of the outputs, risk and uncertainty, and the success and cost of comparable projects also weigh in the decision. The Recommended Plan restores a significant resource while preserving another. It is acceptable to the major stakeholders. The plan is effective, efficient, and complete. Comparison to other projects is difficult due to its uniqueness. Past environmental restoration projects have compared average annual cost to AAHUs to identify whether projects are justified. For this project, a straight comparison is misleading because the benefits were normalized to a maximum score of 100.

When upstream HUs are combined with the site-specific benefits, it would suggest that the Recommended Plan might provide between 176 and 308 AAHUs. More details can be found in Appendix C. Based on an average annual cost of $411,700, this would provide an average cost per AAHU ranging between $1,337 and $2,339 per AAHU.

7. RECOMMENDED PLAN

7.1 General

The Recommended Plan is Alternative 2C: Eastern Diversion with Southern Riffles. A drawing of the Recommended Plan can be found on plate 7. This plan consists of dredging 15 acres, building a diversion berm to reroute the river along the eastern diversion route, excavating the eastern diversion channel for additional conveyance, adding three riffle structures at the southern end of the new channel, and enhancing existing wetlands with dredged material.

7.2 Design Considerations

This section summarizes the design effort to date. More specific design considerations and calculations can be found in the report appendices. Appendix F contains geotechnical considerations; Appendix G contains water quality considerations; Appendix H contains hydrology and hydraulic issues; and Appendix I contains structural engineering issues.

It should be noted that Appendix D contains the Hazardous, Toxic, and Radioactive Waste (HTRW) Documentation Report. However, since no HTRW issues were identified, it did not affect the design. Therefore, no further discussion of HTRW-related design considerations will be included in this section.

7.2.1 Dredging

General Considerations - Dredging is recommended to add variation of depth to the lake, which is conducive to a greater variety of fish habitat. Fifteen acres of lake bottom would be dredged to a depth of 8 feet. In addition to lake dredging, the diversion channel would be excavated using dredging technology. All side slopes would be dredged to a 3:1 (H:V) slope to discourage bankline sloughing. Dredge cuts would be placed in areas less likely to accumulate sediment. It is anticipated that 138,625 cubic yards of material would be dredged from Lake Belle View. Of that material, 43,687 cubic yards would be used for wetland enhancement. The remaining material would be stored in a confined disposal facility (CDF). This area would be surrounded by berms for additional volume containment. In addition, a rock weir would be added for drainage.

Water Quality Considerations - Deepening the lake by 6 feet in designated areas would lower the mean temperature of water exiting the lake by lowering the percentage of water in the lake exposed to the surface, thus limiting surface-atmosphere heat exchange. However, the Recommended Plan increases retention time in the lake; thus, the mean temperature in Lake Belle View during the summer months is expected to increase. Dredging the lake lessens this increase by reducing the surface-atmosphere heat exchange.

Geotechnical Considerations - Borings indicate that the material to be dredged consists mainly of sands, especially at depths below 2 to 4 feet. The most cost-effective method of dredging for these materials is by hydraulic dredging. Because of the silty nature of the upper sediments in the bottom of Lake Belle View, mechanical excavation equipment would bog down in the bottom of the lakebed. Non-uniform, or stepped, dredge cuts are recommended for this operation. Though some sloughing is anticipated in association with the dredging, it is not expected to affect the stability of the deeper marine environment during the project life. Side slopes of the dredged area would be 3:1 (H:V) to limit sloughing.

The berms of the CDF would be constructed with cohesive materials taken from the borrow site. These berms would be semi-compacted and built with 2.5:1 (H:V) embankment slopes in accordance with EM 1110-2-5027, "Engineering and Design - Confined Disposal of Dredged Material". In order to save time and money during construction, a portion of the diversion berm would be used as the northern boundary of the containment area. See plate 7 for the location of the CDF. Refer to Appendix F for boring logs.

Hydraulic and Hydrologic Considerations - Periodic drawdowns would be recommended to compact sediments within the lake.

Structural Considerations - There are no structural considerations for this feature.

7.2.2 Diversion Berm

General Considerations - A diversion berm would be created around the northern and eastern shores of Lake Belle View using suitable cohesive materials taken from the borrow site located just to the west of Lake Belle View. The alignment begins at the peninsula park and ends at the placement site on the western shore. This berm would transport the majority of flow from the Sugar River around the impoundment, which would lead to cooler water temperatures and better water quality downstream. This berm would have a 10-foot top width, with 3:1 (H:V) side slopes, built to an elevation of 862 feet NGVD at the upstream end of the berm. According to Wisconsin Administrative Code Ch. NR 333, Dam Design and Construction, any berm with 6 feet or more of head differential is considered to be a dam. Thus, the area from the peninsula park to the middle riffle structure is considered to be a dam, approximately 1,000 feet in length. Therefore, this section of the berm would be constructed in accordance with dam regulations, designed by a Professional Engineer, and submitted to Wisconsin dam safety personnel for review and approval.

In addition to the above-indicated berm, which provides a 50-year level of separation between the river and the lake, an overflow structure would be installed. This overflow structure would be built at the 25-year level to accommodate overtopping at a specific location, lessening or preventing damage to the rest of the system during large flood events.

In order to control the carp population, a carp gate, similar to the one used successfully at Lake Butte des Morts, Wisconsin, would be placed adjacent to the overflow structure at the upstream end of the berm. This carp gate would prevent carp and other rough fish from entering the lake, but would allow boat passage by non-motor vessels. In addition, the carp gate would allow for oxygenated water to pass into Lake Belle View, thereby preventing fish kills due to low oxygen levels. A detailed explanation of the operation of carp gates can be found in Appendix H - Hydrology and Hydraulics.

Water Quality Considerations - The carp gate would be positioned in such a manner as to limit the introduction of bedload sediment into Lake Belle View. This would limit some of the current sedimentation problems the lake experiences.

Dissolved phosphorous levels within the lake should decrease as a direct result of the decrease in sediments. Downstream temperature should also decrease as a result of river diversion and dredging.

Geotechnical Considerations - Borrow material for the diversion berm construction would be obtained from the borrow area located immediately west of Lake Belle View. This area would be used as a CDF once all borrow operations are complete. The material in this area has been tested and found to be of suitable quality. Refer to Appendix F for boring logs. The dredge cuts adjacent to the diversion berm were a logical first place to obtain borrow material. Unfortunately, this material is soft and has a high organic content, making it unsuitable for berm construction. The use of the underlying sand and gravel is not recommended due to through-seepage issues and erosion concerns.

The diversion berm would be constructed from the cohesive material taken from the borrow/CDF area. The berm would be constructed with 3:1 (H:V) sideslopes. However, when the channel is excavated, it would cut through the existing clay layer to the sand layer underlying the site. At this transition, the sideslopes would be shaped to 5:1 (H:V) to lend stability to the slopes. Bedding stone and riprap would be placed on these slopes to prevent erosion from the channel velocity. Figure 7.1 illustrates the existing conditions with the channel excavation. Refer to plate F-9 for the stability analysis of this system.

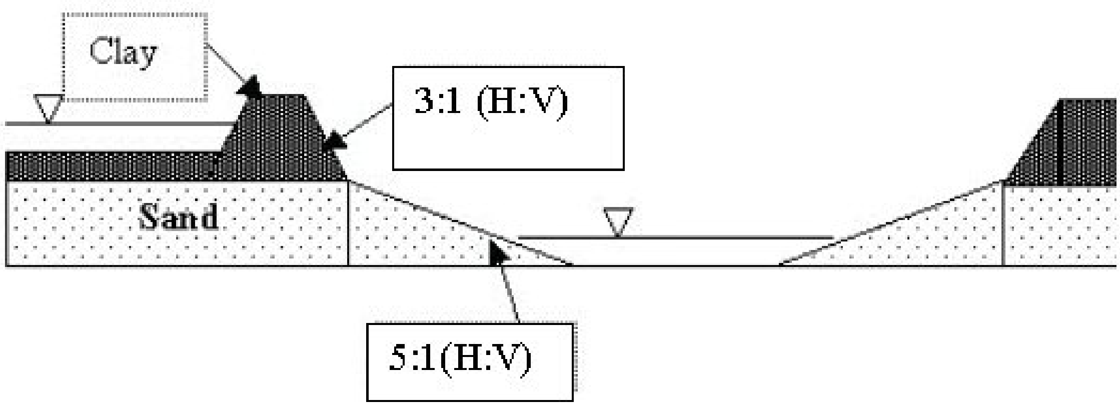

Figure 7.1. Schematic of proposed channel slopes.

In order to provide suitable foundation material for the berm, 2 feet of 400-pound top weight riprap would be used to found the berm. This rock would displace any soft sediment, yielding a foundation suitable for placement of the diversion berm. In addition, this foundation would allow construction equipment to access the area, once the lake is dewatered. The diversion berm must be constructed prior to dredging the lake. Once dredged material is placed in the CDF, the clay material needed to construct the diversion berm would no longer be accessible.

The diversion berm foundation sands exhibit seepage characteristics similar to the sand levee systems on the Mississippi River during high water. The Rock Island District has adopted a design that dictates a 5:1 (H:V) landside slope for these sand levees. This design has proved to be reliable over many years and high water events. It also has been shown that this slope exhibits sliding stability safety factors of approximately 1.5, making it a desirable design for the Lake Belle View diversion berm. Therefore, for berm sections with head differentials greater than 6 feet, 5:1 (H:V) side slopes are recommended.

Hydraulic and Hydrologic Considerations - The diversion berm is designed to a height of 50-year (862 ft NGVD) separation between the river and the lake. However, in order to avoid impact to the 100-year flood profiles in the area, an overflow spillway must be constructed at the 25-year separation level, 861 feet NGVD. This spillway must be riprapped to avoid erosion. The spillway is designed to be 300 feet long.

Structural Considerations - Final design of the carp gate would be completed in the plans and specifications phase of the project. The gate design would include the ability to limit inflow during drawdowns of Lake Belle View.

7.2.3 Channel Excavation

General Considerations - The current channel in the proposed river diversion area is not large enough for the anticipated water conveyance. Therefore, a larger channel would be excavated. This channel excavation would have 3:1 (H:V) side slopes, with the exception of the area where the excavation penetrates the sand layer, where slopes would be 5:1 (H:V) for slope stability. Excavation would begin at the peninsula park and end at the upstream riffle structure, a distance of approximately 1,500 feet. It is estimated that 33,212 cubic yards of material would be excavated and placed in the CDF or the wetland enhancement area. This excavation must occur prior to the installation of riffle structures.

The Bross Circle Bridge would be replaced since the existing bridge is not long enough to span the design width of the new channel, and the anticipated remaining life of the bridge is less than the design life of the project.

Water Quality Considerations - There are no additional water quality considerations associated with this feature.

Geotechnical Considerations - Refer to the Diversion Berm Geotechnical Considerations. These considerations also apply to channel excavation.

Hydraulic and Hydrologic Considerations - There are no additional hydraulic or hydrologic considerations associated with this feature.

Structural Considerations - The Bross Circle Bridge would need to be replaced. The current bridge does not have a span wide enough to accommodate the design channel. In addition, the current bridge is only one lane wide and has limited design life remaining.

It is recommended that a bridge capable of supporting the AASHTO HS20 design vehicle replace the current bridge. This would allow for access of emergency vehicles, maintenance vehicles, and the occasional traffic the bridge currently receives. In addition, the bridge would be widened from one 16-foot-wide lane to two 12-foot-wide lanes. This would accommodate more uniform traffic flows. Final design of this structure would be completed in the plans and specifications phase of this project.

7.2.4 Riffle Structures

General Considerations - Three riffle structures would be constructed to act as fish passage structures for the excavated channel. Refer to plate 7 for the location of these riffle structures. The location of these riffle structures minimizes the amount of riprap used for bankline protection, thus lowering project costs. It is essential that the upstream riffle structure have the same elevation as the dam crest, 857.4 ft NGVD, in order to maintain the current water levels in Lake Belle View. To protect the excavated channel from bankline erosion, riprap would be placed along the channel. It is estimated that 22,300 cubic yards of 400-pound riprap is needed for this feature. It is much more economical to construct this feature with the lake dewatered.

Water Quality Considerations - There are no water quality considerations associated with this feature.

Geotechnical Considerations - Stone suitable for use in riffle structure construction is readily available.

Hydraulic and Hydrologic Considerations - Refer to plates 9 and 10 for detailed drawings of the proposed riffle structures. Total hydraulic capacity for the proposed system was studied during feasibility. It was concluded that the Recommended Plan has more conveyance than the current conditions at Lake Belle View for all flood heights. This increase in capacity varies as water levels rise; at a water elevation of 860 ft, the Recommended Plan increases conveyance by 30%. At a water surface elevation of 863 ft, approximately the 100-year flood level, the increase in conveyance rises to 117%. Refer to Appendix H for the details of this investigation.

Structural Considerations - There are no structural considerations associated with this feature.

7.2.5 Wetland Enhancement

General Considerations - Excess dredged material would be placed in proposed wetland areas to create lake depths suitable for wetland habitat. Fine-grained sediment, taken from the upper 2 to 7 feet of the lake bottom, would be placed in designated wetland areas. A high-solids dredging method is recommended for this application. Traditional hydraulic dredging methods may not be suitable for this feature due to the potential need for a containment berm. Seeding is not required for this effort as there is enough native seed source present in Lake Belle View to assure that the wetland areas would reseed on their own.

Water Quality Considerations - There are no additional water quality considerations associated with this feature.

Geotechnical Considerations - Because of the fine nature of these sediments, the lake must be drawn down to dewater the area before grading, shaping, or planting can occur.

Hydraulic and Hydrologic Considerations - There are no additional hydraulic or hydrologic considerations associated with this feature.

Structural Considerations - There are no additional structural considerations associated with this feature.

7.2.6 Miscellaneous Design Considerations

Flooding - Hydraulic modeling completed by the Rock Island District's Hydrology and Hydraulics Section indicates that the Recommended Plan will not adversely impact flood heights for high flows. Studies completed previously by the University of Wisconsin at Madison (Potter et al. 1995)[8] indicate that there is no adverse impact to flood heights at low flows. The Recommended Plan is designed to keep lake levels and upstream water levels the same as current conditions. Therefore, there will be no impact to flood heights upstream of Lake Belle View. Additional hydraulic modeling will be completed in the plans and specifications phase of the project to fine tune sizing of hydraulic features to ensure proper hydraulic characteristics.

Sedimentation - Since riffle structures are designed to mimic natural streams, if designed correctly, the same physical processes that occur in natural streams will occur in a constructed riffle structure system. Some sedimentation and scour may be seen directly upstream of the riffle structures. This effect is very localized and similar to the depositional cycle of natural streams. During periods of low velocity, some deposition of sediment may occur directly upstream of the riffle structure. However, during higher velocities, the deposition is scoured out, making the system self-regulating. The downstream placement of the riffle structures ensures that docks and properties located on the north shore of Lake Belle View will not be affected by this localized phenomenon.

The upstream-most riffle structure crest elevation will be set to the same height as the crest of the Belleville dam. This ensures that the system will remain as it is today. If the crest were set higher than the crest of the Belleville dam, sedimentation would occur due to lower velocities in backwater areas. If the crest elevation were set lower than the Belleville dam, the lake levels would likewise lower, causing the need for greater dredging and lessening the amount of water flowing over the Belleville dam. By setting the upstream-most riffle structure crest elevation to the height of the Belleville dam, both negative consequences listed above are avoided.

7.3 Construction Considerations

7.3.1 Stormwater Pollution/Erosion Considerations. The potential for stormwater pollution during construction is minimal for this project. Stormwater runoff from nearly all construction activities would be confined to Lake Belle View. Overall, the long-term stormwater runoff characteristics of the site would not be expected to change. Temporary stabilization measures would be employed when excavating the bankline riffle structure placement until final seeding and construction have been completed to ensure that sediment runoff from this area does not continue down the Sugar River.

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[8] Prof. Kenneth W. Potter, et al., Institute for Environmental Studies, University of Wisconsin - Madison, *"Lake BelleView: Research Findings and Alternatives for the Future,"* 1995 Water Resources Management Workshop.

7.3.2 Permits. A public notice, as required by Section 404 of the Clean Water Act, would be made prior to submission of this report for final approval. A Section 401 water quality certificate from the State of Wisconsin and a Section 404(b)(1) Evaluation will be included in the final submission of this report. Because all land disturbances associated with this project are addressed in the Section 404(b)(1) Evaluation, a National Pollutant Discharge Elimination System (NPDES or Section 402) permit for stormwater discharges will not be required.

7.3.3 Historic Properties. There are no construction considerations associated with historic properties in the area.

7.3.4 Construction Sequence. The probable construction sequence is summarized in Table 7.1. Initially, only one drawdown was recommended. However, after more consideration, it was determined that a second drawdown would lower construction costs. The special legislation passed by the State of Wisconsin currently states that one drawdown only will be allowed. Efforts will be made to allow a second drawdown; if these efforts are unsuccessful, the construction sequence will be altered to accomplish the work with one drawdown.

Table 7.1. Recommended construction sequence.*

1. Drain Lake Belle View using the gates on the dam. These gates were utilized for a drawdown in 2000, proving they are still operational.
2. Utilize conventional earth-moving equipment to rock stabilize diversion berm foundation where necessary.
3. Utilize conventional earth-moving equipment to build confined disposal facility (CDF) and diversion berms. Install carp gate.
4. Impound Lake Belle View.
5. Utilize "high solids" and/or conventional hydraulic dredging methodology to move upper fine-grained sediments from dredged areas to wetland enhancement areas.
6. Utilize conventional hydraulic dredging methodology to move underlying sands from dredged areas to the CDF.
7. Drain Lake Belle View.
8. Utilize "low ground pressure" earth-moving equipment as necessary to evenly spread fine-grained dredged material previously placed in wetland enhancement areas.
9. Build riffle structures and add erosion protection as needed.
10. Demolish millrace and Bross Circle Bridge. Replace bridge.
11. Fill Lake Belle View.

* It should be noted that, though this sequence is recommended, no sequence will be required contractually.

7.4. Operational Considerations

Two features of this project have operational requirements—the carp gate and the drawdown. To be most effective, the carp gate may need to be pinned down to the bottom of the channel before winter so that carp may migrate out of the lake. In the spring, the gate is raised to prevent larger carp from entering the lake. In order to effectively stage a drawdown, the gates must be opened for the dam, and the carp gate and inlet structure must be sealed to keep the river flows from dampening the drawdown. During the winter, inflows through the inlet structure would be controlled based on the dissolved oxygen content in the lake.

7.5 Maintenance Considerations

The proposed features have been designed to ensure low annual maintenance requirements. Maintenance may include performing carp netting, shoreline inspections, and adding riprap to the overflow weir, bankline riprap, and riffle structures when needed.

Carp netting would be accomplished through the use of 10 fyke nets temporarily set up throughout the lake. These nets would be fished 10 days out of every year. All carp captured in the nets would be removed from Lake Belle View and disposed of. Any desirable species of fish would be returned to the lake. While the Village of Belleville may develop other disposal options, for the purpose of this operations and maintenance cost estimate, it is assumed that the Village would dispose of the carp in a local landfill.

In order to maintain 8 feet of depth in the dredged area, maintenance dredging must be performed. However, due to the extreme cost of dredging and placement, it is not anticipated that the local sponsor would be able to support this effort. Therefore, maintenance dredging was not considered as a maintenance consideration. All environmental benefits were calculated assuming the lake would be dredged during construction only. If the local sponsor were to dredge the lake, additional long-term environmental benefits would be gained in addition to those outlined in this report.

The estimated annual maintenance costs are presented in Table 7.2. These quantities and costs may change during final design.

Table 7.2. Operation and maintenance costs.

	Quantity	Unit	Unit Price ($)	Total Cost ($)[1]
Operation				
Carp Gate	4	Hours	36.50	146
Drawdown				
Stop Log Structure	4	Hours	36.50	146
Dam Gates	4	Hours	36.50	146
Maintenance				
Carp Gate				
Debris Removal - Labor & Equip.	12	Hours	44.50	534
Debris Disposal	5	CY	-	-
Carp Nets				
Replace Fyke Nets (per year)	2	Each	105.50	211
Fish Nets - Labor & Equip.	60	Hours	47.04	2,822
Dispose of Carp	1	LS		890
Riprap				
Replace Rock	280	TN	29.37	8,224
Subtotal				13,119
Contingency (20%)				2,623
Markup (4%)				526
Total				**16,268**

[1] Rounded to the nearest dollar

7.6 Schedule for Design and Construction

Table 7.3 presents the schedule for project completion steps.

Table 7.3. Schedule for design and construction.

Requirement	Scheduled Date
Distribute Report for Public and Agency Review	May 2003
Submit Final Report to Mississippi Valley Division	June 2003
Receive Plans and Specification Funds	October 2003
Independent Technical Review of Plans and Specifications	January 2004
Construction Approval by Mississippi Valley Division	March 2004
Advertise Contract	April 2004
Award Contract	May 2004
Complete Construction	November 2005