West Newton Beneficial Use Site

Common Name	Scientific Name	Seeding Rate (ounces per acre) Mix 1	Seeding Rate (ounces per acre) Mix 2	Acres To Be Planted On (Mix 1)	Acres To Be Planted On (Mix 2)
little bluestem	*Andropogon scoparius*	32	32	110.33	20.44
sand dropseed	*Sporobolus cryptandrus*	0.5	0.5	110.33	20.44
big bluestem	*Andropogon gerardii*	8	8	110.33	20.44
hoary vervain	*Verbena stricta*	1	1	110.33	20.44
dotted mint	*Monarda punctata*	1	0	110.33	0
common evening primrose	*Oenthera biennis*	0.5	2	110.33	20.44
Canadian milk vetch	*Astragalus canadensis*	0.25	0	110.33	0
silky prairie clover	*Petalostemum villosum*	1.8	0	110.33	0
purple prairie clover	*Petalostemum purpureum*	1	1	110.33	20.44
white prairie clover	*Petalostemum candidum*	1	0	110.33	0
round headed bush clover	*Lespedeza capitata*	2	2	110.33	20.44
lead plant	*Amorpha canescens*	.5	0	110.33	0
showy sunflower	*Helianthus pauciflorus*	.25	0	110.33	0

Table 8-6. Seed Mix 1 Used at West Newton Beneficial Use Site [1]

Forbs	**% by Weight**
Anemone cylindrical (Thimbleweed)	0.07
Anemone patens wolfgangiana (Pasque Flower)	0.17
Artemisia caudata (Beach Wormwood)	0.17
*Artemisia ludoviciana (*Prairie Sage)	0.07
Asclepias tuberosa (Butterfly Weed)	1.33
Asclepias verticillata (Whorled Milkweed)	0.33
Aster azureus (Sky Blue Aster)	0.17
Astragalus canadensis (Canadian Milk Vetch) __ Scarify	0.17
Baptisia leucantha (White Wild Indigo) __ Scarify	1.33
Campanula rotundifolia (Harebell)	0.07
Cassia fasciculata (Partridge Pea) __ Scarify	21.28
Coreopsis palmata (Prairie Coreopsis)	0.33
Crotalaria sagittalis (Rattlebox)	0.67
Desmodium illinoense (Illinois Tick Trefoil)	0.67
Euphorbia corollata (Flowering Spurge)	0.67
Gnaphalium obtusifolium (Sweet Everlasting)	0.13
Helianthus pauciflorus (Showy Sunflower)	0.17
Helianthus occidentalis (Western Sunflower)	0.17
Kuhnia eupatorioides (False Boneset)	0.17
Lespedeza capitata (Round-headed Bush Clover)	1.33
Liatris aspera (Button Blazing Star)	0.67
Monarda fistulosa (Wild Bergamot)	0.67
Monarda punctata (Spotted Bee Balm)	0.67
*Oenthera biennis (*Evening Primrose)	0.34
Petalostemum candidum (White Prairie Clover)	0.67
*Petalostemum purpureum (*Purple Prairie Clover)	0.67
Petalostemum villosum (Silky Prairie Clover)	1.20
Potentilla arguta (Prairie Cinquefoil)	0.17
Ratibida pinnata (Yellow Coneflower)	0.67
Rudbeckia hirta (Black-eyed Susan)	0.67
Sisyrinchium campestre (Prairie Blue-eyed Grass)	0.07
Solidago nemoralis (Old Field Goldenrod)	0.07
Solidago rigida (Stiff Goldenrod)	0.17
Verbena stricta (Hoary Vervain)	0.67
Trees, Shrubs & Vines	
Amorpha canescens (Lead Plant)	0.33
Ceanothus ovatus (Red Root) __ Scarify	0.07
Rosa arkansana (Prairie Wild Rose) __ Scarify	0.33
Grasses, Sedges & Rushes	
Andropogon gerardii (Big Bluestem PLS)	5.32
Andropogon scoparius (Little Bluestem PLS)	21.28
Bouteloua curtipendula (Side-oats Grama PLS)	21.28
Carex brevior (Plains Oval Sedge)	0.33
Carex muhlenbergii (Sand Bracted Sedge)	0.67
Elymus canadensis (Canada Wild Rye PLS)	5.32
Koeleria cristata (June Grass)	1.33
*Panicum virgatum (*Switch Grass PLS)	1.33
Sorghastrum nutans (Indian Grass PLS)	5.32
Sporobolus cryptandrus (Sand Dropseed)	0.33

[1] PLS - Pure Live Seed

Table 8-7. Seed Mix 2 Used at West Newton Beneficial Use Site

Forbs	**Grams**
Cassia fasciculata (Partridge Pea) __ Scarify	453.7600
Lespedeza capitata (Round-headed Bush Clover)	56.7200
Liatris aspera (Button Blazing Star)	28.3600
Oenthera biennis (Evening Primrose)	56.7200
Petalostemum purpureum (Purple Prairie	28.3600
Ratibida pinnata (Yellow Coneflower)	28.3600
Rudbeckia hirta (Black-eyed Susan)	28.3600
Verbena stricta (Hoary Vervain)	28.3600
Grasses	
Andropogon gerardii (Big Bluestem PLS)	226.8800
Andropogon scoparius (Little Bluestem PLS)	907.5200
Bouteloua curtipendula (Side-oats Grama PLS)	907.5200
Elymus canadensis (Canada Wild Rye PLS)	226.8800
Koeleria cristata (June Grass)	56.7200
Panicum virgatum (Switch Grass PLS)	56.7200
Sorghastrum nutans (Indian Grass PLS)	226.8800
Sporobolus cryptandrus (Sand Dropseed)	14.1748

d. Lock & Dam 4 Embankment. The scope of work for this project was to establish trees, shrubs, grass, and forbs vegetation adjacent to Lock and Dam 4 near Alma, WI in the St. Paul District. The project area is approximately 7.5 acres in size and is located on the upstream side of the Mississippi River Lock and Dam 4 embankment, owned by the Corps. The embankment was originally constructed in the 1930s. The purpose of the plantings as well as the offshore berm is to provide protection of the Lock and Dam embankment from erosive wind and wave energy. The berm features four terraces of varying elevation and a woody clear zone that corresponds to the underlying footprint of the embankment. The berm was constructed from coarse-grained sands dredged from the navigation channel of the Mississippi River. The planting plan included five different forest or grass/forbs species combinations based on site elevations or a woody-clear zone over the footprint of the existing embankment. Willow cuttings were planted along the shoreline (667 feet) to 668.5 feet (6 rows total) the entire length of the berm. The hardwood slope section (668.5 to 670.5 feet) included bare root seedlings of cottonwood, silver maple and river birch. The hardwood terrace section (670.5 to 673 feet) included bare root seedlings of moderate flood tolerant species (swamp white oak and hackberry). The hardmast terrace section (above 673 feet) included bare root seedlings of bur oak and black walnut. The “clear zone” was planted with a mix of native grass and forb seed.

The mix (table 8-8) used helps maintain a woody plant-free zone along and just adjacent to the upstream footprint of the existing LD4 embankment. The seeding density was 81 seeds per foot. Plant diversity was comprised of 45 percent grasses, 50 percent cover crops and 5 percent forbs.

Table 8-8. Grass and Forb Mix Used at the Lock and Dam 4 Embankment Project

Grasses	**% of Mix**
Avena sativa (oats)	40
Bouteloua curtipendula (Sideoats grama)	10.00
Bouteloua gracilis (Blue grama)	10.00
Bromus kalmii (Kalm's brome)	5.00
Elymus canadensis (Canadian wild rye)	8.00
Koeleria macrantha (June grass)	2.00
Lolium italicum (Annual Rye grass)	10.00
Schizachyrium scoparium (Little bluestem)	10.00
Forbs	
Aster laevis (Smooth blue aster)	0.10
Astragalus Canadensis (Canada milkvetch)	0.70
Dalea canadida (White prairie clover)	0.60
Dalea purpurea (Purple prairie clover)	0.60
Liatris aspera (Rough blazingstar)	0.60
Penstemon grandiflorum (Showy penstemon)	0.70
Ratibida columnifera (Columnar coneflower)	0.60
Rudbeckia hirta (Black-eyed Susan)	0.30
Solidago rigida (Stiff goldenrod)	0.60
Verbena stricta (Hoary vervain)	0.20

e. Banner Marsh HREP. Banner Marsh is located in the LaGrange Pool on the Illinois Waterway between RMs 138.0 and 144.0 in the Rock Island District. One goal of the project was to enhance terrestrial habitat to increase food and cover for terrestrial birds and mammals by planting native warm season grasses (USACE 2002b). In May 2003, a mix of warm season grasses were planted with the following planting rates per acre:

Species	**Pounds/Acre**
Big bluestem (*Andropogon gerardii*)	3
Little bluestem (*Schizachyrium scoparium*)	3
Indian grass (*Sorghastrum nutans*)	2
Perennial rye grass (*Lolium perenne*)	20
Sideoats gramma (*Bouteloua curtipendula*)	2

All seeding took place at higher elevations (above 439.0). As of 2004, no inspection or monitoring of terrestrial habitat have been performed. The site manager reported prairie seeding of the borrow areas have been successful (USACE 2004b).

f. Spring Lake HREP. Spring Lake Islands are located in lower Pool 5 in the St. Paul District. The Spring Lake EMP PDT designed two grassland seed mixes in 2004 for use on islands as shown in the following two tables (tables 8-9 and 8-10). For sections of islands where vegetative management will be minimal, the abbreviated prairie mix should provide a relatively quick cover of native species. On higher sections (4 feet above average pool), the diverse prairie mix is recommended. Planners should be advised that active management is required to maintain grassland on the river, to include mowing during establishment of the stand and periodic controlled burns later to control invasive species and woody vegetation. In addition to providing habitat benefits, native prairie grasses form deep, dense root systems that will ultimately provide more protection to the islands.

Table 8-9. Abbreviated Prairie Mix Used at Spring Lake

Common Name	Scientific Name	Seeding Rate (ounces per acre)
Virginia wild rye	*Elymus virginicus*	48
Canada wild rye	*Elymus canadensis*	48
Switchgrass	*Panicum virgatum*	32
Indiangrass	*Sorghastrum nutans*	16
Prairie cordgrass	*Spartina pectinata*	3
Black-eyed Susan	*Rudbeckia hirta*	2

Table 8-10. Diverse Prairie Mix Used at Spring Lake

Common Name	Scientific Name	Seeding Rate (ounces per acre)
Big bluestem	*Andropogon gerardii*	25.5
Little bluestem	*Andropogon scoparius*	25.5
Sideoats grama	*Bouteloua curtipendula*	25.5
Rough dropseed	*Sporobolus compositus*	1
Virginia wild rye	*Elymus virginicus*	25.5
Canada wild rye	*Elymus canadensis*	25.5
Switchgrass	*Panicum virgatum*	4
Indiangrass	*Sorghastrum nutans*	25.5
Prairie cordgrass	*Spartina pectinata*	2
Black-eyed susan	*Rudbeckia hirta*	3
Evening primrose	*Oenthera biennis*	2
Purple prairie	*Dalea purpurea*	3
Brown-eyed	*Rudbeckia triloba*	2
Yellow	*Ratibida pinnata*	2
Bergamot	*Monarda fistulosa*	1
Blue vervain	*Verbena hastate*	1.5
Hoary vervain	*Verbena stricta*	1.5
Sky blue aster	*Aster oolentangiensis*	0.5
Frost aster	*Aster pilosus*	0.5
Showy sunflower	*Helianthus laetiflorus*	0.5

G. LEVEE SETBACKS

Within the UMR System, an extensive levee system isolates the floodplain from the mainstem river. The levees reduced flooding and opened the floodplain to rural, industrial, and residential development. Historic maps illustrate the ancient courses of the Mississippi River, which showed a wider meandering channel compared to the currently confined river channel (figures 8-20a and 20b). Levee placement not only straightened the channel, but also substantially altered the form and function of the Mississippi River. Detachment of the floodplains from the main stem river system has resulted in the loss of channel complexity (meanders, sand bars) and floodplain process and function (flood water and sediment storage, riparian and wetland development). These changed conditions greatly reduced off-channel aquatic and riparian habitat for both fish and wildlife by reducing available food sources, cover, and water resources.

Figure 8-20a. Historic Course of Mississippi River Meander Belt Near Cape Girardeau, MO

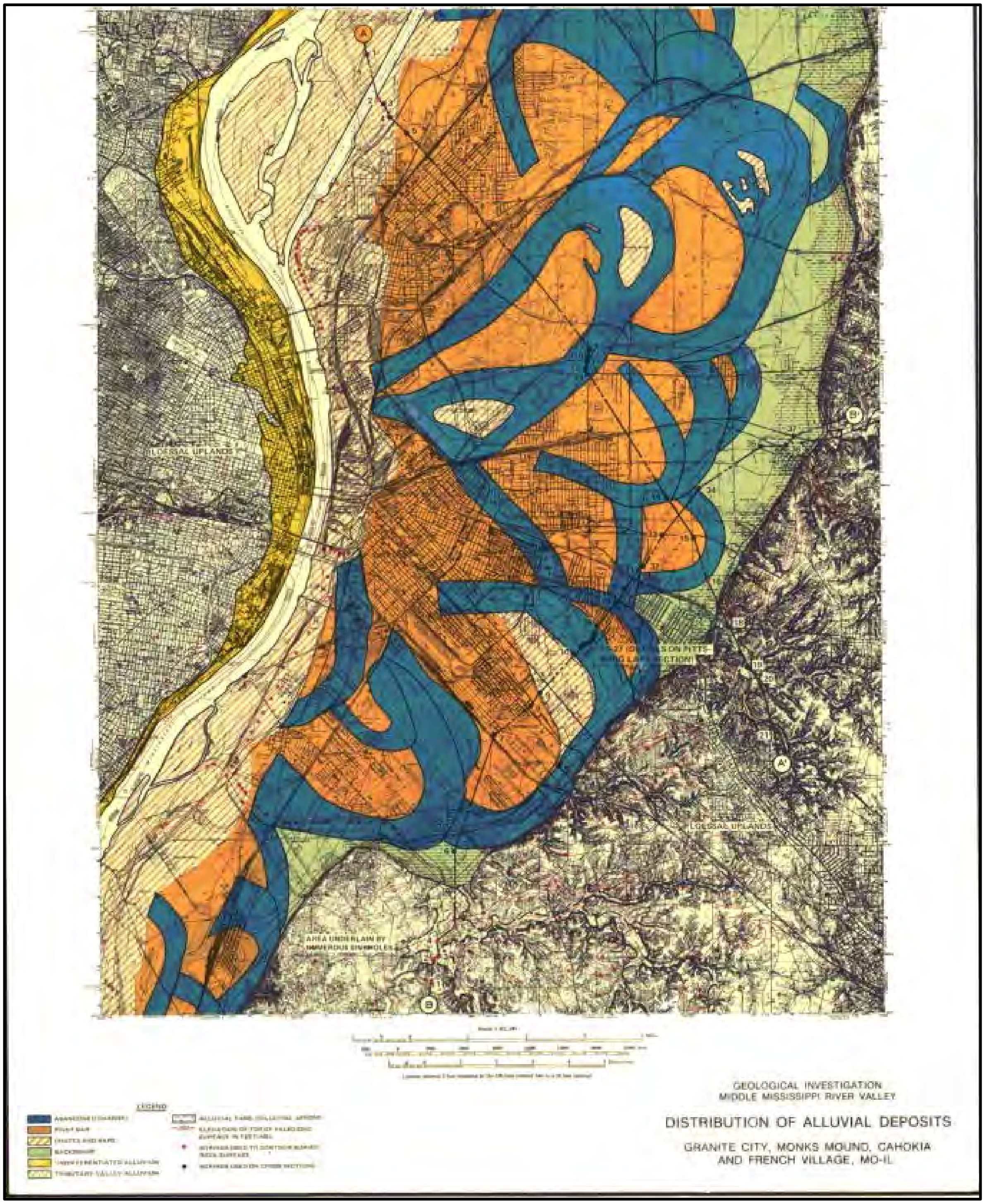


Figure 8-20b. Historic Course of Mississippi River Meander Belt Near St. Louis, MO

The use of setbacks within the Corps of Engineers is a relatively new tool to restore connectivity between the floodplain and the main stem river. A setback levee has been defined as "an earthen embankment placed some distance landward of the bank of a river, stream, or creek. It develops bypasses for the mainstream, flooding a land area usually dry but subject to flooding at high mainstream stages" (USACE 1999b). Setback levees allow the streamflow to spread and slow by creating a wider, connected floodplain with increased conveyance capacity of the floodway. They provide floodplain storage benefits and sustain dynamics of the river system, which depends on recurring flood events. The passage of water and sediment in the channel, and their exchange between the channel and the floodplain, characterizes the physical environment and effects of habitat, biodiversity, and sustainability of the river (Poff et al. 1997). Setback levees would also permit an active natural meander belt on rivers that do not need to be maintained for navigation, thereby improving the floodplain habitat.

1. Design Methodology. Design and construction of setback levees should consult the design guidelines outlined in EM 1110-2-1913 (30 April 2000). A basic levee design cross section is depicted in figure 8-21. The EM is tailored to levees protecting life and property, which are designed to perform at higher flood stages. Less conservative designs (i.e., levee height) are permissible for EMP and other ecosystem restoration projects, but the overall methods of levee construction are the same. Typical earthwork specifications for a Rock Island District levee are as follows:

- Grading tolerance: 0 to +4 inches for clay, 0 to + 6 inches for sand
- Benches: 1 to 3 feet vertical face max
- Fill lift thickness: 8 inches loose
- Compaction
    - Compacted Clay: 95 percent of standard Proctor (ASTM D698)
    - Semi-compacted clay: 90 percent of ASTM D698
    - Sand Levee: 80 percent relative density (ASTM D4253/D4254)
    - One test per left per day or every 3,000 cubic yards
    - Standard proctor or relative density for each soil type or every 10,000 cubic yards
- Moisture Content
    - Field test with microwave oven (ASTM D4643) at Contractor's discretion
    - Lab verify ALL test (ASTM D2216) for each compaction test
- Soil Classification
    - Grain size analysis (ASTM D422) for each Proctor test
    - Atterberg limits (ASTM D4318) for each Proctor test

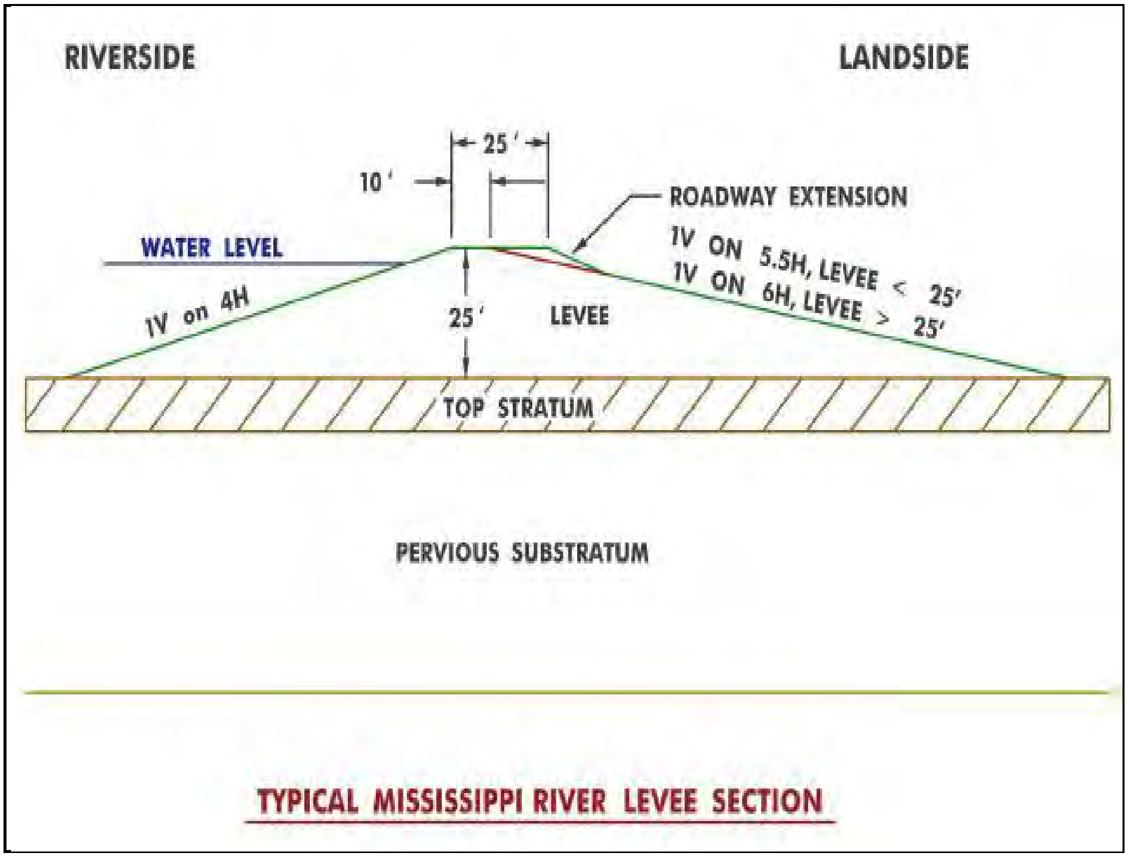


Figure 8-21. Generic Levee Cross-Section for a Sand Levee

2. Lessons Learned. The following statements are hypotheses, rather than facts, since most of the projects that have used levee setbacks are early in planning or construction, with no data on post-construction effects. Further monitoring and evaluation of levee setbacks will be needed to have definitive lessons learned for this restoration technique.

- Setback levees restore ecosystem function such as sediment recharge and nutrient reduction.
- Environmental benefits increase with width of setback (inter-levee distance).
- A spillway along the setback may be needed to reduce scour during overtopping flood events.
- The height of setback levee is based on project goals and objectives.
- Setback levees can be constructed landward of an existing riverside levee. The existing riverside levee can be degraded on the downstream end to allow back-flooding into the setback area. The remainder of the riverside berm can stay intact to act as a sediment deflection barrier during high flood events and provide areas of higher elevation for hard mast tree plantings (if levee maintenance allows this).

- Pre- and post-construction monitoring of biological and physical parameters should be incorporated into the study design to assess setback benefits.
- In terms of general levee design and construction lessons learned, use a multi-disciplinary team and follow these design steps:

  1) Perform geologic survey to identify potential hazards (i.e., shallow bedrock, old sloughs) and conduct preliminary subsurface exploration
  2) Analyze preliminary data, establish preliminary profiles, borrow locations, and embankment sections
     - Clay embankment: 1V:3H side slopes with 10 foot crown width
     - Sand Levee: 1V:4H river side slope with 1V:5H land side slope with 10 foot crown width. 10H base width or add berm for through seepage.
  3) Final exploration to refine stratigraphy, measure shear strengths, and refine borrow material limits
     - Subsurface exploration and testing: 200 ft to 1,000 ft “boring” spacing (disturbed and undisturbed samples, vane shear testing, cone penetration testing); test pits and trenches; piezometers; pump testing
  4) Define stratigraphy and design parameters; calculate rough quantities.
  5) Divide project into design reaches based on geometry, stratigraphy, and design parameters, etc.
  6) Analysis of underseepage and through-seepage (blanket theory, lane’s weighted creep ratio, finite element methods); slope stability (deterministic analyses, Spencer’s Method); settlement (Bousseniesq Stress Distribution); trafficability of levee surface
  7) Design for “problem area” (seepage, stability, settlement, trafficability, non-geotechnical)
  8) Establish final sections for each reach
  9) Compute final quantities, determine final borrow locations
  10) Design slope protection (erosion resistance, resiliency, levee safety)

  Design *continues* through construction http://www.ucs.iastate.edu/mnet/repository/2012 /geotechnical/presentations/levee.pdf; Accessed on 28August 2012)

3. Case Studies

a. Sacramento River, California. Setback levees have been investigated by the Corps’ Sacramento District for the Sacramento River. The Hamilton City Flood Damage Reduction and Ecosystem Restoration is slated to begin summer 2012 (RM 192 to 202), the project focuses on measures that produce both flood risk reduction and ecosystem restoration benefits. The multi-benefit project consists of constructing a setback levee about 6.8 miles long that would have varying heights (7.5 feet to 3 feet) and consequently, varying levels of performance for flood damage reduction while reconnecting approximately 1,500 acres of floodplain (USACE 2004c). The existing degraded levee is privately owned and mostly made of earthen material susceptible to erosion. The goal of the setback levee is increase capacity of the Sacramento River, decrease river velocities, and ease pressure from periodic flooding by allowing 1,500 acres of floodplain to be reconnected to the river.

Another study was performed to evaluate setback levees on the Sacramento River (RM 84 to 143). A preliminary analysis was performed to determine the effect the setback would have along the Sacramento River. This was done using a three-scenario strategy for setback inter-levee width of 3000 feet, 6000 feet, and 9000 feet. Each scenario was analyzed in terms of hydrology, ecology, and economics. The floodplain inundation depth and the change in channel velocity were determined for each scenario at several cross sections using a number of standard flood recurrence intervals. The analysis of the three scenarios indicates that benefits increase with increased inter-levee distance, and the 9000 foot setback scenario was found to provide the greatest benefits. For the aquatic ecosystem, this scenario establishes the most desirable conditions for improving habitat because channel velocity is decreased and there is great potential for backwater habitat formation. In terms of terrestrial ecosystem, the area of willow, cottonwood, and mixed riparian communicates is maximized under this scenario. It also allows the most freedom for channel migration to occur over time. Additionally, the economic analysis also shows this scenario to be the most attractive (Accessed 06March2012 http://www.bren.ucsb.edu/research/2000Group_Projects/Levees/levees_final.pdf).

b. Ted Shanks Conservation Area HREP. This HREP is located in Pool 24, Mississippi River, RMs 286 to 293 in the St, Louis District. At the Ted Shanks Conservation Area, the height of the proposed setback would match the height of the existing exterior berm. The crown width was designed to be 12 feet, and side slopes 1 vertical on 3 horizontal. The bottom width would be approximately 75 feet and construction limits would be approximately 125 feet for the length of the setback. Clearing and grubbing would be required within the berm footprint and recommended within 15 feet of the proposed setback toe. A 1,000-foot segment of the existing exterior berm would be degraded. Degrade location was chosen to avoid impacts to high-quality forest and promote water backing up into the floodplain. Degrading the exterior berm would create a hydrologic connection between riverward lands of setback and the river. The setback and berm degrade should prevent flood waters from ponding on the forest in this area, and provide fish access to inundated floodplain for spawning and rearing.

The bottomland hardwood and floodplain forests within the project site have been degraded due to the elevated water table, prolonged inundation from overtopping floods, and invasion by reed canary grass. The undersized water control structures lack the ability to quickly drain the area; a major contributor to the tree death and degraded wetland habitat. The project features include setback levees in two areas of the existing exterior levee along with a partial exterior levee degrade to allow for back flooding into the areas. Other project features include constructing new water control structures to increase water drainage capacity, constructing interior berms to improve water and vegetation management, reforestation, constructing rock riffles and hard points within a slough, and a new pump station (USACE 2011). The project started construction in fall of 2011. Pre-construction monitoring for trees in the two setback locations was collected in fall of 2011. Post-construction monitoring is planned to assess the benefits of the setback in the future.

c. Clarence Cannon National Wildlife Refuge HREP. This HREP is located in Pool 25, Mississippi River, RMs 263.5 to 260.6 in the St. Louis District. The main resource problems at the project site is loss of native vegetation, limited ability to mimic historic flow regimes, habitat fragmentation, and lack of connectivity with the Mississippi River. The proposed project features include setback levee (with a spillway) with partial exterior berm degrade to allow for back flooding of the area, removal/modification of interior berms, pump station, dredging of sloughs and historic meanders, and native plantings. This project is currently in feasibility. Fish and water quality monitoring was conducted in May of 2011 within the proposed setback area. Post-construction monitoring is planned to assess benefits of the setback in the future.

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