4. DESCRIPTION OF THE PREFERRED COMPREHENSIVE PLAN ALTERNATIVE

Part A of this section summarizes the preferred comprehensive plan alternative, provides some basic descriptions of measures that would be used to achieve the desired goals, and provides a summary of costs and operations and maintenance considerations for individual measures. The preferred comprehensive plan alternative, Alternative 6, was selected because it achieves a balance between increasing system-wide benefits and cost effectiveness. Part B summarizes costs associated with the recommended implementation of Tier I through 2011 and Tier II through 2015. and includes the technologies and innovative approaches component of the preferred comprehensive plan alternative.

Goals of Alternative 6 include:

1. **Ecological Integrity.** Restoration would provide a measurable increase in level of habitat and ecological integrity at the system level. Implementation of Alternative 6 would provide benefits to approximately 225,000 acres and 33,000 stream miles.

2. **Sediment Delivery.** Reduce sediment delivery from direct Peoria Lake tributaries by 40 percent, other tributaries upstream of Peoria Lake by 11 percent, and tributaries downstream of Peoria Lake by 20 percent. System benefits include reduced delivery of 20 percent to Peoria Lake and 20 percent system wide. A reduction in sediment would benefit approximately 16,750 stream miles.

3. **Backwaters and Side Channels.** Restore 12,000 acres in 60 of the approximate 100 backwaters on the system. Dredging an average of 200 acres per backwater, the optimal level of 40 percent of the approximate 500-acre average backwater area. This would create optimal backwater and over-wintering habitat spaced approximately every 5 miles along the system. Restoration of 35 side channels and protection of 15 islands. Restoration measures would benefit approximately 56,020 acres.

4. **Floodplain, Riparian, and Aquatic Restoration.** Restore 75,000 acres of main stem floodplain (approximately 14.9 percent of total main stem floodplain area) including approximately 31,700 acres of wetlands, 25,300 acres of forest, and 18,000 acres of prairie; tributary restoration of 75,000 acres (approximately 8.8 percent of total tributary floodplain area) including approximately 47,600 acres of wetlands, 13,900 acres of forest, and 13,500 acres of prairie; and aquatic restoration including 500 miles of tributary streams (16.6 percent of the approximately 3,000 miles of channelized streams) with a mix of improved instream aquatic habitat structure and channel remeandering. Restoration measures would benefit approximately 150,000 acres and 1,000 stream miles.

5. **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams), Wilmington and Kankakee Dams on the Kankakee River, Bernadotte Dam on the Spoon River, and the Aux Sable Dam. Restoration measures would result in benefits to approximately 4,280 stream miles.

6. **Water Level.** Create 107,000 acres of storage area at an average depth of 1.5 feet and 38,400 acres of infiltration. Increase water level management at navigation dams by using electronic controls, increased flow gaging, and installing new tainter gates at Peoria and LaGrange Dams. Results include an 11 percent reduction in the 5-year peak flows in tributaries, an overall average 20 percent increase in tributary base flows, and up to 66 percent reduction in the occurrence of half-foot or greater fluctuations during the growing season in the main stem Illinois River. This alternative also would see benefits accrue from drawdowns in La Grange or Peoria Pools. Water level management would result in benefits to approximately 20,900 acres and 11,000 stream miles.

7. **Water Quality.** Anticipate improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would result from sediment delivery reduction measures and water level management measures.

A. COMPONENT MEASURES IN RESTORATION PROJECTS

The following summarizes the types of measures planned for each goal as part of restoration projects. The measures described could be used in conjunction with other measures, or singly, to achieve critical restoration project goals. These projects fall under each of the goal categories. Projects and measures would be selected to optimize ecosystem integrity benefits. Project selection criteria would be developed to optimize ecosystem integrity within the framework of project objectives (Section 3, *Plan Formulation*). Costs were developed based on data from previous Rock Island District projects, other Corps projects, and, where no Corps data were available, other agencies. A detailed cost breakdown to achieve 50-year program goals is presented in Appendix E. All estimated construction costs assume a 35 percent contingency. Additionally, planning engineering and design costs were assumed to be 30 percent of construction costs, while contract supervision and administration costs were assumed to be 9 percent of construction cost. Estimated costs to acquire real estate were also included in the construction cost.

Many of the measures would address multiple goals but some are specific to individual goals. While the measures described are not an exhaustive list, they represent proven and common techniques that could be used to achieve the desired restoration goals. The restoration measures listed reflect the suggestions and input received from other Corps Districts and partnering agencies. Refinement and location of measures would occur during site-specific planning activities, adhering to the implementation framework.

1. Overarching Goal - Ecological Integrity. The overarching goal of restoration efforts is to increase the ecological integrity of the Illinois River Basin. Projects formulated under all of the other program goals would contribute towards this goal; therefore, no specific projects or alternatives were formulated for this goal.

2. Goal 1 - Sediment Delivery. Reducing sediment delivery to the Illinois River and its tributaries would be achieved through implementation of in-stream and upland measures. This part of the preferred comprehensive plan alternative would reduce sediment delivery in the Illinois River to Valley City by 20 percent. The major focus of the sediment reduction plan would be on direct tributaries to Peoria Lake, reducing sediment delivery by 40 percent. Implementation of the plan would also result in a sediment delivery reduction of 11 percent from the remainder of the basin upstream of Peoria Lake to Peoria Lake and a reduction of 20 percent from the rest of the basin downstream of Peoria Lake to Valley City. Sediment control through in-channel measures is expected to account for 75 percent of the reduction obtained. Local site conditions and project objectives will dictate specific measures to be implemented and detailed analyses of the geomorphic impacts of the sediment control measures would be conducted during project design. As indicated in Section 3 of this report, in-channel measures are likely to be most cost-effective in the southern and western portions of the watershed. For this reason, project costs were estimated based on the assumption that 75 percent of the work in the western and southern regions would consist of in-stream measures (e.g., grade control and bank stability), while the other 25 percent would consist of upland measures. In the eastern portion of the watershed, an even mix of upstream versus upland measures to control sediment delivery was assumed.

a. Grade Control. Grade control refers to any alteration that produces a more stable streambed. There are two basic types of grade control structures. The first is essentially a bed control structure, using a hard point in the stream or river for protection against the water's erosive forces. The second type is designed to reduce the energy slope in the area of concern such that the water is no longer capable of scouring the bed. The type, location, spacing of structures, and size of structures all are important considerations when designing a grade control structure(s). Rock riffles are the preferred method of grade control (photograph 4-1).

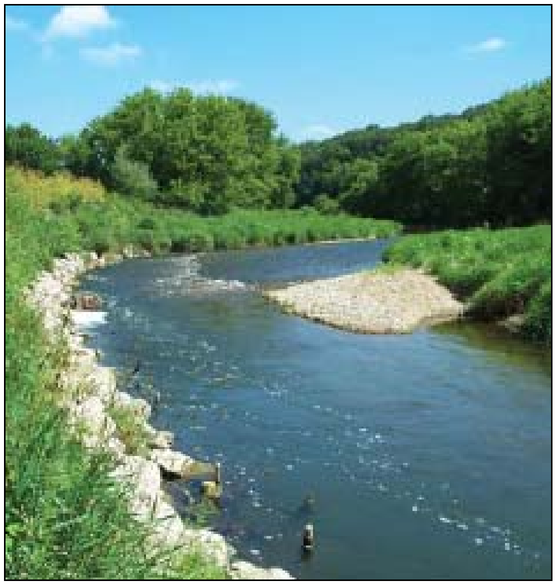
Photograph 4-1. Riffle Structure for Grade Stabilization

Rock riffles act as bed control elements, provide habitat benefits, and require little, or relatively inexpensive, operation and maintenance. Pool and riffle units provide a diverse range of hydraulic and biological niches that are critical to sustaining thriving river habitats. An assessment of channel stability should be conducted such that causes of current instability can be identified (e.g., land use changes leading to increased discharge) and remedial measures and their location can be identified. Upstream and downstream hydraulic and sediment regimes may be impacted through addition of riffle structures; therefore, careful planning should be undertaken to consider these potential ramifications. Priority would be given to areas exhibiting highly degraded habitat in the form of excessive bank erosion and head cutting with no existing pool and riffle habitats. Riffle structure design should accommodate habitat and migration needs of aquatic species.

The cost of riffle structures was estimated based on similar projects performed by the Rock Island District and then adapted to typical dimensions encountered in Illinois River tributaries. The estimated construction cost for a rock riffle structure on a major tributary was estimated to be $210,500, while the estimate for a small tributary was estimated to be $45,500. The main factor affecting the cost difference was the assumed stream width (200 feet for a major tributary, 41 feet for a minor tributary). Operations and maintenance (O&M) costs were developed based on the assumption of 5 percent replacement over a 50-year project life, which would amount to $150 per year on a major tributary and $30 per year on a minor tributary.

b. Bank Stabilization. A range of measures may be implemented to increase river or stream bank stability. Direct (e.g., riprap revetment, photograph 4-2) or indirect (e.g., barbs, bendway weirs) structural measures, generally constructed of riprap, may be used alone or in conjunction with plants, such as willow post plantings. This combination is often referred to as a bioengineered or biotechnical measure (photograph 4-3).

Photograph 4-2. Rock Revetment Used for Bank Stabilization



Photograph 4-3. Bioengineered Stone Toe Protection and Vegetation Used for Bank Stabilization (Univ. of Illinois- Urbana Champaign Water Quality Department: www.wq.uiuc.edu/Pubs/Streambank.pdf

When stream banks are directly exposed to high-velocity flows, directly placing riprap on banks can be used to prevent erosion. Another direct bank protection measure that is likely to be utilized is stone toe protection. One of the advantages of stone toe protection is that it can be placed without grading the bank line, while minimizing tree loss and construction impacts and cost. The upper portion of the bank normally revegetates on its own (resulting in further cost savings). Bendway weirs and stone toe protection can be placed riverward of the existing bank to encourage deposition and floodplain formation (also acting to trap sediment). Stream barbs are low rock sills that project out from a stream bank to redirect flow away from the bank and towards the channel centerline. Geomorphic analysis of the site conditions should be conducted prior to design and construction.

Bioengineered measures are often used in conjunction with other structural measures. As the plants grow, their roots strengthen the soil matrix. The result of using bioengineered methods often provides greater erosion protection than using plants or a structural practice alone and is generally more aesthetically pleasing than a structural practice. Costs associated with each bank stabilization measure are presented in table 4-1. The costs are separated based upon whether the measure would be applied to the main stem or a major or minor tributary. Sediment reduction benefits assume that each practice would perform at design levels. Biedenharn et al. (1997) provided a comprehensive review of stream stabilization practices and design considerations.

Table 4-1. Estimated Construction and O&M Cost for 100 Feet of Streambank Stabilization

Measure	USACE Construction Cost [1]	Estimated Annual O&M Cost
Live Planting (willow posts)		
Main stem	$21,400	$208
Major	$17,700	$171
Minor	$14,000	$134
Stone armor		

Main stem	$39,300	$ 25
Major	$32,400	$ 21
Minor	$25,400	$ 16
In-stream barb/groin/spur [2]		
Main stem	$62,100	$ 80
Major	$18,100	$ 23
Minor	$ 9,800	$ 12
Longitudinal stone toe		
Main stem	$19,900	$ 12
Major	$16,400	$ 10
Minor	$12,900	$ 8

[1] Assumes an additional 35% construction contingency, 30% Planning, Engineering, and Design, 9% Supervision and Administration, and estimated Real Estate costs
[2] Measure applied at 1 per 100 feet

No single technique or streambank restoration measure is applicable in all situations. Selection of appropriate measures would be determined based on evaluation of the engineering, economic, and environmental factors at each site.

c. Sediment Retention Structure. Sediment retention structures store runoff that is transporting suspended sediment and bed material (photograph 4-4). These structures may be designed to be self-dewatering or permanent pond.

Photograph 4-4. Sediment Retention Structure

The major factors controlling the degree of sediment retention include: physical characteristics of the transported sediment; hydraulic characteristics of the basin; inflow time distribution of sediment and water; basin geometry; and water and sediment chemistry. The cost of sediment retention structures was based on the anticipated size of the basin. The basin size is dictated by factors affecting the required storage volume, including drainage area, soils, hydrology, and topography. Design guidance can be found in the Natural Resources Conservation Service's (NRCS) National Engineering Handbook. Costs for small (1 acre), medium (5 acres), and large (150 acres) sediment retention structures were estimated to be $59,200, $195,000, and $6,616,000, respectively. Anticipated O&M costs would be associated with inspection, mowing, potential riprap replacement, and debris and sediment removal. Constructed wetlands can also be used to treat runoff water, though not as a primary settling system, since operation and maintenance require periodic clean out which would severely degrade biological functions.

d. Filter Strips. Though not used for cost estimating purposes, filter strips could serve as an important plan component. It is recommended that the use of filter strips be expanded to applicable areas by other agencies. Filter strips reduce sediment delivery by reducing overland flow velocity, which permits deposition of entrained sediment (photograph 4-5).

Photograph 4-5. Filter Strips Trap Sediment and Pollutants Before Entering a Body of Water

Solids are removed by three primary mechanisms. First, bed material load is deposited as decreased flow velocities reduce transport capacity of the flow. Second, suspended solids become trapped in the litter of the filter strip. Suspended solids trapped in the litter at the soil surface would not as readily become resuspended. However, trapping efficiency would decrease as the litter becomes inundated with sediment and may require maintenance to perform at design levels. Finally, suspended material that moves into the soil matrix along with infiltrating water can become trapped. This is the primary means by which suspended colloidal particles are trapped. Along with the sediment itself, sediment-bound nutrients and chemicals would also be deposited, resulting in better water quality for receiving bodies of water. The cost per acre of filter strips was estimated to be 50 percent of the cost of prairie plantings, as less specialized seed would be required, for a cost of $1,350 per acre. Operations and maintenance costs were estimated to be $5 per acre per year, primarily for inspection.

3. Goal 2 - Backwaters and Side Channels. Backwater and side channel restoration would be accomplished through dredging to restore and maintain deepwater aquatic habitat; island protection to maintain current islands; and measures to improve habitat diversity and depths in side-channels.

a. Dredging. The preferred comprehensive plan alternative calls for dredging 60 of the approximate 100 backwaters in the system. Currently, most backwaters on the system have very shallow depths and an average surface area of approximately 500 acres per backwater. Of the 500 acres in a typical backwater, 5 percent of the area would be dredged to a depth of at least 9 feet; 10 percent to between 6 and 9 feet; 25 percent to between 3 and 6 feet; and 60 percent would require no dredging, resulting in a total dredged area of 200 acres, or 40 percent of a typical backwater. The cost of this dredging configuration would be $19.6 million per backwater. No operations and maintenance costs would be associated with this practice as the backwater would be overdredged to account for sedimentation. Conventional dredging techniques, such as mechanical and hydraulic dredging, in addition to innovative dredging technologies would be used to achieve project goals. Design guidance for traditional dredging techniques is provided in Engineering Manual (EM) 1110-2-5025 (USACE 1983); EM 1110-2-5026 (USACE 1987a); and EM 1110-2-5027 (USACE 1987b). In addition to these standard methods, opportunities to use high-solids dredging and the use of geotechnical tubes (geotubes) would also be considered, as site conditions warrant.

Traditional hydraulic dredging and mechanical dredging with clamshells (photograph 4-6) or draglines have several limitations. These include resuspension of sediments at the point of excavation and free water entrainment in sediments, which require extensive, and potentially expensive, dewatering and return water treatment (Duke et al. 2000).

Photograph 4-6. Island Creation Utilizing a Clamshell Bucket To Mechanically Dredge Sediment

A high-solids dredging technology (photograph 4-7) could be used in place of, or in addition to, more traditional dredging technologies. This type of dredge incorporates a sealed clamshell, which removes sediment at its *in situ* moisture content. The material is then fed into a hopper of a positive displacement pump where it is pumped through a pipe to its discharge location. The discharge has the consistency of toothpaste.

Photograph 4-7. High-Solids Dredging Technology Used Where Fine-grained Sediments Are Prevalent

Specific site conditions as well as defined project objectives would dictate placement sites of dredged material. Where conditions and project objectives permit, dredged material may be used to create islands that would be of habitat value. Other potential uses of dredged sediment are placement on nearby agricultural fields, building up existing islands, or restoration of brownfields, former mined lands, gravel pits, etc. Islands create off-channel areas that are sheltered from river currents and waves. These characteristics create conditions in backwaters that are ideal for a variety of aquatic plants and animals. In addition, islands can serve as either upland or wetland habitat.

The Peoria Lake Rehabilitation and Enhancement project, part of the Environmental Management Program, was a successful project constructed in the mid-1990s (photograph 4-8). Since construction, the barrier island has reduced wave action on a portion of the lake, thereby reducing sediment resuspension and turbidity. While the improved water quality has not stimulated the growth of submergent and emergent aquatic vegetation on the lee side of the island because of undesirable water level fluctuations, the site is utilized by migratory waterfowl and the dredged channel has benefited native fish.

Photograph 4-8. Aerial View of Peoria Lake Habitat Rehabilitation and Enhancement Project

It was assumed that any design involving island creation would incorporate measures to prevent erosion of the island; therefore, there were no O&M costs directly associated with island creation.

b. Island Protection. The preferred comprehensive plan alternative calls for adding protection to 15 of the 56 existing islands on the Illinois River. For cost estimating purposes, it was assumed that each island was 1-mile long and 100-foot wide. Twenty percent of the island perimeter would be protected. Three different measures and methods—off-bank revetments, bankline revetments, and timber piles (photograph 4-9)—were evaluated to provide the 20 percent perimeter protection. Based on this assumed distribution, a representative cost for each island protection was estimated to be

$1,150,000. Annual O&M costs associated with island protection were estimated to be $1,035, under the assumption that 15 percent of the off-bank and 8 percent of the bank revetment would need to be replaced over the 50-year project life. No O&M costs would be associated with timber piles.

Photograph 4-9. Timber Piles Used to Provide Structural Depth Diversity and Island Protection

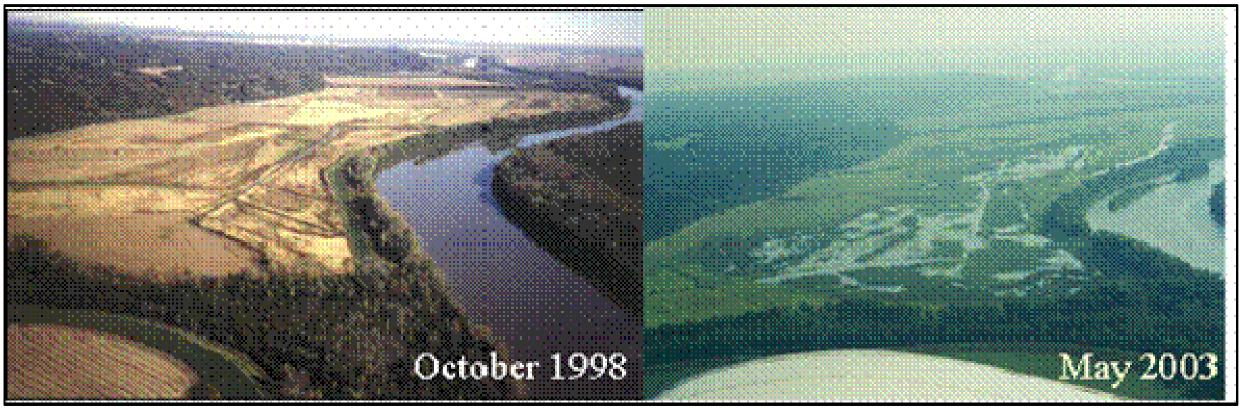
Island protection is a measure utilized to protect an existing or newly created island. Protecting islands from the effects of accelerated erosion, caused by commercial and recreational navigation and wind-fetch, is important where important habitat, private property, or archeological resources are adversely impacted. Protection of the upstream ends and banks of existing islands to maintain, and potentially restore, their historic length would be accomplished through the use of off-bank revetments (photograph 4-10) (rock or timber), bank armoring (riprap, articulating concrete blocks, A-Jacks), or groins. The advantage of articulating concrete blocks or A-Jacks is that not all of the treated surface area is covered with material, permitting vegetation to grow amongst the protection, which can offer additional stabilization and is more aesthetically pleasing. The opportunity to utilize bioengineered island protection measures where they meet project goals and objectives will be pursued.

c. Side Channel Restoration. Under the preferred comprehensive plan alternative, 35 of the 56 side channels in the Illinois River would be restored. Each side channel would be restored through a combination of off-bank structures and dredging. For purposes of cost estimation, it was assumed that stub dikes would be used to create structural depth diversity and to promote suitable hydraulic conditions in the side channel. Stub dikes are constructed of rock built nearly perpendicular to the shoreline, and extending from the shoreline approximately 30 to 40 feet. Seven stub dikes for each mile-long side channel would be used. The cost for adding stub dikes to an individual side channel was estimated to be $127,000. Operations and maintenance costs were estimated to be $164 per year, based on the assumption that 15 percent of the rock would need to be replaced over the 50-year life of the project. Creation of depth diversity could be accomplished through the use of stub dikes, wing dams, log piles, or pile dikes. Wing dams are submerged structures that are constructed perpendicular to an island or bank. Their historic purpose was to reduce flow velocity in the area of the wing dam, inducing deposition, which lead to channelization of the main channel. These flow regulating structures could be modified to increase connectivity between the main channel and off-channel areas.

Photograph 4-10. Off-Bank Revetments Used To Provide Erosion Protection on Islands

4. Goal 3 - Floodplain, Riparian, and Aquatic. The preferred comprehensive plan alternative includes the restoration of 75,000 acres of mainstem and 75,000 acres of tributary floodplain and riparian habitats and 500 miles of aquatic stream restoration. The 75,000 acres of floodplain to be restored on the main stem would be distributed according to approximate historical cover types as follows: 31,700 acres of wetlands, 25,300 acres of forest, and 18,000 acres of prairie. The distribution of the restored floodplain in the tributary areas would be 47,600 acres of wetlands, 13,900 acres of forest, and 13,500 acres of prairie. Five hundred miles of the approximately 3,000 miles of channelized streams of tributary streams would be restored.

a. Floodplain. A total of 150,000 acres of floodplain (75,000 acres mainstem, 75,000 acres tributary), would be restored under the preferred comprehensive plan alternative. Measures that were considered to improve floodplain ecological function were divided among forest, grassland (prairie), and wetland, based on historical cover type. Forest restoration would be achieved through timber stand improvement and planting mast trees. Timber stand improvement costs an estimated $8,200 per acre, with an associated annual O&M cost of $2 per acre. Tree planting would be accomplished at a tree density of 50 trees per acre at a cost of $6,100 per acre, with an associated annual O&M cost of $65 per acre. Prairie or grassland restoration would be accomplished through improvement of site conditions to benefit targeted plant species and planting desirable vegetation. The estimated cost of prairie restoration is $5,500 per acre, with an estimated annual O&M cost of $5 per acre. Wetland habitat would be created or rehabilitated through the creation of Moist Soil Management Units (MSMUs), wetland planting, and/or reconnection of floodplain areas to backwater areas. An example of a floodplain restoration project is shown in photograph 4-11.



Photograph 4-11. Before and After Photographs of Floodplain Restoration at Spunky Bottoms on the Illinois River, a Project Sponsored by the Nature Conservancy

Moist soil management units are shallow-water impoundments created by low-height levees. They incorporate water control structures to flood the impoundment during the fall and winter while reducing water levels and limiting fluctuations in the impoundment during the late spring and summer. Inundated conditions provide suitable habitat for migrating waterfowl and other animals. Summer drawdown promotes germination and growth of plants suited to moist or somewhat flooded conditions. Location of the MSMU relative to the waterfowl flyway, water source, soil type, topography, impoundment size, number of units, levee design, and design of the water control structure are important considerations in MSMU design. The estimated cost per acre of MSMU is $15,000. Estimated annual O&M costs are $20 per acre. More information on the design details of MSMUs can be found in Olin et al. (2000) and Lane and Jensen (1999). Wetland plantings would cost an estimated $8,800 per acre, with O&M costs of $7 per acre per year.

Riparian buffer strips provide much of the same functions as upland grass filter strips (see discussion of Goal 1, page IV-2). When buffer strips are created using mast trees, the strips can provide shade, which reduces water temperature; provide riparian wildlife habitat; protect fish habitat; maintain aquatic species diversity; and provide wildlife movement corridors. Photograph 4-12 shows a typical forest riparian buffer. In addition, vegetation nearest the stream or water body provides litter fall and large woody debris important to aquatic organisms. Woody roots increase the resistance of streambanks to erosion caused by high water flows and waves. The estimated cost of riparian forest buffers was estimated to be $6,100 per acre, the same as planting mast trees.

b. Aquatic Restoration. To accomplish the goal of 500 miles of stream restoration, a combination of riffle structures and stream re-meandering would be used. A brief description of riffle structures can be found in this section under Goal 2, page IV-7. The construction and O&M costs for riffle structures can also be found under Goal 2. Approximately 20 percent of the riffle structure would be constructed in major tributaries with the remainder in minor tributaries. The density (number per mile) of riffle structure partly depends on stream width. For this reason it was assumed that four structures per mile would be required for major tributaries, while minor tributaries would require 22 structures per mile.

Photograph 4-12. Forest Riparian Buffer

Channel re-meandering is a complex subject. Historic and present land use, geology, hydrology, hydraulics, and sediment transport must be considered. Restoring meander planform geometry can be accomplished by analyzing historical maps or meander scars left on the floodplain (Soar and Thorne 2001). However, this method is applicable only if historic hydrologic and sediment regimes are deemed to be representative of the restored channel. Changes in land use may have altered the hydrologic and sediment regimes such that they no longer support a historic meander planform. Soar and Thorne (2001) detail the considerations and design procedure for channel restoration. The cost of channel re-meandering depends greatly on channel dimensions. For major tributaries, it was estimated to cost $177,000 per 100 feet of channel, or $9,350,000 per mile. For minor tributaries, the cost was estimated to be $97,000 per 100 feet of channel, or $5,125,000 per mile. Operations and maintenance costs were estimated to be $713 and $365 for major and minor tributaries, respectively.

5. Goal 4 – Connectivity. Connectivity would be restored by providing fish passage at all dams on the Fox River, all dams on the west branch of the DuPage River, all dams on the Des Plaines River, at Salt Creek (a tributary of the Des Plaines River), the Wilmington and Kankakee Dams on the Kankakee River, the Bernadotte Dam on the Spoon River, and the Aux Sable Dam on the Aux Sable River. These locations were selected because they would provide significant benefit. However, should opportunities to restore connectivity at other locations arise, they would be explored. This portion of the preferred comprehensive plan alternative is estimated to cost $35 million. The total cost was estimated by adding a rock ramp for fish passage. Any decision regarding dam removal would require considerable planning, not only to account for physical impacts, but also cultural impacts.

Dams may be removed for several reasons. They may be structurally or economically obsolete or pose an unnecessary safety concern. In addition, a dam may be removed for ecological restoration (Heinz Center 2002). Under this program, the primary reason for dam removal would be for ecosystem restoration. Dam removal carries with it potential physical, chemical, ecological, economic, and social considerations. Physical effects on the system are hydrology, sediment, and geomorphology; because of the importance of sediment delivery in this system, geomorphological changes and sediment stabilization must be addressed in the design of potential dam removal projects. Negative chemical effects could occur downstream of a removed dam if contaminated sediments are located at the site. Dam removal generally has a positive ecological effect, as fish and other aquatic organisms are able to access more areas of a river; however, invasive species may also become more widespread. Social and economic effects include aesthetics of the dam site and surrounding areas that are impacted by dam removal, potential changes in property values, loss a of culturally significant site, and other economic factors depending on the use and state of the dam.

Several types of fish passage are available and can be classified into vertical slot, Denil, weir, and culvert fishways (Katopodis 1992). Excavated bypass channels backfilled with rock and formed into sills or weirs are also utilized to pass fish and other aquatic organisms around a dam. A rock ramp (photograph 4-13) from the face of a dam to the downstream channel bottom can be used as an alternative to an excavated channel bypass. The most important factors to be considered in fishway design are the hydraulic characteristics of the fishway and the swimming ability and behavior of the fish species to be passed. Fishway efficiency depends on attracting fish to the fishway and providing adequate passage conditions through the fishway and at its exit. Entrance conditions at fishways are critical for attracting fish. Most fish swim in a burst and rest pattern (Katopodis 1992); therefore, it is important to ensure that any fishway is designed such that it has suitable resting spots, as in a pool and riffle design, and that velocities and the lengths over which the velocities occur, do not exceed the targeted species capabilities.

Photograph 4-13. Rock Ramp on the Otter Tail River, Minnesota

6. Goal 5 - Water Levels

a. Stormwater Storage. The preferred comprehensive plan alternative calls for the addition of 160,000 acre-feet of stormwater storage. Tributary hydrologic regimes would be modified by increasing the volume of stormwater storage available within each tributary watershed so that runoff from relatively small events, including those expected to occur every 2 years or more frequently, would be temporarily held back before being released downstream. This storage might take various forms including tile management, detention structures or expanded riparian areas that provide ecological benefits in addition to flood storage. The estimated cost for stormwater storage was based on the assumption of an impoundment constructed to hold water at a depth of 1.5 ft. This cost was estimated at $2,880 per acre-feet with an O&M cost of $5 per acre-feet per year. Since these will be designed to address small events they may have little or no effect on large events; this study does not claim any flood damage reduction benefits from this storage.

b. Increasing Infiltration. This portion of the preferred comprehensive plan alternative would create 38,400 acres of infiltration area. Another approach to improve tributary hydrologic conditions is directing runoff to areas where it can infiltrate into the soil. Infiltration requires the proper soil and subsoil conditions, but if conditions are appropriate, infiltration could be accomplished using tile management or conservation practices, such as filter strips or structures consisting of grassed fields enclosed within a berm. Infiltration can also be increased throughout watersheds using practices that reduce runoff generation or allow runoff to infiltrate close to the point it is generated. Conservation practices on agricultural land that result in more infiltration are conservation tillage and no-till farming. The cost per acre of infiltration practice was estimated to be $7,500, which represents an average of $14,500 per acre of upland pond and $500 per acre of grass filter strip. Average O&M costs are estimated to be $7 per acre.

c. Main Stem Water Level Management. Components of this part of the preferred comprehensive plan alternative would upgrade the controls on dams, revise seven dam regulation manuals, and install 10 flow gages. More intense water level management at the main stem locks and dams, that is, more frequent small gate changes based on a more complete knowledge of pool inflows, would reduce the number of water level fluctuations along the river, especially immediately downstream of the dams. Additional management changes may further reduce fluctuations. To enable this more intense management, dam gate equipment will be upgraded to allow changes to be made more frequently without increasing manpower requirements. These estimated costs are $3,000,000 for new equipment and $756,000 for revision of dam regulation manuals. Tainter gates would be constructed at Peoria and LaGrange Locks and Dams at an estimated cost of $26.6 million each. Also, additional gages would be maintained along the river and significant tributaries to support real-time management decisions, at a cost of $20,250 per gage, with annual O&M costs of $12,500 per gage.

d. Navigation Pool Drawdown. The Upper Mississippi River- Illinois Waterway Navigation Study estimated the cost to conduct drawdowns as the cost to dredge to maintain minimum channel conditions and access to facilities. This cost would create conditions to allow multiple drawdowns over the course of the project life. Preliminary estimates for Peoria Pool and La Grange Pool indicated that an additional 47,000 and 204,000 cubic yards, respectively, of dredging would be required every 10 years to maintain navigation during 1.5 foot drawdowns of these two pools. Assuming that drawing down Peoria Pool by 2 feet would require twice this amount and that the quantities required for a one-foot drawdown of La Grange Pool would be the same, this leads to additional maintenance dredging of 470,000 cubic yards of material in Peoria Pool and 1,020,000 cubic yards in La Grange Pool. Additional dredging would be required to maintain facility access: Appendix C identifies 12 marinas and 20 industrial facilities that would be affected by a drawdown in Peoria Pool and would have to be dredged an additional five times over 50 years.

Using $8 per cubic yard dredging and placement costs (and assuming that placement areas are available), and $25,000 per facility dredging event (from Navigation Study), the added cost to maintain these conditions in Peoria Pool is approximately $14.6 million. Assuming that a similar number of facilities would be impacted in the La Grange Pool, the preliminary cost for maintaining drawdown conditions in that pool can be estimated as $22.9 million. It should be noted that these costs do not reflect additional economic costs such as loss of recreation due to lower water levels. Occasional temporary pool drawdowns would allow sediment to compact and would encourage aquatic plant growth in areas that are currently inundated continuously. During moderate to low-flow periods water levels can be maintained at lower levels at the Peoria and La Grange Locks and Dams but the successful drawdown requires that higher flow conditions, such as due to extensive thunderstorms in the basin, do not occur during the drawdown period. Drawdowns are most likely to be successful in the late summer or fall but would be most beneficial in late spring or early summer, so timing is a key consideration. Also, lower water levels have the potential to adversely affect recreational navigation and water supply uses.

7. Goal 6 - Water and Sediment Quality. Measures to address water quality are described in the previous goals. Those measures targeting sediment reduction would also have a positive impact on increased water clarity. Additionally, a reduction in sediment-bound nutrients and chemicals would be expected, contributing to enhanced water quality.

8. Adaptive Management. An active adaptive management program is recommended in conjunction with construction and monitoring programs to ensure the attainment of restoration outputs and seek opportunities to reduce overall project costs below the current estimates. The systematic process of modeling, experimentation, and monitoring would compare the outcomes of alternative restoration or management actions. Based on the large study area, the complexity of the ecosystem restoration, and the opportunities for increased cost effectiveness, Illinois River Basin Restoration projects should include funding for adaptive management of up to 3 percent of the construction implementation costs. If, over time, less adaptive management funding is needed, these funds would be applied to implementing other restoration projects. The adaptive management component is described in more detail in Section 6 of this report, *Plan Implementation.*

9. Technologies and Innovative Approaches. A Technologies and Innovative Approaches component would address the other three components called for in Sec 519 (b)(3)—a long-term resource monitoring program; a computerized inventory and analysis system; and a program to encourage innovative dredging technology and beneficial use of sediments. One of the most critical aspects assessing ecosystem responses is that a scientifically rigorous long term monitoring program should be implemented from the onset of any restoration process (Likens 1992). These long term data provide the foundation for evaluating accomplishment of program goals. This information feeds back into the adaptive management process as more knowledge is gained on how a given ecosystem works. This feedback will work specifically towards measuring accomplishments made towards restoration goals and objectives, and will also identity areas where additional work may be needed. Long term data are also essential in providing information that will assist in understanding the underlying processes that define an ecosystem's structure and function, which can also be useful in implementation of restoration projects (Thomas 1999). All of these aspects highlight the fact that dedication and support of long term study of an ecosystem is a fundamental requirement for restoration. The information gained will provide invaluable insight for managers, scientists, and policy makers to make decisions in the future. The over-riding mechanism for this process is such that as long term information is fed into the iterative, adaptive management process, to provide a direct means to gauge the efficiency and efficacy of restoration work. The outputs of all monitoring efforts would be closely coordinated with project teams and adaptive management efforts to maximize the effectiveness of restoration activities.

a. **System-Level & Goal Level Monitoring.** System-level monitoring would be designed to develop a snapshot of the overall system health using system indicators. Goal-level monitoring would integrate and build on existing monitoring data to evaluate the progress in each of the supporting goals, thereby indicating progress for each particular system-limiting factor identified by the project team (reducing sediment delivery, improving backwater habitats, etc.). This plan acknowledges that a certain degree of systemic risk and uncertainty exist in a large, dynamic system such as the Illinois River Basin. Long term resource monitoring is an effective means of reducing risk and uncertainty inherent in project planning in this environment. Long term resource monitoring will result in better projects that return higher benefits for less cost.

b. **Project Level Monitoring.** Project-specific monitoring is critical to validating and refining the approach to system restoration. Monitoring results provide information on the need for adaptive management and help direct future restoration efforts to the most cost effective techniques helping to guide design improvements to better meet ecosystem goals.

c. **Computerized Inventory and Analysis (CIA) System.** A CIA would be developed to inventory and analyze monitoring information. All monitoring data will be posted to a CIA.

d. **Special Studies.** These efforts would be directed at efforts to improve the understanding of the condition of the system and improve the analysis techniques available.

e. **Innovative Sediment Removal and Beneficial Use Technologies.** Technologies would be evaluated and tested to evaluate more ecologically sound, cost effective, and beneficial ways to dredge and place material. These efforts would be closely coordinated with ongoing Corps activities related to dredging and regional sediment management. Potential efforts include demonstrations of various methods to build islands and utilize sediments on farmland as a soil amendment. Funding would be drawn from special studies or incorporated in construction activities.

B. IMPLEMENTATION THROUGH 2011 AND 2015

The Comprehensive Plan recommendations call for continuing restoration efforts under the existing authority of Section 519. Corps of Engineers cost shared restoration efforts would begin with $131.2 million in funding through 2011 (Tier I), increasing to $345.6 million in restoration efforts through 2015 (Tier II).

Implementation of the Comprehensive Plan would include three major elements:

1) System Management
2) Critical Restoration Projects
3) Technologies and Innovative Approaches
    a. System-Level, Goal Level, and Site-Specific Monitoring
    b. Computerized Inventory and Analysis (CIA) System
    c. Special Studies
    d. Innovative Sediment Removal and Beneficial Use Technologies

Each of these components is described in more detail in Section 6 of this report

The recommendation for the 7-year authorization, or Tier I, (table 4-2) includes extending the current authorization through 2011 and increasing the total funding authorization to $131.2 million. This funding level would provide approximately $122.3 million for restoration projects; $6.1 million for developing technologies and innovative approaches (includes $2.6 million for system monitoring, $3.5 million for site-specific monitoring, $0 for a computerized inventory and analysis system, and $0 for special studies); and $2.75 million for system management. Restoration efforts would be cost shared 65 percent Federal, or $85.3 million, and 35 percent non-Federal, or $45.9 million. The annual O&M costs for features constructed through Tier 1 (2011) are estimated to be $125,000.

Table 4-2. Program First Costs Through Implementation of Tier I
(October 2003 Price Levels)

Lands and Damages	$ 18,000,000
Fish and Wildlife Facilities	$ 71,950,000
Planning, Engineering, and Design	$ 27,680,000
Construction Management	$ 4,680,000
Technologies and Innovative Approaches	$ 6,140,000
System Management	$ 2,750,000
Total Program Costs	**$131,200,000**

The recommendation for the 11-year authorization, or Tier II, (table 4-3) includes extending the current authorization through 2015 and increasing the total funding authorization to $345.6 million. This funding level would provide approximately $309.1 million for restoration projects, $30.8 million for developing technologies and innovative approaches (includes $18.6 million for system monitoring, $9.0 million for site-specific monitoring, $1.2 million for a computerized inventory and analysis system, and $2 million for special studies), and $5.75 million for system management. Restoration efforts would be cost shared 65 percent Federal, $224.6 million, and 35 percent non-Federal, $121 million. The annual O&M costs for features constructed through Tier II (2015) are estimated to be $201,000.

The following sections highlight the types of efforts to be accomplished under each of the three major elements—System Management, Critical Restoration Projects, and Technologies and Innovative Approaches. Cumulative component costs for both Tier I and Tier II are presented in table 4-3, and annual component costs are presented in table 4-4. Section 6, *Plan Implementation*, includes additional detailed information about implementation of the selected plan.

1. System Management. Considerable management and coordination efforts would be required to manage the comprehensive ecosystem restoration program. Efforts associated with management include direct costs for Corps of Engineers Project Management and Illinois DNR staff. Management costs would correspond with the size of the program, and are estimated to be approximately $750,000 in 2011 and 2015.

2. Critical Restoration Projects. The majority of the funding, roughly 93 percent or $122.3 million (including $3.1 million in adaptive management if required) of the initial $131.2 million would be targeted to address component 3.B of Section 519 (WRDA 2000) calling for the development and implementation of a program to plan, design, and construct restoration projects. By 2015, approximately 89 percent , or $309 million, of the $345.6 million program would be used to construct restoration projects. While all goal categories are important and would be addressed to some extent in efforts through 2015, initial activities will emphasize the most critical restoration issues: reduce sediment delivery (Goal 1), restore side channels and backwaters (Goal 2), and reduce water level fluctuations (Goal 5). The following priority areas will be addressed initially, with potential for more depending on actual costs. The descriptions below describe restoration efforts through 2011 and 2015.

a. **Small Watersheds.** Specific projects would address sediment delivery, riparian restoration, and water level fluctuations. Activities would seek 20 to40 percent reductions in sediment delivery from these areas, 11 percent decreases in 5-year peak flow, and 20 percent increase in base flow on the assumption of a continuation of 1970-2000 climatic conditions. Roughly one third of these tributaries would be direct tributaries to the Peoria Pool and two thirds spread throughout the basin.

   i. **Tier I (2011).** Complete restoration activities in eight small watersheds with drainage areas of roughly 100 square miles each. The Illinois River Basin contains approximately 300 areas of this size. Start or complete feasibility investigation for an additional five small watersheds. Estimated costs through 2011: $59.54 million.

   ii. **Tier II (2015).** Complete or start restoration of 20 small watershed projects and completed feasibility investigations for four additional small watersheds. Estimated costs through 2015: $171.9 million.

b. **Major Tributaries.** Focuses would include sediment reduction; floodplain, riparian, and aquatic restoration; and fish passage.

   i. **Tier I (2011).** Restore two reaches of the eight major tributaries and start restoration of one additional reach. Estimated costs through 2011: $12.1 million.

   ii. **Tier II (2015).** Restore three reaches and start restoration of one additional reach. Estimated costs through 2015: $23.2 million.

c. **Mainstem.** Efforts would address backwater and side channel degradation and restore system limiting aquatic and floodplain habitat. Projects would be divided approximately equally among the three lower pools (Peoria, LaGrange, and Alton).

   i. **Tier I (2011)-** Complete restoration of two backwater, start construction on one additional backwater, and complete feasibility investigation on one additional backwater- $29.8 million. Start construction of four side channel/ island restoration projects in two pools- $8.73 million. Restore one floodplain area and start feasibility one additional floodplain area - $7.2 million. Complete feasibility investigation for one pool drawdown in one mainstem pool- $1.8 million. Estimated total costs through 2011: $47.53 million.

   ii. **Tier II (2015).** Complete restoration of four backwaters and complete planning and design of two additional backwaters- $59.7 million. Complete construction of four side channel/ island restoration projects in two pools and start construction of four additional projects- $13.7 million. Restore two floodplain areas- $11.6 million. Complete pool drawdown in one mainstem pool- $20.5 million. Estimated total costs through 2015: $105.5 million.

3. Technologies and Innovative Approaches. Approximately 5 percent, or $6.1 million, of the $131.2 million authority would be utilized to conduct a Technologies and Innovative Approaches component. By 2015, approximately 9 percent, or $30.7 million of the $345.6 million dollar program would be used for technologies and innovative approaches.

- **a. System-Level & Goal Level Monitoring.** Estimated costs through 2011: $2.625 million. Estimated costs through 2015: $18.625 million.

- **b. Project Level Monitoring.** Estimated costs through 2011: $3.5 million. Estimated costs through 2015: $9 million.

- **c. Computerized Inventory and Analysis (CIA) System.** Estimated costs through 2011: $0. Estimated costs through 2015: $1.2 million.

- **d. Special Studies.** Estimated costs through 2011: $0. Estimated costs through 2015: $2 million.

- **e. Innovative Sediment Removal and Beneficial Use Technologies.** Funding would be drawn from special studies or incorporated in construction activities.

Table 4-3. Comprehensive Plan Cumulative Component Costs

Illinois River Basin Restoration Comprehensive Plan													
Cumulative Component Costs (in 000's of Dollars)													
							TIER 1					**TIER 2**	
Component	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**		**Year 8**	**Year 9**	**Year 10**	**Year 11**	
Technologies and Innovative Approaches	**$0**	**$75**	**$767**	**$1,626**	**$2,924**	**$4,624**	**$6,143**	**4.7%**	**$12,297**	**$18,262**	**$24,430**	**$30,784**	**8.9%**
System Monitoring	$0	$0	$350	$775	$1,275	$1,875	$2,625	2.0%	$6,625	$10,625	$14,625	$18,625	5.4%
Site-Specific Monitoring	$0	$75	$417	$851	$1,649	$2,749	$3,518	2.7%	$4,872	$6,037	$7,405	$8,959	2.6%
Computerized Inventory and Analysis System	$0	$0	$0	$0	$0	$0	$0	0.0%	$300	$600	$900	$1,200	0.3%
Special Studies	$0	$0	$0	$0	$0	$0	$0	0.0%	$500	$1,000	$1,500	$2,000	0.6%
System Management	**$0**	**$100**	**$200**	**$800**	**$1,400**	**$2,000**	**$2,750**	**2.1%**	**$3,500**	**$4,250**	**$5,000**	**$5,750**	**1.7%**
Critical Restoration Projects	**$711**	**$4,426**	**$15,833**	**$30,717**	**$58,128**	**$95,891**	**$122,305**	**93.2%**	**$168,765**	**$208,774**	**$255,740**	**$309,109**	**89.4%**
Sub Watershed (Minor Tributary)	$73	$1,062	$3,670	$7,704	$23,774	$51,515	$59,540	45.4%	$78,406	$96,675	$125,423	$171,948	49.7%
Major Tributary	$433	$867	$1,614	$2,398	$6,509	$8,872	$12,096	9.2%	$16,040	$16,599	$18,806	$23,183	6.7%
Floodplain Restoration (Main Stem)	$16	$37	$1,788	$5,232	$6,975	$7,093	$7,211	5.5%	$7,446	$8,180	$11,589	$11,595	3.4%
Pool Drawdown (LaGrange Pool)	$0	$0	$0	$0	$435	$870	$1,816	1.4%	$10,386	$19,732	$20,511	$20,511	5.9%
Backwater Restoration (Dredging)	$189	$2,269	$8,316	$13,960	$17,795	$20,141	$29,812	22.7%	$39,693	$49,367	$59,266	$59,680	17.3%
Side Channel Restoration/ Island Protection	$0	$191	$445	$990	$1,408	$5,068	$8,728	6.7%	$12,339	$12,600	$13,157	$13,650	3.9%
Adaptive Management	$0	$0	$0	$434	$1,232	$2,332	$3,101	2.4%	$4,454	$5,620	$6,988	$8,542	2.5%
TOTAL	**$711**	**$4,601**	**$16,801**	**$33,143**	**$62,452**	**$102,515**	**$131,198**	**100.0%**	**$184,561**	**$231,286**	**$285,170**	**$345,643**	**100.0%**
Federal Share of Total	$462	$2,991	$10,920	$21,543	$40,594	$66,634	**$85,279**		$119,965	$150,336	$185,360	**$224,668**	
Operations and Maintenance	$0	$0	$0	$0	$1	$28	**$93**		$218	$344	$493	**$694**	

Table 4-4. Comprehensive Plan Annual Component Costs

Illinois River Basin Restoration Comprehensive Plan Annual Component Costs (in 000's of Dollars)													
							TIER 1				TIER 2	TOTAL	
Component	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Years 1-11**	**% of Total**
Technologies and Innovative Approaches	**$0**	**$75**	**$692**	**$859**	**$1,298**	**$1,700**	**$1,519**	**$6,153**	**$5,965**	**$6,168**	**$6,354**	**$30,784**	**8.9**
System Monitoring	$0	$0	$350	$425	$500	$600	$750	$4,000	$4,000	$4,000	$4,000	$18,625	5.4
Site-Specific Monitoring	$0	$75	$342	$434	$798	$1,100	$769	$1,353	$1,165	$1,368	$1,554	$8,959	2.6
Computerized Inventory and Analysis System	$0	$0	$0	$0	$0	$0	$0	$300	$300	$300	$300	$1,200	0.3
Special Studies	$0	$0	$0	$0	$0	$0	$0	$500	$500	$500	$500	$2,000	0.6
System Management	**$0**	**$100**	**$100**	**$600**	**$600**	**$600**	**$750**	**$750**	**$750**	**$750**	**$750**	**$5,750**	**1.7**
Critical Restoration Projects	**$711**	**$3,715**	**$11,407**	**$14,884**	**$27,410**	**$37,763**	**$26,414**	**$46,460**	**$40,010**	**$46,966**	**$53,369**	**$309,109**	**89.4**
Adaptive Management	$0	$0	$0	$434	$798	$1,100	$769	$1,353	$1,165	$1,368	$1,554	$8,542	2.5
Sub Watershed (Minor Tributary)	$73	$990	$2,608	$4,034	$16,070	$27,741	$8,026	$18,865	$18,269	$28,748	$46,525	$171,948	49.7
Major Tributary	$433	$433	$747	$784	$4,112	$2,362	$3,224	$3,945	$559	$2,207	$4,377	$23,183	6.7
Floodplain Restoration (Main Stem)	$16	$22	$1,751	$3,444	$1,743	$118	$118	$235	$735	$3,408	$6	$11,595	3.4
Pool Drawdown (LaGrange Pool)	$0	$0	$0	$0	$435	$435	$946	$8,570	$9,347	$779	$0	$20,511	5.9
Backwater Restoration (Dredging)	$189	$2,080	$6,047	$5,644	$3,835	$2,346	$9,671	$9,881	$9,674	$9,898	$415	$59,680	17.3
Side Channel Restoration/ Island Protection	$0	$191	$254	$545	$418	$3,660	$3,660	$3,611	$261	$557	$493	$13,650	3.9
TOTAL	**$711**	**$3,890**	**$12,199**	**$16,343**	**$29,309**	**$40,063**	**$28,683**	**$53,363**	**$46,725**	**$53,884**	**$60,474**	**$345,643**	**100**
Federal Share of Total	$462	$2,529	$7,930	$10,623	$19,051	$26,041	$18,644	$34,686	$30,371	$35,024	$39,308	**$224,668**	**65**
Operations and Maintenance	$0	$0	$0	$0	$1	$27	**$65**	$125	$126	$149	**$201**	**$694**	