GLMRIS – Brandon Road

The Great Lakes and Mississippi River Interbasin Study – Brandon Road Draft Integrated Feasibility Study and Environmental Impact Statement – Will County, Illinois

August 2017

US Army Corps of Engineers
Rock Island & Chicago Districts

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Executive Summary

ES.1 Purpose and Need

The U.S. Army Corps of Engineers (USACE) is preparing a Feasibility Study and an integrated Environmental Impact Statement to evaluate alternatives for controlling upstream transfer of aquatic nuisance species (ANS) from the Mississippi River Basin into the Great Lakes Basin through the Chicago Area Waterway System (CAWS), and the impacts of those alternatives on waterway uses and users. The purpose of this study is to evaluate structural and nonstructural options and technologies near the Brandon Road Lock and Dam site to prevent the upstream transfer of ANS from the Mississippi River Basin into the Great Lakes Basin, while minimizing impacts on existing waterway uses and users. For this study, "prevent" means the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.[1] The need for this study is to address the problem of the interbasin transfer of ANS between the Great Lakes Basin and Mississippi River Basin. Refer to Chapter 1, Introduction, of the main report for a complete discussion of the study purpose and need.

ES.2 Background and Study Scope

The Great Lakes and Mississippi River Interbasin Study – Brandon Road (GLMRIS-BR) Draft Integrated Feasibility Study and Environmental Impact Statement builds on *The Great Lakes and Mississippi River Interbasin Study (GLMRIS) Report* released in 2014 (USACE 2014a). The Assistant Secretary of the Army (Civil Works) concluded that an appropriate next step is a formal evaluation of potential alternative control options and technologies near the Brandon Road Lock and Dam in Will County, Illinois, to prevent one-way upstream movement of ANS from the Mississippi River Basin to the Great Lakes Basin. Brandon Road Lock and Dam was chosen for the following reasons:

- The physical configuration of Brandon Road Dam prevents the upstream transfer of Mississippi River Basin ANS. There is a 24-foot (7.3-meter) difference in water elevation from the downstream side of the dam to the upstream side of the dam, for a flood that has a 2% chance of occurring in any given year (commonly known as a 500-year flood discharge); this effectively limits upstream transfer. Therefore, operation of the Brandon Road lock currently provides the only known continuous aquatic pathway that allows Mississippi River Basin ANS to transfer into the Great Lakes Basin at this location.

- The approach channel and lock provide a unique opportunity to control ANS transfer in a relatively small section of the river where flow is controlled by lock operations.

- Establishing a control point at Brandon Road Lock and Dam for Mississippi River Basin ANS species does not adversely impact flood risk or water quality of the system.

- A control point at Brandon Road Lock and Dam would provide near term risk reduction for certain ANS by providing additional defense in depth for Asian carp, when combined with the current Chicago Sanitary and Ship Canal (CSSC) Electric Dispersal Barrier System in Romeoville, Illinois (CSSC-Electric Barriers).

[1] Defining the term "prevent" to mean reducing the risk to the maximum extent possible is entirely reasonable. Michigan v. U.S. Army Corps of Engineers, 911 F. Supp. 2d 739, 766 (N.D. Ill. 2012), aff'd, 758 F.3d 892 (7th Cir. 2014).

In addition, establishing a one-way control point for ANS of concern could lead to new long-term solutions to prevent two-way species transfer. This study evaluates alternatives to prevent the upstream transfer of ANS from the Mississippi River Basin into the Great Lakes Basin near the Brandon Road Lock and Dam, incorporating input from federal, state, and local agencies and nongovernmental stakeholders.

The scope of this study is to evaluate options and technologies near Brandon Road Lock and Dam, with the goal of preventing upstream transfer of ANS from the Mississippi River Basin into the Great Lakes Basin through the Chicago Area Waterway System (CAWS) (Figure ES-1). This study does not examine downstream aquatic transfer of ANS from the Great Lakes Basin to the Mississippi River Basin, nor does it examine aquatic transfer of ANS along the remaining basin divide or ANS transfer through nonaquatic pathways.

Although the GLMRIS-BR alternative evaluation was conducted specifically for three species (i.e., Bighead Carp [*Hypophthalmichthys nobilis*], Silver Carp [*H. molitrix*], and *A. lacustre*), the GLMRIS-BR alternatives were purposely formulated to prevent the interbasin movement of ANS that swim (i.e., fish), float (i.e., fish eggs or larvae and plant fragments), or foul/hitchhike on vessel hulls (i.e., hull fouling crustacean or plants attached to vessels). Therefore, these alternatives are adaptable for future ANS that use these transport mechanisms.

Refer to Chapters 1 (Introduction) and 2 (Background, Existing Projects, and Prior Reports) of the main report for a complete discussion of the study background and scope.

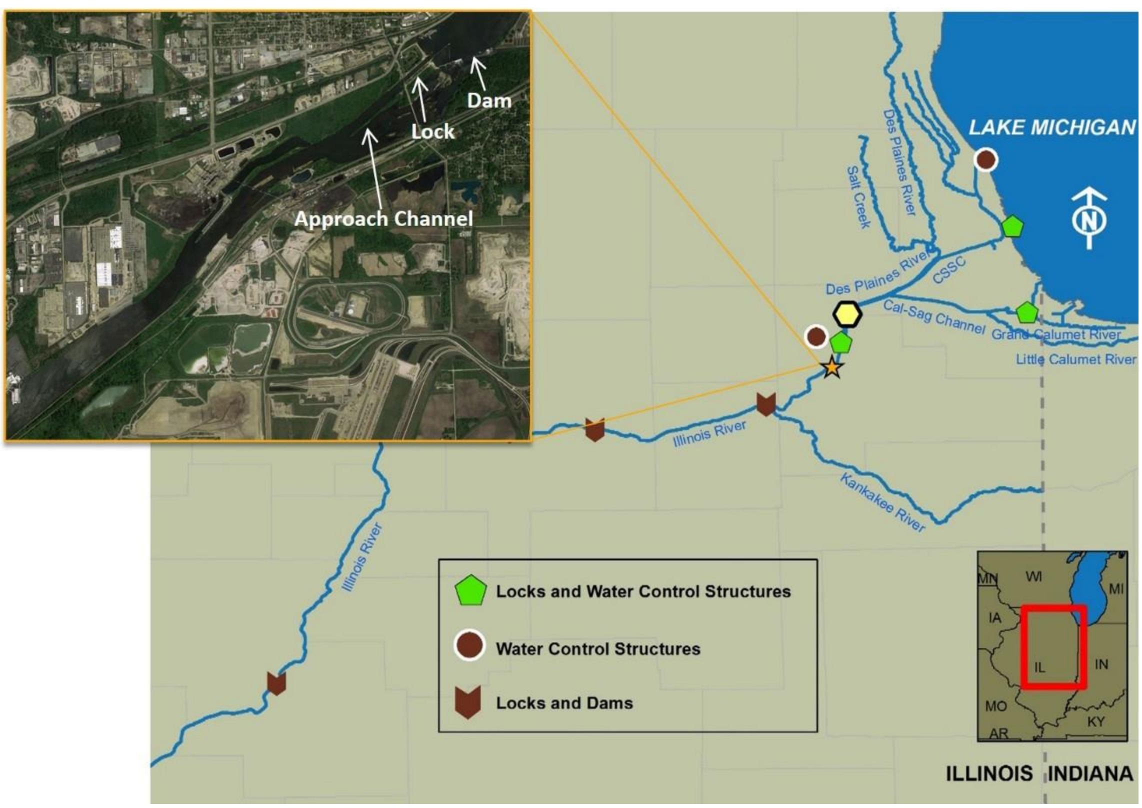

Figure ES-1 GLMRIS-BR Study Area

ES.3 Study Goal, Problems, and Opportunities

The study goal is to prevent the transfer of ANS from the Mississippi River Basin to the Great Lakes while considering the authorized purposes of the Illinois Waterway with the needs of multiple users and uses of the Upper Illinois Waterway, and in the spirit of shared responsibility of ANS control consistent with Executive Order 13112.

Study area problems and opportunities were drawn from the GLMRIS Report (USACE 2014a) and from public input and interagency information exchanged during the National Environmental Policy Act public scoping process.

The problems identified were as follows:

- ANS Cause Impacts: Mississippi River Basin ANS may transfer through the CAWS and cause significant environmental, economic, and sociopolitical impacts within the Great Lakes Basin.

- ANS Transfer Via Aquatic Pathways: Mississippi River Basin ANS may transfer to the Great Lakes via aquatic pathways.

The opportunities identified were as follows:

- Control Point near Brandon Road Lock and Dam: Establishment of a control point near Brandon Road Lock and Dam could prevent the transfer of Mississippi River Basin ANS to the Great Lakes Basin through the CAWS.

- Prevention is the most efficient and effective method of combating the environmental, economic, and sociopolitical impacts of invasive species (Figure ES-2).

- Management Zone: The CSSC-Electric Barriers is a control point for swimming ANS (Figure ES-1). Establishing a second control point in the vicinity of Brandon Road Lock and Dam provides an opportunity to create a management zone that augments the CSSC-Electric Barriers' effectiveness at preventing swimming Mississippi River Basin ANS from transferring to the Great Lakes Basin.

- Location Minimizes Flood Bypass: Alternatives that include implementation of a structural control point near the Brandon Road Lock and Dam site would minimize the likelihood of Mississippi River Basin ANS bypassing the CSSC-Electric Barriers during flood events.

- Approach Channel and Lock: The approach channel and lock provide the opportunity to evaluate and optimize the operational characteristics of ANS controls, maximize the efficiency of applied technologies, and minimize the associated costs for implementation and operation.

- Maintain Existing Uses: To the extent possible, alternatives should be developed with control measures that allow for navigation and other waterway uses and users while effectively preventing the spread of ANS.

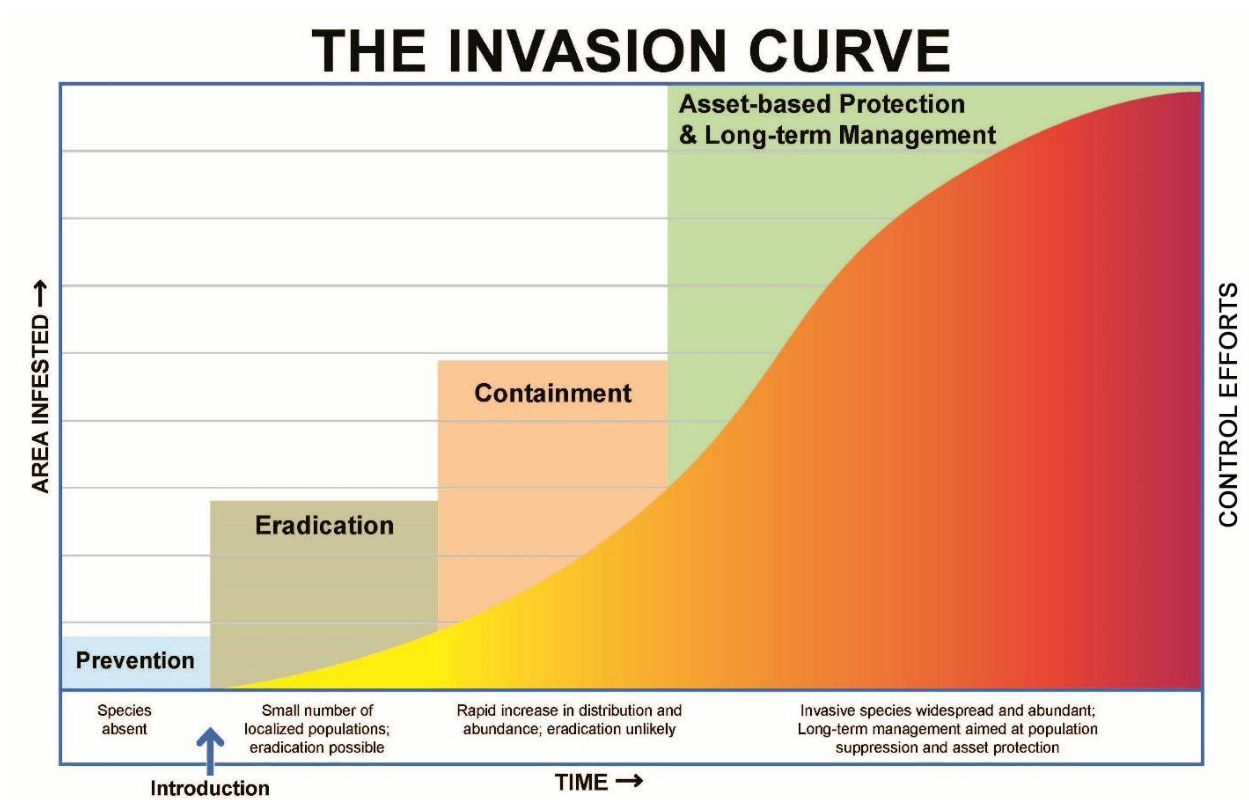

Figure ES-2 The Invasion Curve Describes How Management Changes over Time as an Invasive Species Becomes Established in New Environments (Source: U.S. Department of the Interior 2016)

- Future Adaptability: Alternatives that include an engineered channel provide a platform for future control technologies near Brandon Road Lock and Dam. Information gathered during the implementation of an alternative could be used to inform future applications of ANS controls in the CAWS and elsewhere.

Refer to Chapter 3, Need for and Objectives of Action, of the main report for a complete discussion of the study goal, problems, and opportunities.

ES.4 Study Objective and Constraints

The study objective is to prevent the upstream transfer of ANS from the Mississippi River Basin to the Great Lakes Basin through the CAWS in the vicinity of the Brandon Road Lock and Dam through the planning period of analysis.

Formulation and evaluation of GLMRIS-BR alternatives for the proposed project are constrained by the following factors:

- *Nonaquatic Pathways*: Study authorization is limited to evaluating ANS controls to prevent ANS transfer between the Great Lakes Basin and the Mississippi River Basin through aquatic pathways. Nonaquatic, human, and wildlife-mediated transfers are not within the purview of the study authority.

- *Waterway User Impacts*: Each alternative that allows for continued use of Brandon Road Lock for navigation will attempt to minimize disruptions to waterway use while maximizing the effectiveness of the alternative.

- *Natural and Human Environment Impacts*: Alternative formulation would attempt to protect the natural and human environment by minimizing impacts on significant natural, cultural, and social resources while maximizing the effectiveness of the alternative.

- *Prevention*: The USACE defines "prevent" to mean the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.

Refer to Chapter 3, Need for and Objectives of Action, of the main report for a complete discussion of the study objective and constraints.

ES.5 ANS Populations

Refer to Chapter 4, Affected Environment (Existing Conditions), of the main report for a complete discussion of ANS populations.

ES.5.1 Current Conditions and Control Efforts Regarding Bighead and Silver Carp

Bighead and Silver Carp are considered established and abundant in the Illinois Waterway (IWW). The detectable Bighead and Silver Carp population front (the most upstream pool where detection/presence of adult fish are consistently caught across the pool) is in the Dresden Island Pool, near river mile 280, approximately 6 miles (9.7 kilometers) downstream of Brandon Road Lock and Dam and approximately 47 miles (75.6 kilometers) downstream of Lake Michigan. The U.S. Fish and Wildlife Service maintains the most current information on Asian carp location and abundance at http://asiancarp.us.

The Asian Carp Regional Coordinating Committee's (ACRCC's) Monitoring and Response Working Group (MRWG) currently coordinates planning for Asian carp monitoring and control activities within the IWW and CAWS. Actions are conducted by state and federal resource management and research agencies, universities, and commercial entities. The MRWG prepares an annual Asian Carp Monitoring and Response Plan (MRP) that coordinates activities in the waterway, as well as the implementation of new technologies and methods as they are discovered. The MRP also provides new information on member project plans. The 2016 MRP includes the Upper Illinois Waterway Contingency Response Plan, which describes specific actions members would take in the event a change is detected in the status of Bighead and Silver Carp. Additional details regarding the ACRCC's activities can be found at http://asiancarp.us.

The USACE is contributing to this effort through the implementation of a four-pronged strategy, which includes (1) operation of the CSSC-Electric Barriers, (2) conducting studies to evaluate the effectiveness of the CSSC-Electric Barriers, (3) participating in extensive monitoring of the IWW for Asian carp, and (4) conducting the GLMRIS-BR. Additional detailed information on USACE efforts against Asian carp can be found at www.lrc.usace.army.mil.

ES.5.2 Current Conditions and Control Efforts Regarding Apocorophium lacustre

A. lacustre have established just above the Dresden Island Lock and Dam, less than 20 miles (32.2 kilometers) from the Brandon Road Lock and Dam. There are no current efforts to control the spread of *A. lacustre*.

ES.6 Consequences of Establishment

The potential environmental, economic, and sociopolitical consequences specific to Bighead Carp, Silver Carp, and *A. lacustre* establishment in the Great Lakes Basin were evaluated using the best available information. Refer to Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, of the main report for a complete description of the consequence of establishment for Bighead Carp, Silver Carp, and *A. lacustre*.

ES.6.1 Consequence Evaluation for Bighead and Silver Carp Establishment

ES.6.1.1 Environmental Consequences

Modeling studies and monitoring data from previously invaded systems have documented significant changes in the abundance, health, and composition of resident fish species following Asian carp establishment (Kolar et al. 2005; Cudmore et al. 2012; Ickes 2014; Solomon et al. 2016; Aycock 2016). These studies along with modeling studies specific to the Great Lakes (Zhang et al. 2016) also suggest Asian carp have the potential to become a dominant species in portions of the Great Lakes Basin with suitable habitat conditions. The five Great Lakes cover about 302,000 square miles (782,176 square kilometers) and within the Great Lakes Basin there are more than 5,000 tributaries and associated floodplain water bodies. Asian carp are known to occupy a wide range of aquatic habitat; although not all of the Great Lakes Basin will be suitable for these species, this does suggest that if Asian carp were to negatively affect resident species, the effects could be widespread. However, there is significant uncertainty about the ultimate population size of Asian carp the Great Lakes Basin can support and therefore there is significant uncertainty about the extent and magnitude of environmental impacts.

Estimates of ecosystem changes were only available for Lake Erie's biomass; these estimates are based upon varied model input, which results in uncertainty in model output. Specifically, changes in biomass due to the introduction of Asian carp were estimated by National Oceanic and Atmospheric Administration (NOAA) using a model of the Lake Erie food web (Zhang et al. 2016). The GLMRIS-BR Project Delivery Team then used the output from this model to quantify how Asian carp might affect fish biomass, which in turn would affect recreational fishing, charter fishing, and commercial fishing. NOAA ran the Lake Erie model under multiple scenarios to reflect different assumptions such as the diet of Asian carp, their eating efficiency, and the vulnerability of Asian carp to predation. The biomass output from the model was used to calculate the percent difference in biomass of the species group compared to baseline conditions (no Asian carp) and each Asian carp establishment scenario.

ES.6.1.2 Economic Consequences

The Great Lakes and their tributaries are used for numerous economically important commercial and recreational purposes, such as fishing activities, shoreline real estate, boating, beach going, and many others. Estimating the economic consequences of Asian carp establishment on each of these uses requires knowledge of how the ecosystem would change, and in turn affect the use of each water body. Estimates of ecosystem changes were only available for Lake Erie's biomass, and are varied and uncertain. Refer to Chapter 5, Consequence of ANS establishment in the Great Lakes Basin, for more information.

Economic consequences were not estimated for the remaining uses such as, but not limited to, beach going, boating, and real estate values of Lake Erie. Economic consequences were not estimated for any uses of the remaining four Great Lakes, and over 5,000 Great Lakes tributaries. However, information regarding these other uses in the Great Lakes Basin highlights activities that could be adversely affected by Asian carp establishment.

Social consequences refer to services the environment provides for human use, regardless of any associated economic consequences. Political consequences refer to potential implementation of new regulations and restrictions to address prevention or control of ANS. The potential social and political consequences of Bighead and Silver Carp establishment in the Great Lakes Basin include the following:

- *Legislative and Regulatory Actions*. The U.S. Fish and Wildlife Service listed Bighead and Silver Carp as injurious wildlife species under the Lacey Act. In response to this designation, additional and continued state and local regulatory actions to prevent, control, and manage these species are anticipated.

- *International Considerations*. The government of Canada has expressed concern due to the potential effects Bighead and Silver Carp would have on Canadian waters.

- *Tribal Considerations*. Federally recognized Native American tribes co-manage fisheries with federal and state governments to meet sustainable, target levels of harvest for treaty species (Figure ES-3). If Bighead and Silver Carp establishment in the Great Lakes Basin "substantially frustrates achieving the harvest goals and objectives within the 1836 Treaty waters, [their establishment] could result in reopening the terms of [a 2000 and 2007 Consent] Decree and cause each of the parties to spend considerable resources to renegotiate the terms of the Decree[s]" (USFWS 2016).

- *Safety and Nuisance Concerns*. Due to their jumping behavior, Silver Carp would reduce boater safety and recreational activity in the Great Lakes Basin.

- *Management Expenditures*. The establishment of Bighead and Silver Carp in the Great Lakes Basin would expand the management burden to areas where they are not currently found.

ES.6.2 Consequence Evaluation for A. lacustre Establishment

Environmental consequences may include impacts on native mussels. However, there is uncertainty regarding the potential impact of *A. lacustre* because little research has been done on this species. At this time, no economic or sociopolitical consequences as a result of *A. lacustre* establishment in the Great Lakes Basin are expected.

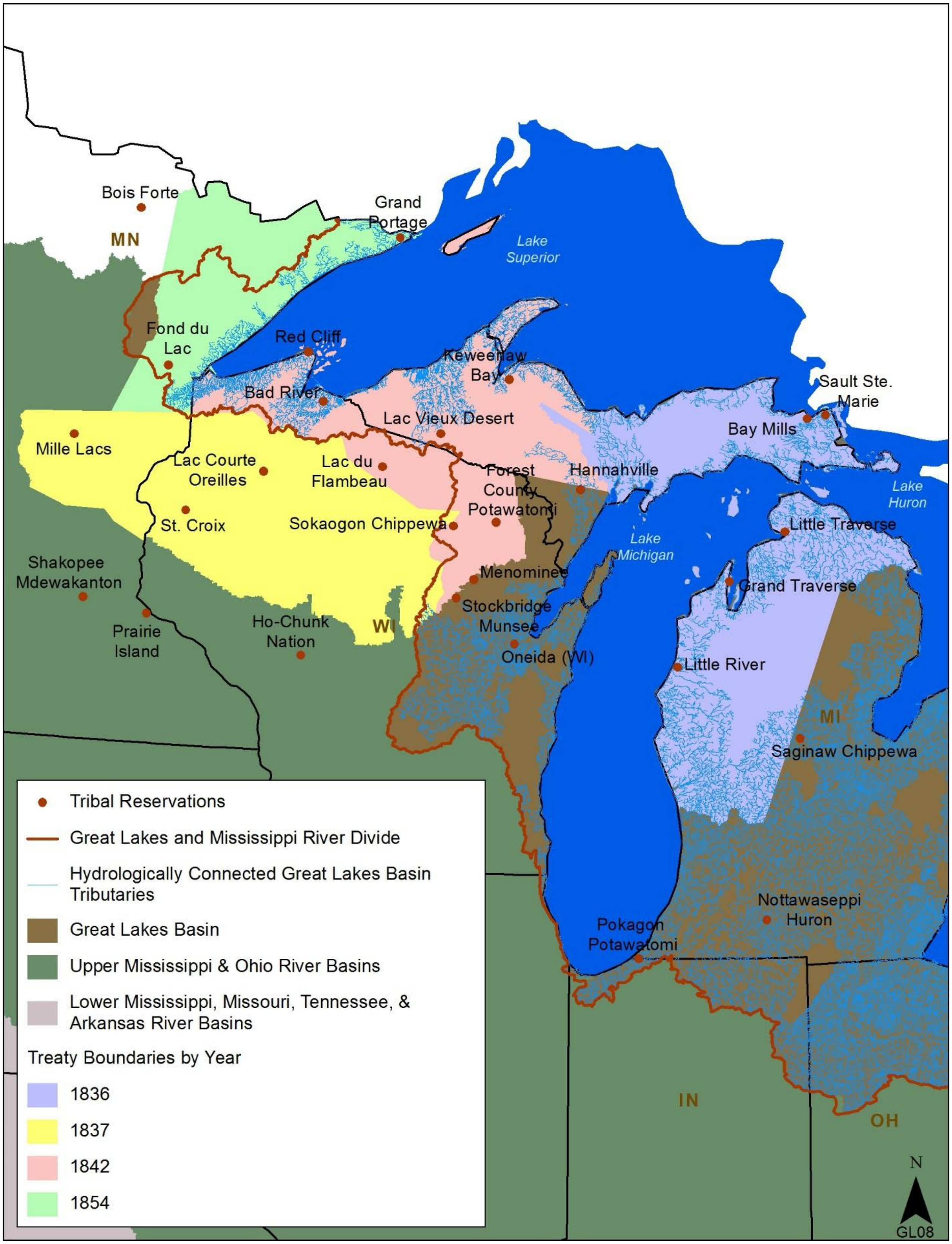

Figure ES-3 Great Lakes Basin Tributaries Located in Lands That Could Be Accessible by Silver and Bighead Carp

ES.7 Alternative Formulation

The alternatives were formulated to prevent the upstream transfer of ANS that swim, float, or hitchhike. Alternative effectiveness was evaluated for Bighead Carp, Silver Carp, and *A. lacustre*. The alternatives were formulated to address future ANS with modes of transport similar to Bighead Carp, Silver Carp, and *A. lacustre*. The measures used to formulate alternatives included both nonstructural control measures and structural control measures (Sections ES.7.1 and ES.7.2) (Figure ES-4). Refer to Chapter 6, Alternative Formulation, of the main report for a complete description of the measures used in formulation of the alternatives.

ES.7.1 Nonstructural Control Measures

Nonstructural controls do not require the construction of a permanent feature in the waterway. Nonstructural control measures included education and outreach, integrated pest management, manual or mechanical removal, nonstructural monitoring, piscicides, and research and development.

ES.7.2 Structural Control Measures

Structural controls require the construction of a permanent feature in the waterway. Structural measures include complex noise, an electric dispersal barrier, an engineered channel, a flushing lock, lock closure, and water jets. Boat launches and a downstream mooring area are supporting measures.

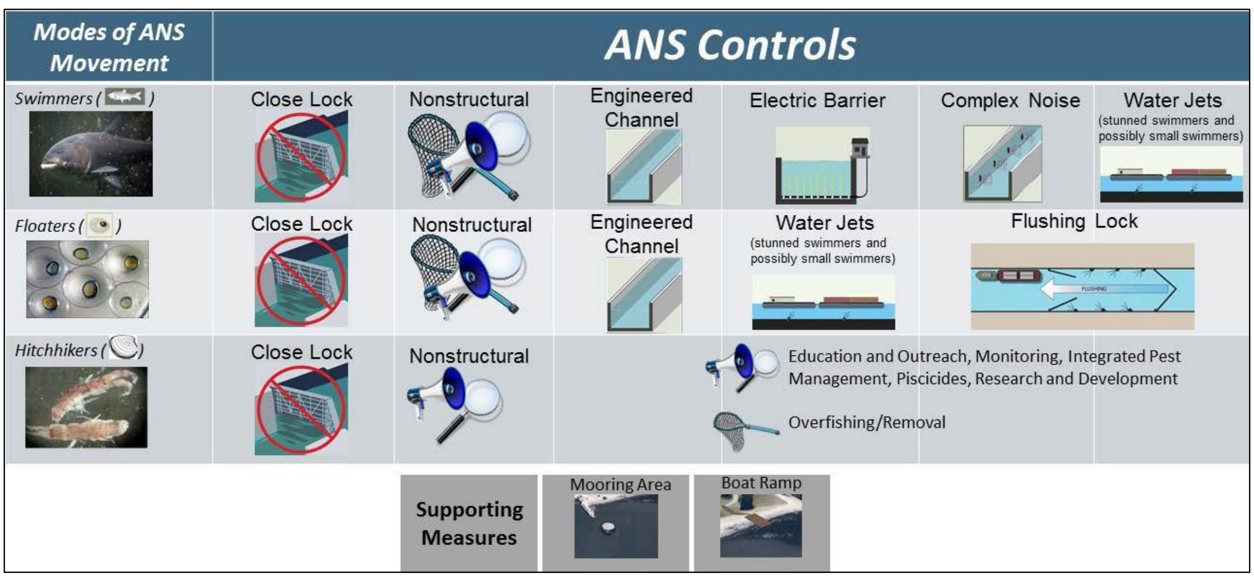

Figure ES-4 Modes of ANS Movement Addressed by the GLMRIS-BR Control Measures

ES.8 Alternatives

Refer to Chapter 6, Alternative Formulation, of the main report for a complete description of the alternatives.

ES.8.1 No New Federal Action

The No New Federal Action Alternative (Figure ES-5) means no new or additional federal action, but current activities would likely continue. However, the study assumed a reduced level of effort throughout the planning period of analysis because these future actions are subject to the availability of future appropriations and allocation decisions. Current activities include education and outreach, monitoring, manual or mechanical removal, research and development, the potential application of piscicides, and integrated pest management.

ES.8.2 Nonstructural Alternative

This alternative (Figure ES-5) ensures that the current level of ANS control efforts are maintained. It also includes additional overfishing, monitoring for *A. lacustre*, and construction of boat launches. Although the boat launches are a structural measure, they reduce the response time for accessing the upstream and downstream pools adjacent to Brandon Road Lock for nonstructural activities.

ES.8.3 Three Technology Alternatives

All technology alternatives include measures that comprise the Nonstructural Alternative, in addition to the following structural measures: a flushing lock, water jets, and an engineered channel. The flushing lock and water jets would be designed and operated to address the upstream movement of floating and entrained ANS. The engineered channel would increase the effectiveness of the structural and nonstructural ANS control measures installed within it. In addition to assisting with nonstructural measure implementation, the boat launches also reduce response time for safety actions and for operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) actions. Technology alternatives are differentiated by combinations of structural measures. Additional measures used in each alternative are discussed in Sections ES.8.3.1 through ES.8.3.3.

ES.8.3.1 Technology Alternative – Electric Barrier

This alternative (Figure ES-5) includes each measure described in the previous section, and the following structural measures: an electric barrier and a mooring area. A continuously operated electric barrier would address swimming ANS, and the engineered channel would be designed to reduce stray current impacts of the electric barrier. The mooring area provides a reconfiguration area that is closer than the currently available fleeting area, if operators need to reconfigure their barges to meet navigation restrictions due to the presence of an electric barrier in the engineered channel.

ES.8.3.2 Technology Alternative – Complex Noise

This alternative (Figure ES-5) includes each measure described in Section ES.8.3, in addition to the complex noise structural measure. Complex noise would address swimming ANS by deterring fish from entering the engineered channel.

ES.8.3.3 Technology Alternative – Complex Noise with Electric Barrier

This alternative (Figure ES-5) includes each measure described in Section ES.8.3, in addition to the following structural measures: complex noise, an electric barrier, and a mooring area. The electric barrier and complex noise controls would address swimming ANS. It is uncertain whether it will be possible to operate the electric barrier at optimal operating parameters when vessels travel through the downstream approach channel, due to two complicating factors: (1) it must address life safety considerations, and (2) operating parameters of the barrier may prohibit operation when vessels travel over the barriers (the water depth in the Brandon Road approach channel is about 10 feet (3 meters) less than the water depth at the CSSC-Electric Barriers, which vessels can safely travel over). During this time, complex noise would be used to deter fish from entering the engineered channel and passing upstream through the lock. The engineered channel would be designed to reduce the stray current impacts of the electric barrier. The mooring area provides a reconfiguration area that is closer than the currently available fleeting area, if operators need to reconfigure their barges to meet navigation restrictions due to the presence of an electric barrier in the engineered channel.

ES.8.4 Lock Closure

This alternative (Figure ES-5) includes all actions comprising the Nonstructural Alternative, as well as the lock closure structural measure. Lock closure would consist of constructing a permanent concrete wall that ties into the existing concrete gate sill and existing lock walls to structurally separate the upper pool from the lower pool.

ES.9 Comparison of Alternative Plans

Refer to Chapter 8, Comparison of Alternative Plans, of the main report for a complete discussion on comparison of the alternative plans.

ES.9.1 Alternative Plan Evaluation Criteria

The alternative evaluation considered the following criteria: reduction in the probability of establishment in the Great Lakes Basin; relative life safety risk; system performance robustness; costs that include construction and mitigation, nonstructural measures, OMRR&R, and navigation impacts; and anticipated implementation date. The criteria names, including the ways of presenting the costs as either project first costs or average annual costs, correspond to the column names in Figure ES-6. Criteria definitions appear on the second page of Figure ES-6.

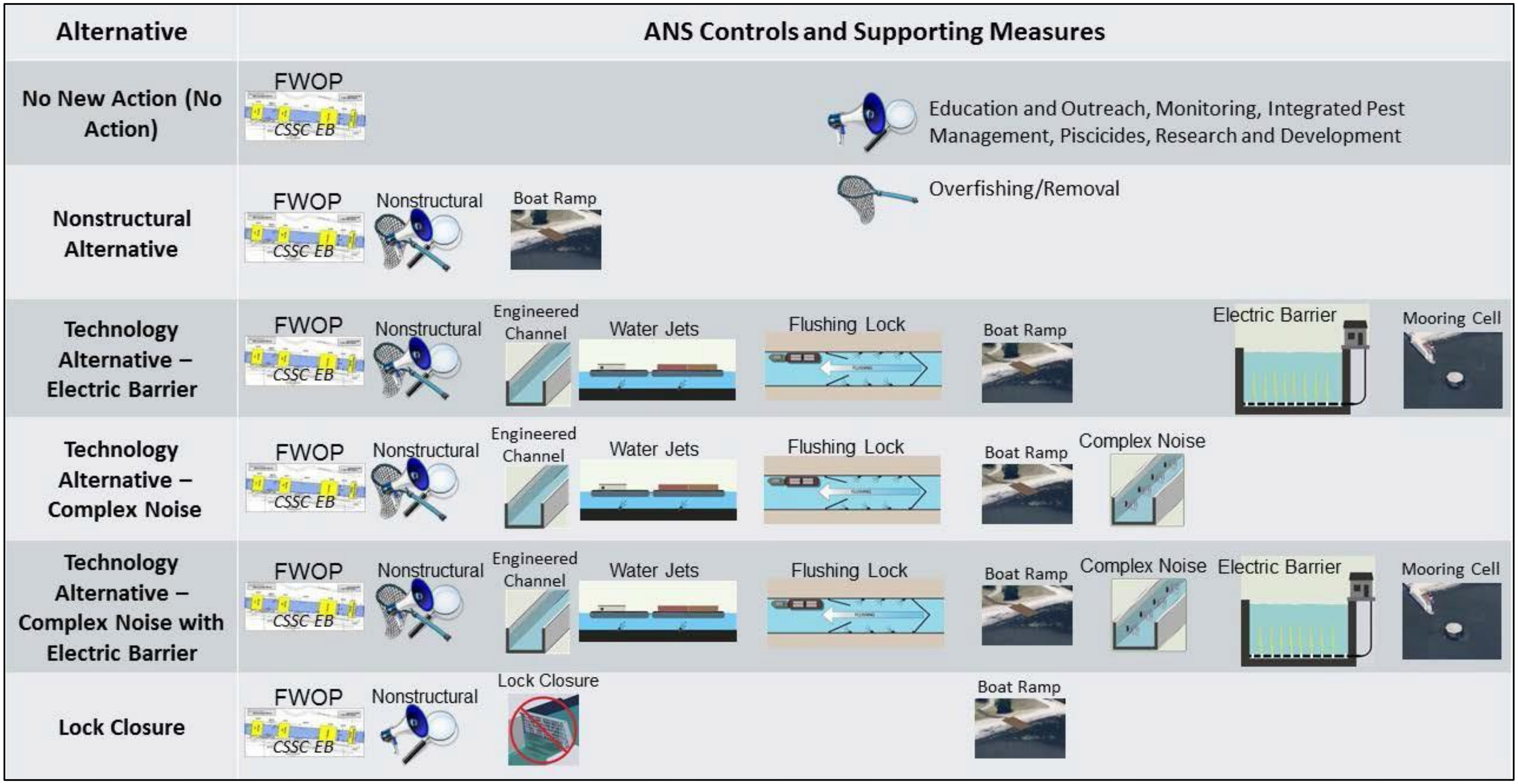

Figure ES-5 GLMRIS-BR Alternatives

NOTE: All costs presented were estimated using the FY 2017 federal discount rate and price level.

[a] Evaluation criteria descriptions are located on the reverse side of this table.

[b] Composite expert values.

[c] System performance robustness.

[d] Ability to cycle in nonstructural controls: NS

[e] Ability to cycle in structural controls: S

[f] Number of structural control points:

One control point: CP

Two control points: CP CP

[g] Modes of transport:

Swimmers:

Floaters:

Hitchhikers:

[h] Assumed authorized for construction in FY 2021 and capability funding for planning, engineering design, and construction.

[i] "No Action" means no new federal or additional action, but current activities could continue.

[j] Permanent closure requires Congressional authorization.

GLMRIS – Brandon Road Alternative Evaluation Criteria[a]

Objective: Prevent the upstream transfer of aquatic nuisance species (ANS) from the Mississippi River Basin to the Great Lakes Basin through the Chicago Area Waterways in the vicinity of the Brandon Road Lock and Dam through the planning period of analysis.

	Alternative	Probability of Establishment for Silver and Bighead Carp in the Great Lakes[b] (Composite Expert Results)	Probability of Establishment for *A. lacustre* in the Great Lakes[b] (Composite Expert Results)	Relative Life Safety Risk	System Performance Robustness[c]: Ability to Cycle in Nonstructural[d]	System Performance Robustness[c]: Ability to Cycle in Structural[e]	System Performance Robustness[c]: Number of Structural Control Points[f]	System Performance Robustness[c]: Modes of Transport[g]	Project First Costs – Present Value: Construction Cost (CON) = Construction + PED + Con Mgmt. + Monitoring and Adaptive Management + Mitigation + LERRDS	Average Annual Costs: Construction Cost	Average Annual Costs: Nonstructural (NS) + OMRR&R	+ Costs of Impacts to Navigation (NAV) (NED)	= Total NED Costs (CON + NS + OMRR&R + NAV)	Anticipated Implementation Date[h]
	No New Federal Action (No Action)[i]	29% (22–36%)	61% (36–88%)	LOW	NS		CP		N/A	N/A	N/A	N/A	N/A	Ongoing
	Nonstructural Alternative	20% (15–26%)	61% (36–88%)	LOW	NS		CP		$600K (Mitigation: $0)	$20K	NS: $11.5M OMRR&R: $20K	N/A	$11.5M	2020: NS 2023: Construction Complete
Technology Alternatives	Electric Barrier	11% (8–14%)	58% (34–86%)	HIGH	NS	S	CP CP		$266.8M (Mitigation: $2.2M)	$10.1M	NS Measures: $11.3M OMRR&R: $7.8M	$31.4M	$60.6M	2020: NS 2025: Construction Complete
Technology Alternatives	Complex Noise	15% (11–19%)	58% (34–86%)	INTERMEDIATE	NS	S	CP CP		$113.9M (Mitigation: $2.2M)	$4.4M	NS Measures: $11.3M OMRR&R: $1.4M	$26.0M	$43.0M	2020: NS 2025: Construction Complete
Technology Alternatives	Complex Noise with Electric Barrier	13% (10–17%)	58% (34–86%)	HIGH	NS	S	CP CP		$275.3M (Mitigation: $2.2M)	$10.5M	NS Measures: $11.3M OMRR&R: $8.2M	$26.2M	$56.2M	2020: NS 2025: Construction Complete
	Lock Closure	2% (1–3%)	42% (17–78%)	LOW	NS		CP CP		$5.9M (Mitigation: $2.3M)	$200K	NS Measures: $9.2M OMRR&R: $20K	$318.7M	$328.2M	2020: NS + Lock Closed[j] 2023: Permanent Lock Closure Construction Complete

Figure ES-6 Brandon Road Alternative Evaluation Criteria

Probability of Establishment for Asian carp in the Great Lakes. This criterion estimates the probability of establishment for Asian carp within the Great Lakes for each alternative. The probability of establishment range is a composite based on results from the Asian carp expert elicitation. The GLMRIS-BR alternatives can impact Probability of arrival (P(arrival)) and Probability of passage (P(passage)). The mean value of the composite expert result is shown as well as the low and high ranges in parentheses.

Probability of Establishment for A. lacustre *in the Great Lakes.* This criterion estimates the probability of establishment for *A. lacustre* within the Great Lakes for each alternative. The probability of establishment range is a composite based on results from the *A. lacustre* expert elicitation. The GLMRIS-BR alternatives can impact P(arrival) and P(passage). The mean value of the composite expert result is shown as well as the low and high ranges in parentheses.

Relative Life-Safety Risks. This criterion represents the relative life-safety risk of navigators and facility operators associated with the alternatives. The qualitative risk assigned to each alternative is relative to the remaining alternatives. Low represents a low safety risk as compared to the other alternatives; high represents a high life-safety risk as compared to the other alternatives; and intermediate represents a safety risk between the alternatives ranked as low and high.

System Performance Robustness. This criterion has been evaluated as an alternative's ability to accomplish/address the following:

(1) *Ability to Cycle in Nonstructural Measures* – Ability to cycle in nonstructural measures refers to whether the alternative can cycle in new nonstructural measures.
(2) *Ability to Cycle in Structural Measures* – Ability to cycle in structural measures refers to whether the alternative can cycle in new structural measures.
(3) *Number of Structural Control Points* – Number of structural control points refers to the number of structural control points within the GLMRIS-BR Upper Illinois Waterway. The system currently has one structural control point, the CSSC Electric Dispersal Barriers. If a new structural control point is added at Brandon Road Lock and Dam, then the system would have two structural control points; this is also known as "defense in depth."
(4) *Modes of Transport* – Number of ANS modes of transport that are addressed by the alternative (modes of transport). This shows whether the alternative contains measure(s) that control the transfer of ANS that swim, float, and/or hitchhike. For example, if an alternative prevents swimmers and floaters, then the alternative addresses two modes of transport.

Project First Cost – Construction Cost. This criterion is the total estimated construction costs for an alternative. Construction costs include construction; lands, easements, rights-of-way, relocation, and disposal areas; preconstruction engineering and design (PED); construction management; performance monitoring and adaptive management; and mitigation. Although they are included in the total construction costs, the mitigation costs are noted in brackets. Mitigation costs are included for adverse effects on the connectivity of the Des Plaines River and the movement of native aquatic species due to the implementation of a technology alternative or Lock Closure. Mitigation costs also include the costs to mitigation for adverse and visual effects from the addition or modifications because of implementation of a Technology Alternative or Lock Closure. These would affect the original fabric of the dam and the new construction within the Brandon Road Lock and Dam Historic District boundaries. Neither the No Action Alternative nor the Nonstructural Alternative would require mitigation.

Average Annual Cost – Construction Cost. This criterion is the individual average annual costs for the construction project first cost.

Average Annual Costs – NS and OMRR&R Costs. This criterion is the individual average annual costs for nonstructural measures (NS) and Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R).

Average Annual Cost – Navigation Impacts (NED). This criterion is the estimated loss in average annual transportation cost savings for the alternative.

Average Annual Cost – Total NED Costs (Construction (CON) + Nonstructural Measures (NS) + OMRR&R + Navigation (NAV) Impacts). This criterion is total National Economic Development (NED) costs, which are the average annual costs of construction, nonstructural measures, OMRR&R, and navigation impacts.

Anticipated Implementation Date. This criterion is the expected calendar year when measures of an alternative would be implemented, assuming the alternative is authorized in FY 2021 and capability funding for pre-construction engineering design and construction.

ES.10 Tentatively Selected Plan

The Tentatively Selected Plan (TSP) is the Technology Alternative – Complex Noise with Electric Barrier, which includes the following measures: nonstructural measures, complex noise, water jets, an engineered channel, an electric barrier, a flushing lock, boat launches, and a mooring area (Figure ES-7). Assuming the project is authorized and USACE receives funding for preconstruction engineering and design (PED) and construction activities, the project would be constructed in approximately 4 years from authorization for construction. The nonstructural component of the plan would begin once funding is received. The implementation of nonstructural measures is a shared responsibility with other federal agencies.

The TSP was selected because it meets the project objective by reducing the risk of Mississippi River Basin ANS establishment in the Great Lakes Basin to the maximum extent possible, and it provides for continued navigation. The TSP addresses two modes of ANS transport, swimming and floating, and creates a second structural control point in the GLMRIS-BR Illinois Waterway Study Area where swimming ANS would be deterred from upstream passage to the Great Lakes Basin. The TSP includes an engineered channel. The engineered channel would increase the effectiveness of the ANS control measures installed within it and should reduce the stray current impacts of the electric barrier. This feature provides a platform from which to test new controls and, if appropriate, to install future controls.

Figure ES-7 Aerial View of Brandon Road Lock and Dam Incorporating the Tentatively Selected Plan

The TSP will be most effective if the electric dispersal barrier operates continuously at optimal parameters to deter fish. However, life safety must be considered, and the TSP will include life-safety considerations in its design in addition to fish deterrence. Testing of the measures will be conducted to address site-specific operating considerations that cannot be addressed until after construction. Once the measures have been constructed, USACE and USCG will conduct an evaluation of the operation of the electric dispersal barrier, complex noise, and water jets, all within an engineered channel, to assess safe operating parameters for each measure. Lock flushing will also be included in the assessments. Life safety will be a primary consideration. The USACE expects it would initially operate the electric dispersal barrier measure only when vessels are not immediately downstream of the engineered channel, are not within the engineered channel, and are not proceeding through the lock. In lieu of operating the electric dispersal barrier during these times, complex noise will serve as the fish deterrent. Informed by the results of safety testing and continued coordination with USCG and the navigation community, USACE would work to maximize TSP effectiveness, which may include increasing the operating duration or continuously operating the electric dispersal barrier, while minimizing life safety impacts.

Refer to Chapter 8, Comparison of Alternative Plans, of the main report for a complete discussion on selection of the TSP.

ES.11 Performance Monitoring and Adaptive Management

Performance monitoring includes two types of monitoring: biological monitoring of the fish populations below Brandon Road Lock and Dam and their response to the TSP, and monitoring the measures to determine whether the measures are performing as designed (i.e., is the electric barrier producing the desired field strength in the water, are the speakers producing the desired characteristics of the complex noise in the water column). Adaptive management allows the TSP to be modified in response to performance monitoring results to maximize the plan's effectiveness and reduce its impact on waterway uses and users. Performance monitoring and adaptive management have been estimated to be equal to 10% of the construction costs and will occur within 10 years of project implementation. Refer to Chapter 9, Description of the Tentatively Selected Plan, of the main report for a complete discussion on performance monitoring and adaptive management.

ES.12 Future Technologies

Much research continues, especially for swimming ANS. To address the evolving nature of ANS control technologies, USACE recommends, as part of this report, that USACE be authorized to study and implement options and technologies that improve the efficacy of the ANS control measures at Brandon Road Lock and Dam similar to the efficacy study authority associated with the CSSC-Electric Barriers. Refer to Chapter 9, Description of the Tentatively Selected Plan, of the main report for a complete discussion on implementation of future technologies.

ES.13 Cost Apportionment

USACE Headquarters directed the GLMRIS-BR team to develop a federal plan for authorization that implements the structural measures of the TSP by USACE and a nonfederal sponsor. The responsibilities for the execution of the nonstructural measures would be shared between USACE and other federal agencies.

Per Section 210 of the Water Resources Development Act of 1996 (33 *United States Code* §2213[c][7]), the nonfederal share of the implementation costs for ecosystem restoration/protection projects is 35% of the project unless project authorization specifies otherwise. The nonfederal share includes PED, implementation, construction management, engineering during construction (EDC), and project management costs (Table ES-1). The nonfederal sponsor shall provide 100% of the lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) and OMRR&R. The value of LERRDs shall be included in the nonfederal 35% share. Once a nonfederal sponsor is identified, the nonfederal sponsor will need to certify that they are aware of their financial obligations and have the financial capability to satisfy obligations for the project. Refer to Chapter 9, Description of the Tentatively Selected Plan, of the main report for a complete discussion on cost apportionment for the TSP.

Table ES-1 Cost Apportionment of TSP

Contribution	Estimated Project First Costs[a]
TSP	
USACE (65%)	$179,000,000
Nonfederal (35%)	$96,400,000
Total Federal Contribution	$179,000,000
Total Nonfederal Contribution	$96,400,000
Cash	$96,200,000
LERRDs	$200,000
Total Implementation Cost	$275,400,000
Nonstructural Measures (Average Annual Cost)[b]	
Federal	
USACE	$130,000
Other Federal Agencies	$11,110,000
Nonfederal	$70,000
OMRR&R (Average Annual Cost)[c]	
USACE	$260,000
Nonfederal	$7,950,000

[a] All costs presented at a 2016 price level, and discounted using the FY 2017 Federal Discount Rate of 2.875%.

[b] USACE's portion (e.g., monitoring) of nonstructural measure costs pertains to monitoring the control point. That yearly estimate will be cost shared; 65% will be federal and 35% will be nonfederal.

[c] OMRR&R costs are 100% federal for the flushing lock and 100% nonfederal for the remaining alternative features.

ES.14 Milestone Schedule and Procedures

The current schedule for completing the feasibility report is as follows:

- Agency Decision Milestone June 2018
- Internal Progress Review February 2019
- State and Agency Review begin February 2019
- Chief's Report Milestone August 2019

Upon completion, the Report of the Chief of Engineers will also be submitted to Congress for authorization. If Congress makes funds available, PED can begin. The report will also be reviewed by the Office of the Assistant Secretary of the Army (Civil Works) and the Office of Management and Budget for potential inclusion in future administration budget requests. Refer to Chapter 9, Description of the Tentatively Selected Plan, of the main report for a complete discussion on milestone schedule and procedures.

ES.15 Unresolved Issues and Areas of Controversy

Refer to Chapter 9, Description of the Tentatively Selected Plan, of the main report for a complete discussion on unresolved issues and areas of controversy.

ES.15.1 Nonfederal Sponsor

The GLMRIS authority authorizes completion of the study at full federal expense. USACE has engaged with a wide variety of stakeholders during GLMRIS-BR with a goal of identifying a nonfederal sponsor for implementation of a GLMRIS-BR project. A nonfederal sponsor has not committed at this time.

ES.15.2 Environmental Conditions of Real Estate

The current plan sites certain project features on the right descending bank of the channel. If future investigation indicates historic uses preclude use of the property, then siting of the project on the left descending bank would be evaluated.

ES.15.3 Lock Closure

The Lock Closure Alternative was ranked the most effective alternative in preventing Bighead and Silver Carp establishment in the Great Lakes Basin. However, it would negatively impact navigation, and result in higher transportation costs (NED costs). The Lock Closure Alternative would result in a discontinuation of navigation through Brandon Road Lock and Dam, and would cause businesses that currently ship goods through this infrastructure to shift to less-efficient routings, or go out of business. Based on the navigation economic analysis, the average annual loss in transportation cost savings (NED costs) for the 50-year period of analysis (2021–2070) was estimated to be $318.7 million (2016 price levels).

ES.15.4 Mitigation Requirements

Although USACE assessment of the alternative impacts reveals that impacts are expected to be minor overall, there is concern that the reduction in connectivity within the Des Plaines River will need to be mitigated if the TSP is implemented. The mitigation requirements will need additional coordination with the U.S. Fish and Wildlife Service and the Illinois Department of Natural Resources.

ES.15.5 Other Federal Agencies

The nonstructural measures of the TSP are integral to maximizing the effectiveness of the TSP. The responsibilities for the execution of the nonstructural measures would be shared between USACE and other federal agencies.

ES.15.6 Optimization of Flushing Lock Operation

During PED, a scaled physical model will be constructed of the Brandon Road Lock to optimize the flushing operating parameters to maximize flushing effectiveness while minimizing navigation impacts.

ES.15.7 Minimizing the Impact of TSP Construction on Navigation

To better inform the construction schedule and associated navigation restrictions, additional engineering and economic analysis, safety testing, and coordination with navigation stakeholders and the USCG would be completed as the study continues and during the PED phase. If possible, construction activities will be scheduled to coincide with other scheduled waterway maintenance in order to minimize impacts on navigation.

ES.15.8 Navigation Considerations

The navigation community has expressed the following main concerns:

1. *Navigation Impact Estimates.* The navigation community has expressed concern about whether USACE has adequately estimated the economic impact on navigation to inform an evaluation of alternatives and TSP selection. USACE used the best available engineering and economic information to estimate economic impacts of the alternative. Information was incorporated from the following sources: USACE navigation databases (e.g., Waterborne Commerce Statistics Center; Lock Performance Management System), Agency-certified economic models, responses to shipper and carrier surveys administered for both GLMRIS and GLMRIS-BR studies, information gathered from the USCG and navigation stakeholders during the GLMRIS-BR safety workshop, and other informative data sources. During PED, the economic impact estimates will also be updated to reflect more detailed engineering analysis.

2. *Safety Implications of Operating the TSP, in Particular the Electric Barrier.* The navigation community has expressed concern over the safety impacts of adding ANS control features to the downstream approach channel, in particular an electric barrier. USACE in coordination with USCG would conduct an evaluation of the ANS control measures included in the TSP. The evaluation results and input gained through coordination with the navigation community will inform operating parameters and safety protocols for the control measures.

3. *Mooring Cell Location and Layout.* The navigation community has expressed concern about whether the proposed mooring location and design would meet their navigation needs. Informed by stakeholder input during National Environmental Policy Act scoping, USACE incorporated four mooring cells downstream of Brandon Road Lock and Dam into the TSP. To better inform the mooring cell location and layout, USACE will conduct working sessions with the USCG and navigation communities to obtain additional input during PED.

4. *Impacts the TSP May Have on the Brandon Road Lock and Dam Infrastructure.* The navigation community has expressed concern over whether the operation of the TSP could impact the current infrastructure of the Brandon Road Lock and Dam, which may decrease its reliability. During the feasibility study, USACE performed an engineering assessment of the potential corrosion impacts the electric barrier could have on the Brandon Road Lock and Dam. The assessment identified that with increased monitoring, potential impacts could be mitigated. See Appendix H, Engineering, for more information.

Chapter 1 Introduction

The United States Army Corps of Engineers (USACE) is preparing a Feasibility Study (FS) and an integrated Environmental Impact Statement (EIS) to evaluate alternatives for controlling upstream transfer of aquatic nuisance species (ANS) from the Mississippi River Basin (MRB) into the Great Lakes Basin (GLB) through the Chicago Area Waterway System (CAWS), and the impacts of those alternatives on waterway uses and users.

ANS are a continued threat throughout the United States. They cause losses in biodiversity, changes in ecosystems, and impacts on economic enterprises such as commercial and recreational fisheries, power production, and international trade. An "aquatic nuisance species" is a species that is "1) non-native to the ecosystem under consideration, and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (Executive Order [E.O.] 13112, "Safeguarding the Nation from the Impacts of Invasive Species"). Multiple initiatives have been undertaken at both the federal and state levels to address the control and management of ANS.

Numerous Great Lakes and Mississippi River Interbasin Study (GLMRIS) ANS of Concern can be found within the MRB that have the potential to transfer into the GLB. However, only those species that were identified as a GLMRIS ANS of Concern in the GLMRIS Report (USACE 2014a) are the focus of the Great Lakes and Mississippi River Interbasin Study – Brandon Road (GLMRIS-BR) project. These include two fish species – Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*) – and an invertebrate species (*Apocorophium lacustre*) that only has a scientific name (i.e., no common name).[1] Bighead Carp and Silver Carp will be referred to collectively throughout this report as Asian carp (though the term is often used to refer to all four species now found in North America – Bighead and Silver Carp, Grass Carp [*Ctenopharyngodon idella*], and Black Carp [*Mylopharyngodon piceus*]). As Asian carp populations have spread northward up the Illinois River, the threat of these species gaining access to Lake Michigan and the rest of the GLB has become a concern to many in the environmental community, as well as among federal, state, and local government agencies. There is a potential for significant ecological and economic consequences should reproducing populations of Asian carp become established in the CAWS, Lake Michigan, in the other Great Lakes, and connected tributaries (refer to Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin). Although there are uncertainties as to the specific levels of environmental, economic, and sociopolitical impacts that could be realized if introduced, federal and state partners acknowledge the need for proactive measures and are currently taking action to reduce the risk that a sustainable population of Asian carp could establish in the GLB.

1.1 Study Purpose and Need*

USACE's purpose and need for the GLMRIS-BR project are to evaluate structural and nonstructural options and technologies near the Brandon Road Lock and Dam (BRLD) site to prevent the upstream transfer of ANS from the MRB into the GLB, while minimizing impacts on existing waterway uses and users. For GLMRIS, USACE has defined the term "prevent" to mean the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.[2]

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[1] Common names for fish are capitalized throughout this report, in accordance with the American Fisheries Society's 2013 *A Guide to AFS Publications Style*.

[2] Defining the term "prevent" to mean reducing the risk to the maximum extent possible is entirely reasonable. Michigan v. U.S. Army Corps of Engineers, 911 F. Supp. 2d 739, 766 (N.D. Ill. 2012), aff'd, 758 F.3d 892 (7th Cir. 2014).

The need for this study is to address the problem of the interbasin transfer of ANS between the GLB and MRB.

The GLMRIS-BR Report is a study that builds on the foundation of the GLMRIS Report released in January 2014 (USACE 2014a). The GLMRIS Report (USACE 2014a) identified several alternatives to address the interbasin transfer of ANS; however, full implementation of several of the alternatives would require a substantial investment of time and of money. Given the potential urgency of the ANS threat and in response to a growing consensus, the Secretary of the Army (Secretary) determined that a formal evaluation of potential control options and technologies to be applied near the BRLD was an appropriate next step. The BRLD brings singular advantages for further study. The approach channel and lock provide a unique opportunity to control upstream MRB ANS transfer in a relatively small section of the Des Plaines River (i.e., the upper Illinois Waterway), because the majority of the waterway flows downstream over a high-head dam, with the only potential upstream passage through the lock. These conditions afford the opportunity to optimize the operational characteristics of the ANS controls, maximize the efficiency of applied technologies, and minimize the associated costs for implementation and operation. Establishing a control point near BRLD for upstream transfer of MRB ANS does not adversely impact flood risk or water quality of the CAWS. It does, however, provide for additional defense-in-depth for particular species of concern (i.e., Asian carp), when combined with the current Chicago Sanitary and Ship Canal – Electric Dispersal Barrier System (CSSC-EB) located in Romeoville, Illinois, which was implemented in 2002 with the construction of the demonstration barrier (see Section 2.2.2, CAWS).

1.2 Study Authority

The GLMRIS was authorized in Section 3061(d) of the Water Resources Development Act (WRDA) of 2007, Public Law 110-114 as follows:

> FEASIBILITY STUDY – The Secretary, in consultation with appropriate Federal, State, local and nongovernmental entities, shall conduct, at Federal expense, a feasibility study of the range of options and technologies available to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins through the Chicago Sanitary and Ship Canal and other aquatic pathways.

This authority differs from traditional USACE FS authorizations in that the study is conducted at full federal expense.

In July 2012, the GLMRIS authority was modified by Section 1538 of the Moving Ahead for Progress in the 21st Century Act, Public Law 112-141 (MAP-21). MAP-21 directs the Secretary to expedite the completion of the report for the study authorized by Section 3061(d) of WRDA 2007 and, if the Secretary determines a project is justified in the completed report, to proceed directly to preconstruction engineering and design (PED). The full text of Section 1538 of MAP-21 is as follows:

> (a) DEFINITIONS.—In this section:
> (1) HYDROLOGICAL SEPARATION.—The term ''hydrological separation'' means a physical separation on the Chicago Area Waterway System that—
> (A) would disconnect the Mississippi River watershed from the Lake Michigan watershed; and
> (B) shall be designed to be adequate in scope to prevent the transfer of all aquatic species between each of those bodies of water.
> (2) SECRETARY.—The term ''Secretary'' means the Secretary of the Army, acting through the Chief of Engineers.

(b) EXPEDITED STUDY AND REPORT.—

(1) IN GENERAL.—The Secretary shall—

(A) expedite completion of the report for the study authorized by section 3061(d) of the Water Resources Development Act of 2007 (Public Law 110–114; 121 Stat. 1121); and

(B) if the Secretary determines a project is justified in the completed report, proceed directly to project preconstruction engineering and design.

(2) FOCUS.—In expediting the completion of the study and report under paragraph (1), the Secretary shall focus on—

(A) the prevention of the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins, such as through the permanent hydrological separation of the Great Lakes and Mississippi River Basins; and

(B) the watersheds of the following rivers and tributaries associated with the Chicago Area Waterway System:

(i) The Illinois River, at and in the vicinity of Chicago, Illinois.

(ii) The Chicago River, Calumet River, North Shore Channel, Chicago Sanitary and Ship Canal, and Cal-Sag Channel in the State of Illinois.

(iii) The Grand Calumet River and Little Calumet River in the States of Illinois and Indiana.

(3) EFFICIENT USE OF FUNDS.—The Secretary shall ensure the efficient use of funds to maximize the timely completion of the study and report under paragraph (1).

(4) DEADLINE.—The Secretary shall complete the report under paragraph (1) by not later than 18 months after the date of enactment of this Act.

(5) INTERIM REPORT.—Not later than 90 days after the date of enactment of this Act, the Secretary shall submit to the Committees on Appropriations of the House of representatives and Senate, the Committee on Environment and Public Works of the Senate, and the Committee on Transportation and Infrastructure of the House of Representatives a report describing—

(A) interim milestones that will be met prior to final completion of the study and report under paragraph (1); and

(B) funding necessary for completion of the study and report under paragraph (1), including funding necessary for completion of each interim milestone identified under subparagraph (A).

In 2014, per the direction of MAP-21, USACE completed the GLMRIS Report (USACE 2014a), which included an array of alternatives addressing the threat of ANS.

Further direction was provided in the Explanatory Statement for the Consolidated Appropriations Act, 2016, Public Law 114-113 (*Congressional Record*, December 17, 2015, at H10056):

> "Asian carp.—The Corps is directed to expedite authorized actions related to addressing the threat Asian carp pose to the Great Lakes Basin, including the Brandon Road Study. Given the promise Brandon Road Lock and Dam holds as a single point to control upstream transfer of invasive species, delays to this study would pose an unnecessary threat to the Great Lakes. Upon completion of the study, the Corps is directed to expeditiously pursue authorization of any proposed modification to Brandon Road Lock and Dam through the appropriate congressional committees."
>
> The Corps is further directed to establish formal emergency procedures under authorities provided under Section 1039 of the Water Resources Reform and Development Act of 2014 (P.L. 113-121), including rapid response protocols, monitoring, and other countermeasures, that are appropriate to prevent Asian carp from passing beyond the

Brandon Road Lock and Dam while still complying with the Lock's existing authorized purposes and the River and Harbor Act of 1899 (33 USC §401, et seq.). These procedures shall be established in coordination with the U.S. Fish and Wildlife Service and in consultation with the Asian Carp Regional Coordinating Committee.

1.3 Description of the Feasibility Study Process

In February (Walsh 2012a) and March (Walsh 2012b) 2012, two planning memoranda were issued that collectively revised USACE's approach to planning studies and emphasized risk-based decision-making and early vertical team, commonly known as leadership chain, engagement during the FS process. The new process is called Specific, Measurable, Attainable, Risk Informed, and Timely (SMART) Planning, and is derived from the Principles and Guidelines and the USACE Planning Guidance Notebook (Engineering Regulation [E.R.]) 1105-2-200). With SMART Planning, a FS still works progressively through the six-step planning process (Figure 1-1), but includes five key decision points or milestones (Figure 1-2) that mark key decisions along the path to an effective and efficient study. Studies conducted within the new SMART Planning paradigm are expected to be completed within 3 years, at a cost not to exceed $3 million and fully coordinated among the three levels of USACE's vertical team.

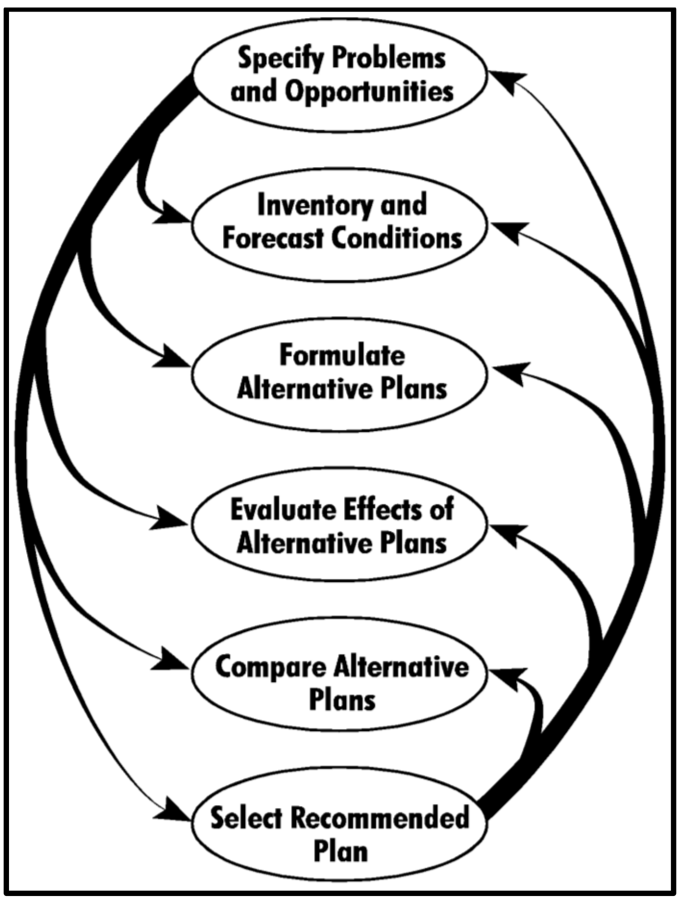


Figure 1-1 USACE Six-Step Planning Process

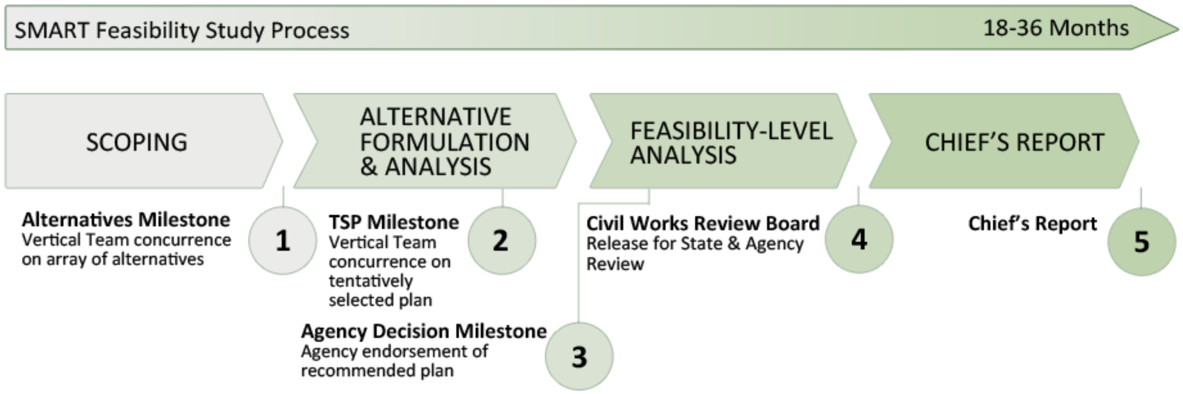


Figure 1-2 SMART Planning Milestones

1.4 Nonfederal Sponsor

At this time, the GLMRIS-BR Project Delivery Team (PDT) has not identified a nonfederal sponsor(s) for implementation of a GLRMIS-BR project. The GLMRIS authority approves completion of study activities at full federal expense. Throughout the completion of the GLMRIS Report (USACE 2014a), the PDT engaged with a wide variety of stakeholders and plans to continue doing so during the GLMRIS-BR FS, with the goal of identifying a nonfederal sponsor.

1.5 Cooperating Agencies

Title 40, *Code of Federal Regulations* (40 CFR), §1501.6 and §1508.5, of the Council on Environmental Quality (CEQ) Regulations address cooperating agencies, which are federal agencies other than a lead agency that have jurisdiction, by law or special expertise, with respect to any environmental impact involved in a proposal or reasonable alternative. These regulations implement the National Environmental Policy Act of 1969 (NEPA) requirement that federal agencies prepare NEPA analyses and documentation "in cooperation with State and local governments" and other agencies with jurisdiction by law or special expertise (Title 42, *United States Code* [42 USC], §4331(a) and §4332). During GLMRIS (USACE 2014a), the USACE reached out to other federal agencies to become formally designated cooperating agencies on

GLMRIS pursuant to the CEQ's regulations implementing NEPA (40 CFR § 1501.6 and 40 CFR § 1508.5). Memoranda of Understanding (MOU) were entered into by USACE and the following agencies: U.S. Coast Guard (USCG), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS), and U.S. Geological Survey (USGS). The MOU memorialize the commitment of USACE and the aforementioned signatory agencies to work together cooperatively on GLMRIS. In general, cooperating agencies provide pertinent data/analysis within their expertise, input on alternatives, and assistance and technical expertise, and they participate in pertinent meetings and provide comments on draft documents.

1.6 Study Area

The GLMRIS-BR System-Wide Study Area includes the GLB within the United States, with attention given to bordering watersheds (Figure 1-3). Potential aquatic pathways between the MRB and GLB exist along the boundary between the two watersheds, indicated by the brown/white dashed line. The GLMRIS-BR Illinois Waterway Study Area consists of the upper Illinois Waterway (from Peoria Lock and Dam upstream), lower Kankakee River, CAWS, and lower and upper Des Plaines River (Figure 1-4). The GLMRIS-BR Site-Specific Study Area is the BRLD, the downstream approach channel, and adjacent upland parcels (Figure 1-5).

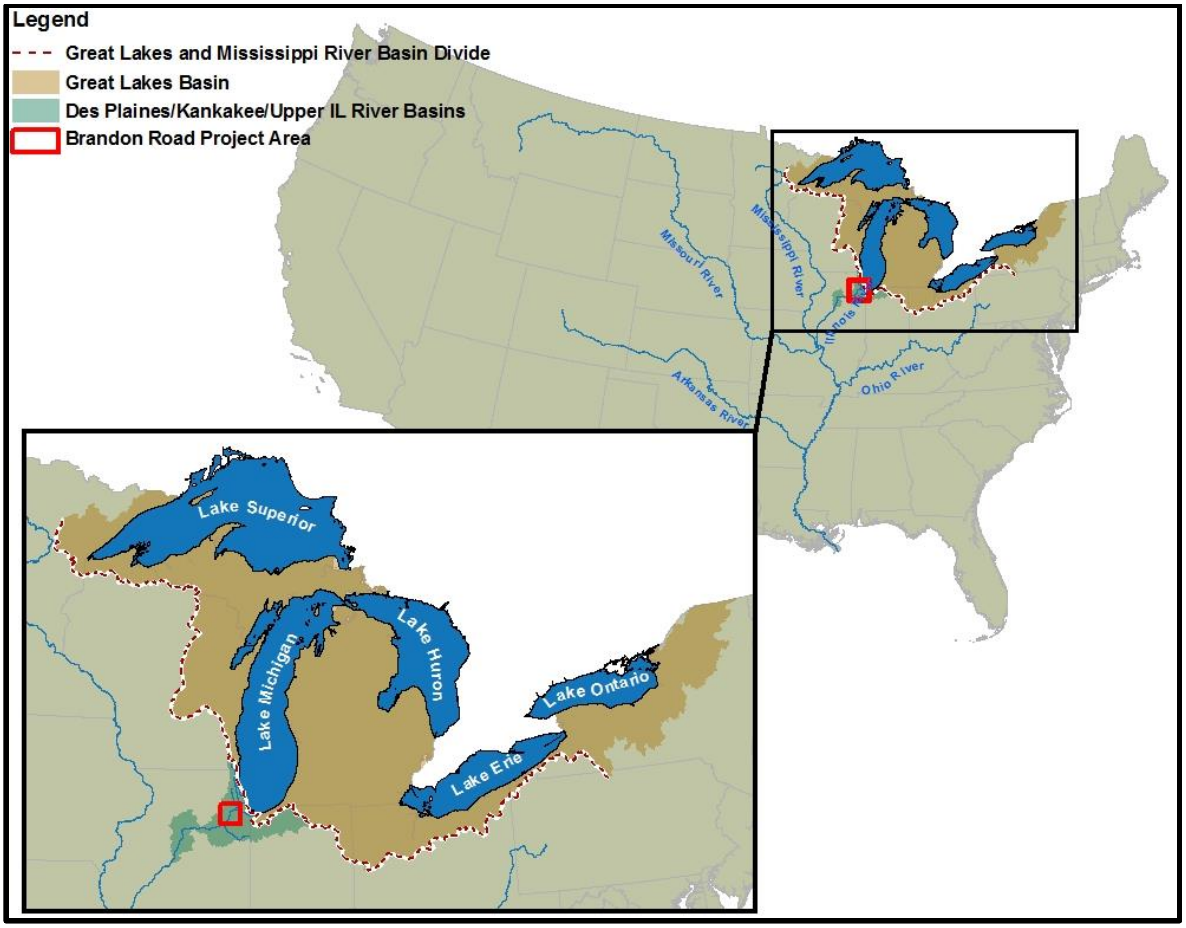


Figure 1-3 GLMRIS-BR System-Wide Study Area

Figure 1-4 GLMRIS-BR Illinois Waterway Study Area

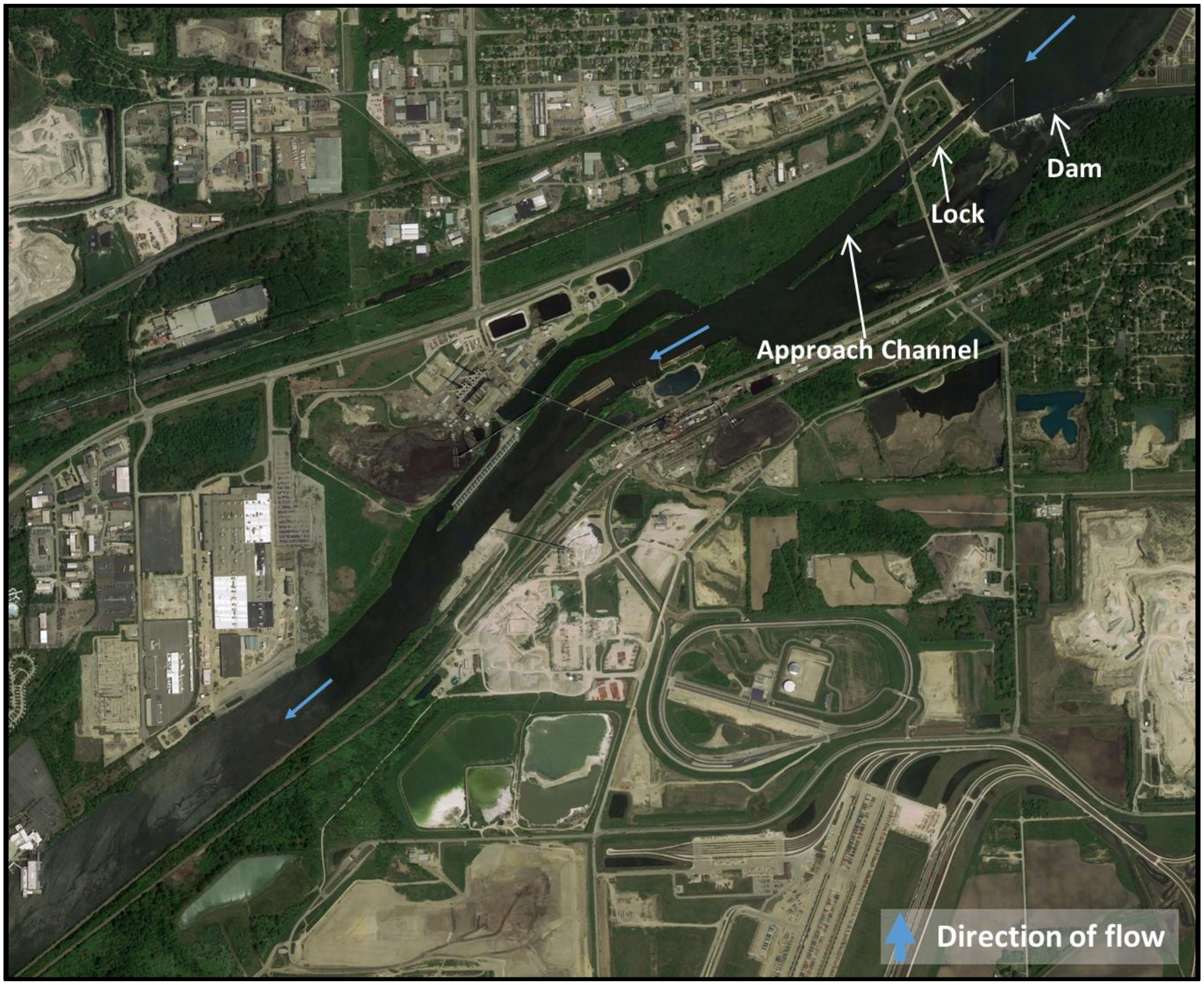


Figure 1-5 GLMRIS-BR Site-Specific Study Area

1.7 Project Area

While the GLMRIS Report (USACE 2014a) identified multiple control points that could be used to prevent the transfer of ANS between the MRB and GLB, BRLD was recognized as a unique control point that could address the upstream transfer of MRB ANS through all CAWS pathways (see Chapter 6, Alternative Plan Formulation section for additional details). In addition, the following considerations warranted the further study of BRLD as a one-way control point for ANS transfer between the MRB and GLB:

1. The BRLD is located south (downstream) of the confluence of the lower Des Plaines River and the CSSC (Figure 1-6). USACE was authorized in Section 3061(b)(1)(D) of WRDA (2007) to conduct a study of a range of options or technologies for reducing impacts of hazards that may reduce the efficacy of the CSSC-EB, referred to commonly as the Efficacy Study. The CSSC-EB were designed to reduce the risk of upstream movement of fish from the MRB to the GLB via the CSSC. Previous investigations under this Efficacy Study have indicated that a potential hydrologic bypass can occur, during periods of high precipitation, from the Des Plaines River to

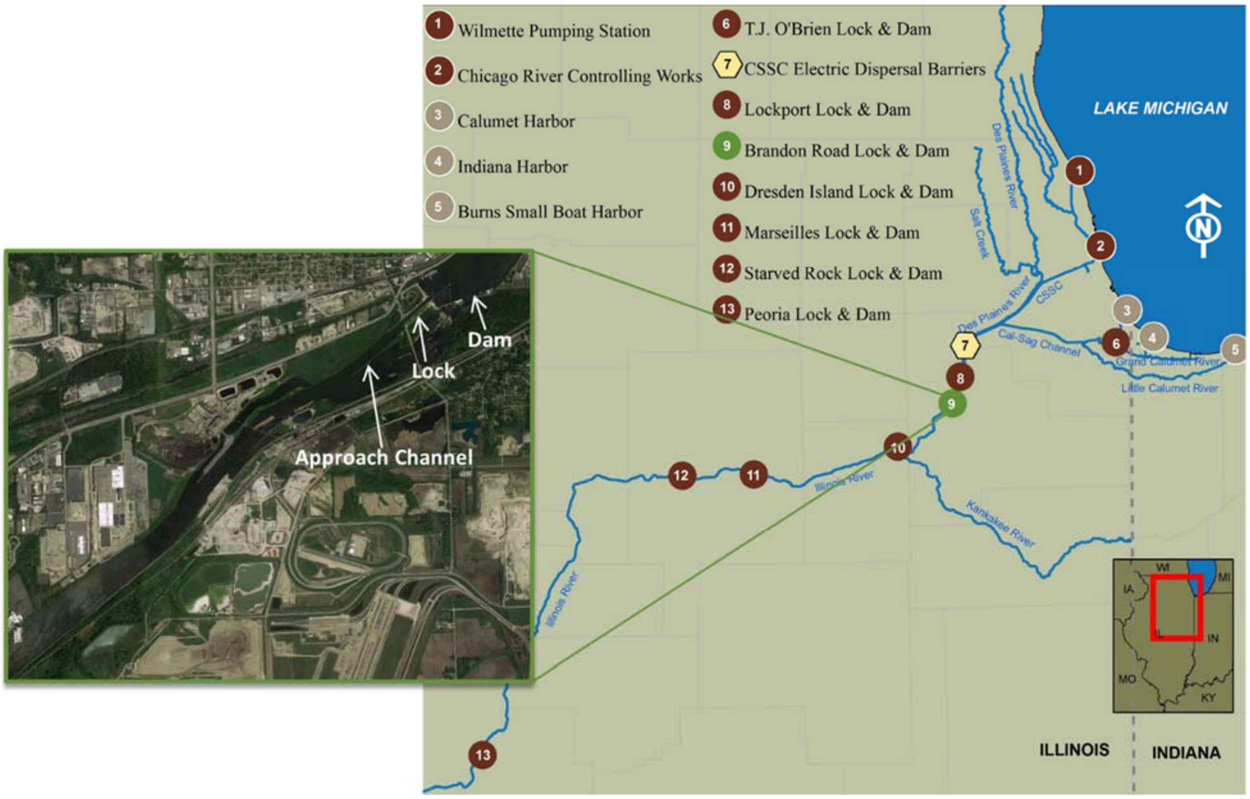


Figure 1-6 Location of BRLD in Relation to the CSSC Electric Dispersal Barriers

the CSSC. A one-way control point at the BRLD site would minimize the likelihood of bypass of MRB ANS into the GLB during flood events via the Des Plaines River to the CSSC.

2. The physical configuration of the BR Dam prevents the upstream transfer of MRB ANS. There is a minimum 24-foot (ft) (7.3-meter [m]) difference in water surface elevation from the downstream side of the dam to the upstream side of the dam (i.e., for the 500-yr discharge), which effectively limits upstream transfer over the top of the dam from fish potentially jumping (Figure 1-7). Fish are also unable to swim through the dam when head gates are open, which would thus not provide a viable aquatic connection. When the head gates are in operation, the minimum velocity through the gates during various flow conditions is calculated to be 28 ft per second (8.5 m per second), which exceeds fish swimming capability and effectively limits upstream transfer through the head gates when they are in an open position. The only aquatic connection, therefore, is the BR Lock which provides an aquatic pathway that potentially would allow MRB ANS to transfer to the GLB via the CAWS, either freely swimming or being carried passively in the movement of water through the lock chamber.

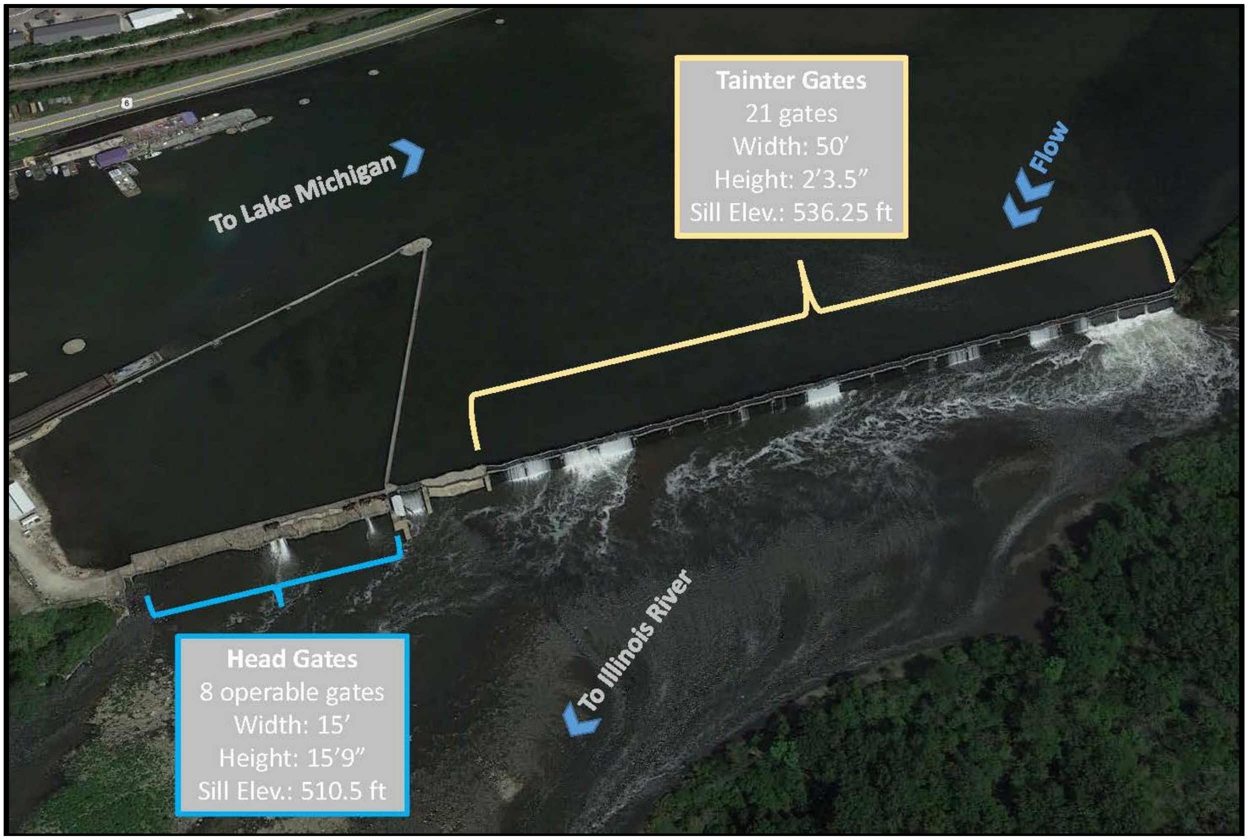


Figure 1-7 Brandon Road Lock and Dam Aerial View Showing Head Gate and Tainter Gate Characteristic

3. The BRLD approach channel and lock provide a unique opportunity to control ANS transfer in a relatively small section of the river where flow is controlled by lock operations. These conditions provide the opportunity to optimize ANS control operations, maximize the efficiency of applied technologies, and minimize the associated costs for implementation and operation. The physical lock structure also provides an additional control in the event of scheduled maintenance, repair, or rehabilitation, or temporary failure or malfunction of any potential control technologies employed downstream.

4. Establishment of a control point at BR for MRB species does not adversely impact flood risk or water quality of the system and creates a management zone to control swimming ANS, when combined with the CSSC-EB located in Romeoville, Illinois.

5. Three of six structural alternatives presented in the GLMRIS Report (USACE 2014a) (Alternatives 4, 7, and 8) utilized the BRLD as a control point for ANS transfer in the upstream direction.

6. Establishment of a one-way control point for MRB ANS of Concern could provide additional information on the effectiveness of various control technologies for potential long-term solutions to prevent two-way species transfer.

Chapter 2 Background, Existing Projects, and Prior Reports

2.1 Background Information

2.1.1 Illinois Waterway

The Illinois Waterway is a major tributary of the Upper Mississippi River. It supports navigation from Lake Michigan and Chicago to the Upper Mississippi River, linking the Great Lakes with the inland waterway system. The term "Illinois Waterway" is used in place of the Illinois River, since navigation between the UMR and Great Lakes includes all or portions of the Illinois River, Des Plaines River, Chicago Sanitary and Ship Canal, Cal-Sag Channel, Little Calumet River, and Calumet River. The Illinois Waterway has been continuously developed for navigational purposes since 1822 (Table 2-1). In 1927, Congress approved legislation authorizing a 9-ft by 200-ft-wide channel on the Illinois River from Utica, Illinois, to Grafton, Illinois. This project was to complement a similar project then under construction by the State of Illinois extending from Utica to Lockport, Illinois. In 1930, Congress enacted legislation enabling the Federal Government to assume responsibility of the Utica-to-Lockport segment, already about 75 percent completed. Three years later, the Corps of Engineers completed the project, and combining it with the earlier authorized Federal project between Utica and Grafton, opened the Illinois Waterway to navigation in 1933. Navigation on the waterway was further improved with the construction of locks and dams at Peoria and La Grange from 1936 to 1938, and the addition of the Thomas J. O'Brien Lock and Controlling Works on the Calumet River in Chicago in 1960.

Congress designated the Upper Mississippi and Illinois Waterway System as a "nationally significant ecosystem and nationally significant commercial navigation system" in the Water Resources Development Act of 1986 (Public Law [P.L.] 99-662). The Upper Mississippi River Illinois Waterway System has the authorized purpose of inland navigation and funds appropriated for operation and maintenance of the system must support the modernization and improvement of the waterway for navigation (Flood Control Act of 1970 [P.L. 91-611]). Operation and maintenance responsibility must comply with environmental laws and policies to minimize environmental impacts from project activities. The Water Resources Development Act of 2007 (P.L. 110-114) and Water Resources Reform and Development Act of 2014 (P.L. 113-121) authorize the maintenance and improvement of Illinois waterways for navigation, ecological sustainability, and ecosystem restoration.

2.1.2 GLMRIS

GLMRIS was authorized by Section 3061(d) of the Water Resources Development Act of 2007 (WRDA 2007 [P.L. 110-114]). Specifically, the statute authorized the Secretary of the Army, acting through the Chief of Engineers, to conduct a feasibility study of the range of options and technologies available to prevent aquatic nuisance species from spreading between the GLB and the MRB. Per the MAP-21 authority, the GLMRIS Report (USACE 2014a) focused on the five direct connections between the CAWS and the GLB and the MRB. USACE evaluated all potential aquatic pathways between the GLB and the MRB, and then divided them into two focus areas. Focus Area 1 consisted of the aquatic pathways within the CAWS, which are the only continuous aquatic connections between the basins. Focus Area 2 included all other potential aquatic pathways between the basins.

The GLMRIS-BR Report builds on the foundation of the GLMRIS Report released in January 2014 (USACE 2014a). The GLMRIS Report (USACE 2014a) identified several alternatives to address the interbasin transfer of ANS; however, full implementation of several of the alternatives would require a substantial investment of time and of money. Given the potential urgency of the ANS threat and in

Table 2-1 Timetable of Navigation Development Activities on the Upper Mississippi River and Illinois Waterway

Activity	Year
Upper Mississippi River	
Congress authorizes removal of snags and local obstructions	1824
Congress authorizes 4.5-ft channel from mouth of Missouri River to St. Paul	1878
Congress authorizes 6-ft channel	1907
Construction of Meeker Island Dam (first Lock and Dam 1)	1913
Construction of Lock and Dam 19	1914
Construction of Lock and Dam 1	1917
Congress authorizes 9-ft-deep, 300-ft-wide channel from St. Louis to Cairo, Illinois	1927
Congress authorizes extension of 9-ft channel to St. Paul, Minnesota, through construction of locks and dams	1930
Construction of 29 locks and dams	1930–1940
Construction of 1,200-ft chamber at Lock and Dam 19	1957
Upper and Lower St. Anthony Falls authorized	1937
Lower St. Anthony Falls constructed	1956
Upper St. Anthony Falls constructed	1963
Congress authorizes new dam and single 1,200-ft chamber at Lock and Dam 26	1978
Congress authorizes construction of second chamber (600 ft) at Lock and Dam 26 (R)	1985
Construction of 1,200-ft chamber at Melvin Price Locks and Dam (formerly L&D 26 [R])	1990
Construction of 600-ft chamber (2nd lock) at Melvin Price Locks	1994
Major rehabilitation/maintenance	1986–present
Illinois Waterway	
Congress authorizes construction of the Illinois and Michigan Canal	1822
Construction of Chicago Sanitary and Ship Canal and five low navigation locks and dams	1900
Construction of present-day system of seven locks and dams	1933–1939
Construction of Thomas J. O'Brien Lock and Controlling Works	1960
Major rehabilitation/maintenance	1975–present

response to a growing consensus, the Secretary of the Army determined that a formal evaluation of potential control options and technologies to be applied near the BRLD was an appropriate next step.

2.2 Pertinent Prior Reports

2.2.1 GLMRIS Report

The GLMRIS Report (USACE 2014a), dated January 6, 2014, evaluated eight potential alternatives to reduce the risk of transfer of ANS between the GLB and MRB (http://glmris.anl.gov). Three of the eight alternatives included the BR site as the proposed option. The GLMRIS Report (USACE 2014a) also established basin-wide Existing (Baseline), Future without Project (FWOP), and Future with Project (FWP) conditions.

Focus Area 1

Focus Area 1 of the GLMRIS Report (USACE 2014a) consisted of the 128 mi (206.0 kilometers [km]) of waterways in and around the Chicago Metropolitan Area, referred to as the CAWS. There are five continuous aquatic pathways located within the system between the GLB and MRB. The CAWS is a network of canals and channelized rivers in northeastern Illinois and northwestern Indiana. It is a complex, heavily used waterway that has many uses and users that evolved as the needs of the City of Chicago and its population grew and the economy expanded. Current uses and users of the CAWS include, but are not limited to, stormwater management, effluent conveyance, water supply and discharge, emergency response, commercial navigation, recreational boating, sport fishing, and power generation.

The CAWS is operated by the USACE for the purpose of commercial navigation. The *Code of Federal Regulations* (33 CFR §207.420 and 33 CFR §207.425) requires that the CAWS is to be operated such that the water levels downstream of the Chicago Harbor Lock and Controlling Works and the T.J. O'Brien Lock and Dam – the Chicago River and the Little Calumet River, respectively – remain at a lower level than Lake Michigan. The USACE operates the T.J. O'Brien Lock and Dam and coordinates the operation of the Chicago Harbor Lock and Chicago River Controlling Works with the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) to ensure the needs of flood risk management and navigation missions are addressed. Just over half of the CAWS consists of formerly natural streams that have been highly altered and no longer resemble their original conditions. The remainder is made up of excavated, man-made, and perched channels. Flow of water through the CAWS is generally from north to south and from east to west. The system slowly drains away from Chicago and Lake Michigan downstream toward Lockport Lock and Dam and eventually into the MRB. Much of the water in the CAWS comes indirectly from Lake Michigan. Water intakes located offshore in Lake Michigan supply water that is treated and then used in homes, offices, and industries. That water eventually makes its way to wastewater treatment plants. Approximately 70% of the annual flow in the CAWS, as measured at Lockport Powerhouse and Lock, is from discharge of treated municipal wastewater effluent from MWRDGC's Water Reclamation Plants (USACE 2012a).

Focus Area 2

Focus Area 2 of the GLMRIS Report (USACE 2014a) evaluated the potential for surface water connections between the GLB and MRB in the states of New York, Pennsylvania, Ohio, Indiana, Wisconsin, and Minnesota. Any surface water connections within the state of Illinois were incorporated within Focus Area 1 of the GLMRIS Report (USACE 2014a). Focus Area 2 encompassed all natural and man-made surface water pathways and hydraulic connections that exist or may form intermittently between basins outside of the CAWS. The focus of this investigation was along the approximately 1,500-mi (2,414-km) basin divide that delineates the GLB from the MRB (Figure 2-1). However, areas throughout each basin located away from the divide were also given consideration during the Focus Area 2 investigation, because this was important for developing lists of ANS of Concern for each applicable pathway location. The known existing ANS locations contributed to the rating of each species and its ability to encroach over the basin divide at each aquatic pathway.

In 2010, the USACE and partner agencies completed a preliminary assessment (USACE 2010a) that identified a total of 36 locations along the basin divide where it appeared that interbasin flow might occur (see http://glmris.anl.gov/other-pathways/ for more information). These were locations situated in a mixture of rural, forested, suburban, and urban areas, and included locations where surface water flow patterns have been modified from water management operations. This preliminary report was completed

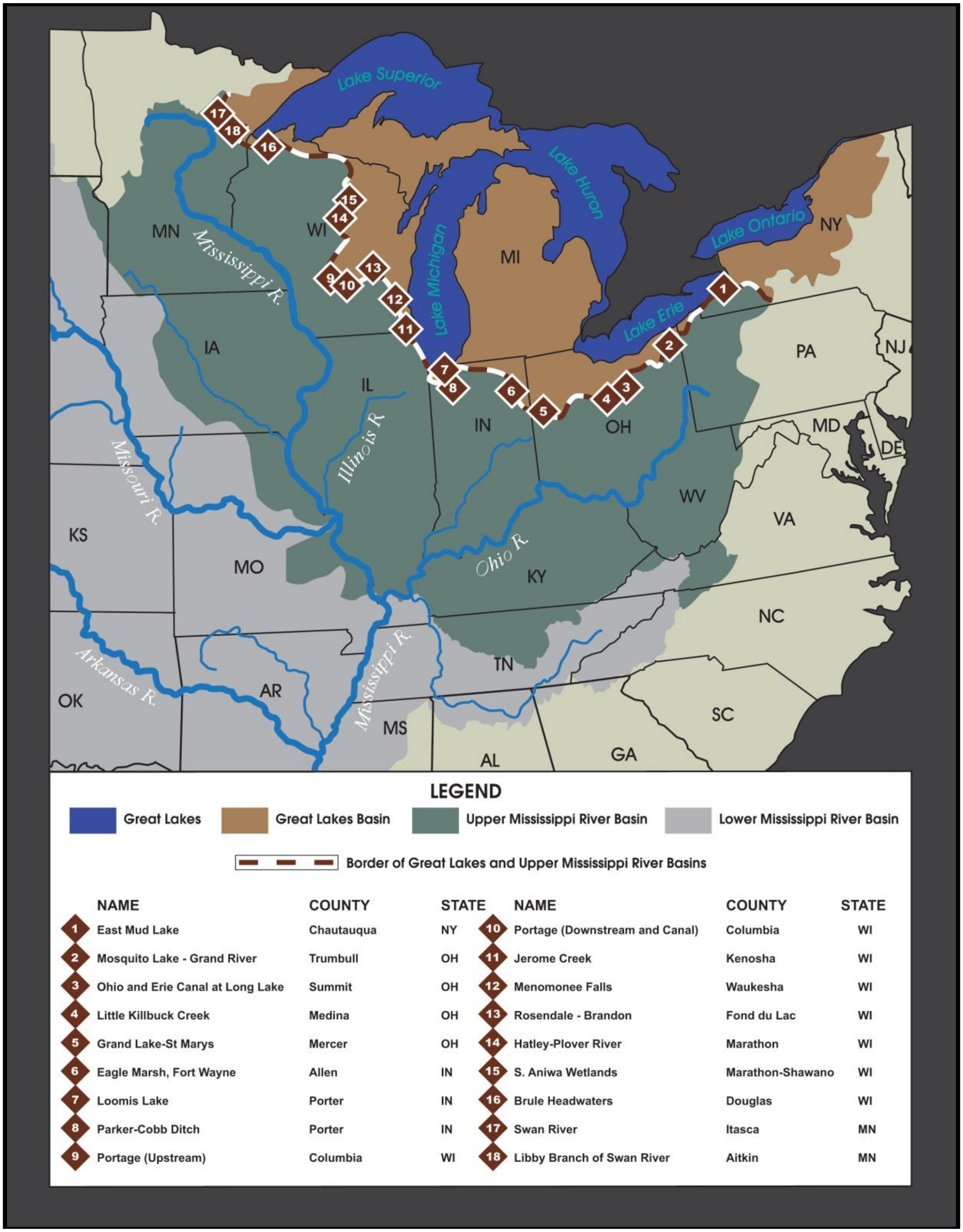


Figure 2-1 Potential Aquatic Pathway Locations within Focus Area 2

and approved for public release by engaging with and receiving significant contributions from the USGS; USFWS; National Oceanic and Atmospheric Administration (NOAA); EPA; the departments of natural resources of Minnesota, Wisconsin, Indiana, and Ohio; the New York Department of Environmental Conservation; and the Great Lakes Fishery Commission (GLFC). Many of the potential aquatic pathways identified in 2010 were locations where extensive natural wetlands exist in close proximity to, and in some instances appear to span, the basin divide.

The first and primary objective of the 2010 preliminary assessment was to determine whether any of the 36 locations initially identified within the GLMRIS-BR System-wide Study Area, aside from the CAWS, were believed to present a near-term risk for the interbasin spread of ANS. “Near-term,” in this case, implied that implementation of a measure(s) might be warranted to reduce the potential for ANS transfer at a particular location in the short term. The only location that was determined to meet this criterion for near-term risk was Eagle Marsh, located south of Fort Wayne, Indiana. The Eagle Marsh location is indicated as site number six in Figure 2-1. Because it was identified as having an impending threat for potential transfer of adult Asian carp, the State of Indiana installed a chain-link fence across Eagle Marsh in late 2010. The purpose of this temporary measure was to reduce the likelihood of adult Asian carp moving into the GLB during significant precipitation events at or near the Eagle Marsh location.

At 18 of the identified 36 locations, the interagency group determined that a precipitation and flooding event as the result of a greater than 1% annual recurrence interval storm event would likely be required for an aquatic pathway to form across the basin divide. Since flooding events in excess of this size are statistically less likely to occur, these 18 locations are considered to have a low probability for aquatic pathway formation and were not recommended for further investigation. This determination was made to allocate limited resources quickly to focus on evaluating those locations that exhibited the most likely potential threats of aquatic pathway formation. This 1% threshold criterion was established through collaboration with the USGS; USFWS, Natural Resources Conservation Service (NRCS); GLFC; and departments of natural resources in the states of Michigan, Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and New York. This threshold also aligns with the most readily available hydrologic information in more rural or remote areas. Although no locations were identified within the Commonwealth of Pennsylvania in 2010, additional investigations in 2011 – in collaboration with the USGS and NRCS – led to the reassessment of six potential aquatic pathways in Pennsylvania. This reassessment confirmed the 2010 findings reported by the USACE; none of these six locations were determined to be viable aquatic pathways.

A more detailed analysis of the 18 remaining sites along the basin divide (Figure 2-1) was completed between 2011 and 2013, in collaboration with the USGS, NRCS, USFWS, state natural resource agencies, and county surveyors. The detailed results for each location were released by each state for public review between September 2012 and March 2013, as GLMRIS Interim Products in July 2013, and as part of the *GLMRIS Report, Appendix N, Focus Area 2* (USACE 2014a) in January 2014.

Through ongoing efforts at Eagle Marsh, the U.S. Department of Agriculture (USDA) NRCS worked with the USACE and other federal, state, and local agencies to identify options for designing a berm to permanently restrict Asian carp from entering the GLB via Eagle Marsh. The NRCS holds a water reclamation plant (WRP) easement on the site. To implement the closure, WRP funding was used for changes within the area of the easement, and Great Lakes Restoration Initiative (GLRI) funding was expended to tie the berm in at the ends of the project, off the WRP property.

The Eagle Marsh project consists of an earthen berm constructed across the floodway to prevent mixing of the watersheds at the 100-yr flood level. It will be built in two phases to quickly maximize prevention of interbasin spread of ANS while also preventing potential induced flood damages to properties currently in and adjacent to the floodplain between the basins.

The first phase was completed in December 2015. This consisted of 9,080 linear ft (2,767.6 m) of berm averaging 8 ft (2.4 m) high, as well as two notches (total 350 ft [106.7 m]) that were built to the approximate 50-yr flood elevation. Chain-link fence was installed along the length of the notches to prevent alteration of the flood crests while blocking ANS transfer at elevations that exceed the 100-yr flood event. The second phase will remove the screen and fill in the notch, but this cannot be completed until all flood risk in the area has been mitigated.

The GLMRIS Aquatic Pathway Assessment Report (USACE 2013a) – developed by the USACE for Little Killbuck Creek connection, in Ohio – assessed the risk for transfer of ANS between the MRB and GLB. This connection was rated a medium risk for the transfer of Silver Carp, Bighead Carp, Black Carp, Inland Silverside (*Menidia beryllina)*, and Northern Snakehead (*Channa argus*), and a low risk for the transfer of Skipjack Herring (*Alosa chrysochloris*), between the MRB and GLB. This connection was rated a medium risk for the transfer of Threespine Stickleback (*Gasterosteus aculeatus*), Ruffe (*Gymnocephalus cernua*), Tubenose Goby (*Proterorhinus semiluanris*), Parasitic Copepod (*Neoergasilus japonicas)*, and Viral Hemorrhagic septicemia (*Novirhabdovirus)*, and a low risk for the transfer of European Fingernail Clam (*Sphaerium corneum)* and European Stream Valvata (*Valvata piscinalis*) between the GLB and MRB.

The Ohio Department of Natural Resources (Ohio DNR) has facilitated numerous meetings with the Medina Soil and Water Conservation District, USDA-NRCS. A consultant has been selected to conduct a preliminary investigation of closure options at the Little Killbuck Creek connection site. This study will be used to refine the closure options so that a final engineering study can be completed. The consultant will complete final design in 2017. The Ohio DNR will then meet with the primary landowner and other potentially affected parties to evaluate and identify the preferred alternative for closure. This alternative will be based on cost and potential impacts on local landowners.

The GLRMIS Aquatic Pathway Assessment Report (USACE 2013a) developed for the Ohio-Erie Canal (OEC) connection calculated that the risk for the transfer of ANS from the MRB to the GLB is medium for transfer of Silver Carp, Bighead Carp, Black Carp, and Northern Snakehead, and low for Skipjack Herring. There is no risk from transfer of ANS in the opposite direction. The Ohio DNR and the USACE discussed two primary areas of concern:

- The direct transfer of water from the MRB to the GLB at the feeder gates to the canal that transfer water from Long Lake to the Lake Erie watershed.
- Flooding at the tow path that allows water to move from the MRB to the GLB.

The USACE completed a preliminary closure assessment in September 2014 with an array of potential options presented in the "Ohio-Erie Canal Aquatic Nuisance Species Control Conceptual Design Measures." Preliminary designs were initially developed and presented for all potential options. At the request of the EPA and Ohio DNR, the USACE completed final designs for these measures in September 2016. The USACE expects to assist Ohio DNR in completing all necessary environmental compliance and coordination requirements in preparation for construction in 2018.

2.2.2 CAWS

The following are ANS control projects in the CSSC and the dates refer to completion of the study and not necessarily the date the feature began operation.

Aquatic Nuisance Species Dispersal Barrier Demonstration Project, Chicago Sanitary and Ship Canal, Between Lemont and Romeoville, Cook and Will Counties, Illinois, U.S. Army Corps of Engineers, 1999

This project (Figure 2-2) was authorized by Congress in 1996 as a demonstration project under Section 1202(i)(3) of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, P.L. 101-646, as amended by Section 2(e)(3) of the National Invasive Species Act of 1996, P.L. 104-332 (16 USC §4722[i][3]). The goal of the project was to conduct a demonstration to identify an environmentally sound method for preventing and reducing the dispersal of nonindigenous ANS through the CSSC. The demonstration barrier is located near Romeoville, Illinois, at river mile 296.2 of the CSSC, and was activated in April 2002. The demonstration barrier was the CSSC's first barrier and consists of an array of electrodes installed on the channel bottom of the CSSC. When power is provided, a pulsing electrical field is created within the water that repels fish. The demonstration barrier operates at a maximum in-water field strength at the water surface ($IWFS_0$) of 1 volt per inch (V/in.), at 5 pulses per second (Hertz [Hz]), and each pulse lasts 4 milliseconds (ms). The demonstration barrier is currently being upgraded to Permanent Barrier I, which is described separately. For additional information on the demonstration barrier, refer to the USACE Aquatic Nuisance Species Portal at http://www.lrc.usace.army.mil/Missions/CivilWorksProjects/ANSPortal.aspx.

Chicago Sanitary and Ship Canal Dispersal Barrier II, U.S. Army Corps of Engineers, 2007

This project (Figure 2-2) was initiated under Section 1135 of the Continuing Authority Program (CAP), WRDA of 1986, P.L. 99-662. In October 2005, the project became specifically authorized by Section 345 of the Fiscal Year 2005 DC Appropriations Act (P.L. 108-335). Dispersal Barrier II consists of two independently operated permanent barriers, IIA and IIB, which include design improvements that were identified during monitoring and testing of the demonstration barrier. Barrier IIA and Barrier IIB each consist of two sets of electrodes installed along the channel bottom and extending the width of the canal. A parasitic system (e.g., conductive materials) was also installed in the canal to limit the extent of the electric fields generated by the barriers to the areas designated for fish deterrence.

Barrier IIA was activated in April 2009 at the same settings as the demonstration barrier. These settings were increased in August 2009 to $IWFS_0 = 2$ V/in., 15 Hz, and 6.5 ms in response to eDNA monitoring results that suggested Asian carp were closer to the barriers than previously believed and research results indicating the new parameters were more effective for smaller Asian carp (Holliman et al. 2015). Barrier IIB was activated in April 2011 at Barrier IIA's settings, and Barrier IIA was placed into warm standby mode. From April 2011 to December 2013, the standard operating protocol was to operate either Barrier IIA or Barrier IIB with the other inactive, but in a warm standby state from which it could be quickly activated. The operating protocol was changed in January 2014, when both Barrier IIA and Barrier IIB began to operate simultaneously to provide increased redundancy.

Operating parameters for both Barrier IIA and Barrier IIB were once again changed in October 2011 to $IWFS_0 = 2.3$ V/in., 30 Hz, 2.5 ms after research results indicated these parameters should be even more effective at deterring Asian carp (Holliman 2011). Since then, the pulse parameters have been changed multiple times in response to further research results (Holliman 2015) and concerns about interference with a nearby railroad crossing signal. Barriers IIA and IIB currently operate at a maximum $IWFS_0$ at the water surface of 2.3 V/in., 34 Hz, and 2.3 ms. For additional information on Barriers IIA and IIB, refer to the USACE Aquatic Nuisance Species Portal at http://www.lrc.usace.army.mil/Missions/CivilWorksProjects/ANSPortal.aspx.

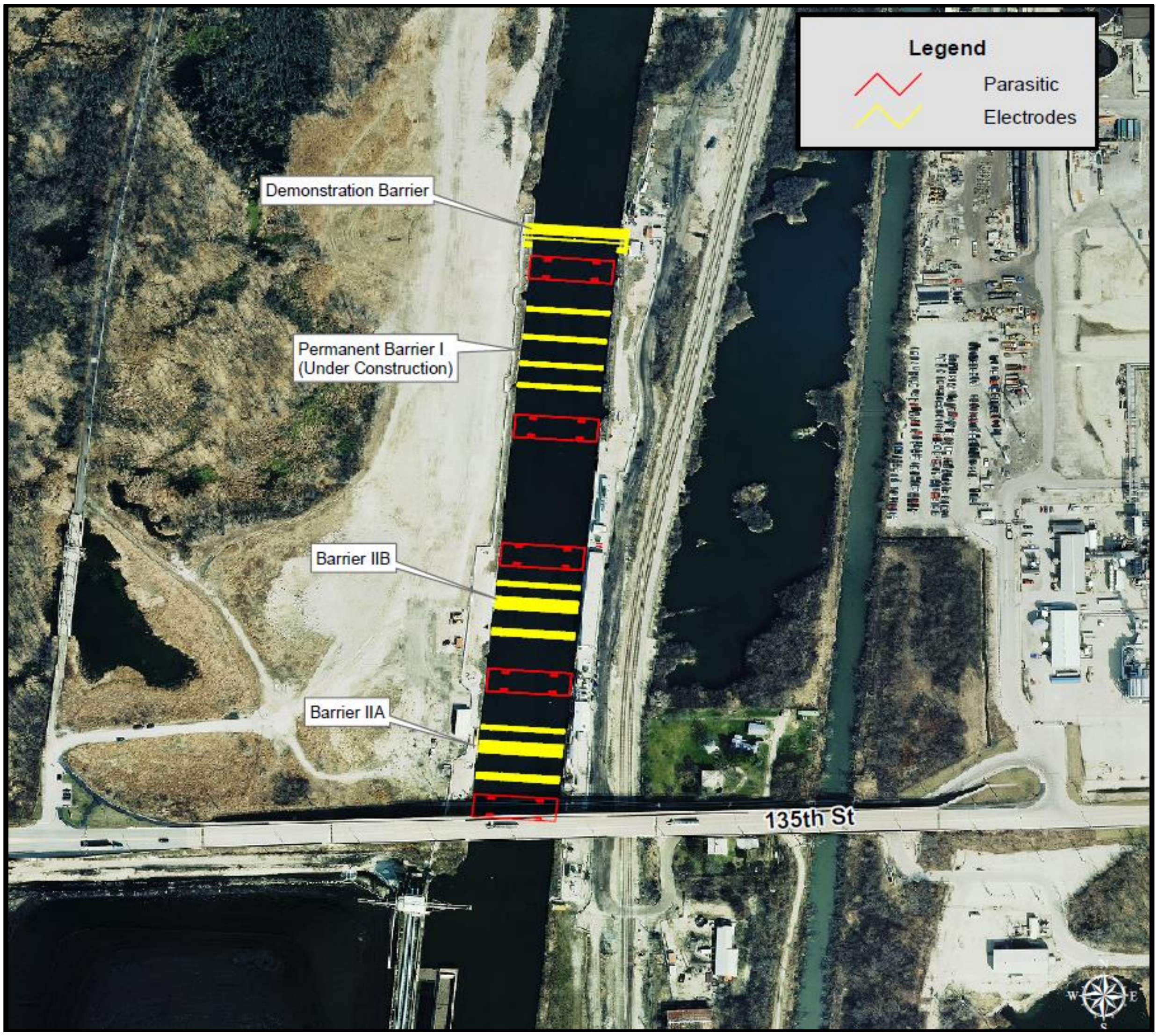


Figure 2-2 Aerial View of the Romeoville Electric Dispersal Barriers

Permanent Barrier I, Lockport Pool Chicago Sanitary and Ship Canal, Will County, Illinois, U.S. Army Corps of Engineers, 2013

This project (Figure 2-2) was authorized in Section 3061(b) of the Water Resources Development Act of 2007, P.L. 110-114. Permanent Barrier I consists of four sets of electrodes installed along the channel bottom and extending the width of the canal. Two parasitic arrays are situated on either side of the electrode field and are designed to reduce the amount of electricity that extends upstream and downstream beyond the area designed for fish deterrence. Permanent Barrier I is designed to have the highest power capability of any of the barriers, up to 6 V/in., and is designed to work in concert with Barriers IIA and IIB to prevent the movements of fish past the Romeoville project area. Construction of Permanent Barrier I commenced in 2013. For additional information on Permanent Barrier I, refer to the USACE Aquatic Nuisance Species Portal at http://www.lrc.usace.army.mil/Missions/CivilWorksProjects/ANSPortal.aspx.

2.3 Studies, Reports, and Existing Water Projects within the GLMRIS-BR System-wide Study Area

Numerous studies have been conducted within the GLMRIS-BR System-wide Study Area to prevent and control ANS, and to restore aquatic habitat to protect native species. Section 2.3.1, Great Lakes and Connected Tributaries, through Section 2.3.5, Kankakee River, describe selected projects that have been constructed or are proposed for construction within the GLMRIS-BR System-wide Study Area.

2.3.1 Great Lakes and Connected Tributaries

Numerous studies have been conducted within the GLB that address the full range of Great Lakes resources, including water supply, fisheries, recreational and commercial navigation, coastal storm damage, coastal processes, and recreation. Recently, the GLRI has supplied resources to federal agencies to strategically target the greatest threats to the Great Lakes ecosystem. The GLRI was launched in 2010 to accelerate efforts to protect and restore the largest system of fresh surface water in the world, the Great Lakes. The focus of these projects is primarily (1) cleaning up toxics and areas of concern, (2) combating invasive species, (3) promoting nearshore health by protecting watersheds and other habitats, (4) restoring wetlands and other habitats, and (5) tracking progress, education, and working with strategic partners. A complete list of projects that have been implemented through this initiative can be found on the EPA GLRI website (available at https://www.glri.us//projects/epa.html). The following is a selection of specific projects (Figure 2-3) that the USACE has undertaken recently with nonfederal partners to restore habitat for native species within the GLB (additional information is provided in Appendix B, Planning). The projects listed below were implemented under the Great Lakes Fishery and Ecosystem Restoration Program (GLFER) authorized by Section 506 of the Water Resources Development Act of 2000, P.L. 106-541, as amended (42 USC §1962d-22):

- Keweenaw Stamp Sands, Michigan.
- St. Marys River Habitat Restoration, Michigan.
- White Rapids/Chalk Hill Dams, Menominee River, Michigan.
- Grand Rapids Dam, Menominee River, Michigan.
- Menominee and Park Mill Dams, Menominee River, Michigan.
- Fort Sheridan Ravine & Coastal Restoration, Illinois.
- Saganashkee Slough-McMahon Woods Ecosystem Restoration, Illinois.
- Little Calumet River Riparian, Indiana.
- Elkhart River, Indiana.
- Boardman River Dam Removal, Michigan.
- Frankenmuth Dam Fish Passage, Michigan.
- Ford Estate Dam Fish Passage, Michigan.
- Harpersfield Dam, Ohio.
- Conneaut Creek, Pennsylvania.
- Elk Creek, Pennsylvania.
- Springville Dam, New York.

Figure 2-3 Map Detailing Selected Great Lakes Fishery and Ecosystem Restoration (GLFER) Projects by the USACE Currently Underway

2.3.2 CAWS

The following is a selection of projects that the USACE has undertaken recently with nonfederal partners to restore aquatic habitat within the CAWS and improve connectivity around low-head dams (Figure 2-4) (additional information on these studies is provided in Appendix B, Planning):

- *Bubbly Creek, South Branch of the Chicago River, Illinois, Draft Integrated Feasibility Report and Environmental Assessment* (USACE 2015a).
- *Eugene Field Park Section 206 Ecosystem Restoration, Integrated Feasibility Report and Environmental Assessment* (USACE 2007a).
- *Horner Park, Section 206, Aquatic Ecosystem Restoration, Integrated Feasibility Report and Environmental Assessment* (USACE 2013c).
- *Indian Ridge Marsh, Section 1135, Integrated Feasibility Report and Environmental Assessment* (USACE 2011a).
- *Little Calumet River Riparian Restoration, Section 506, Detailed Project Report and Environmental Assessment* (USACE 2012b).

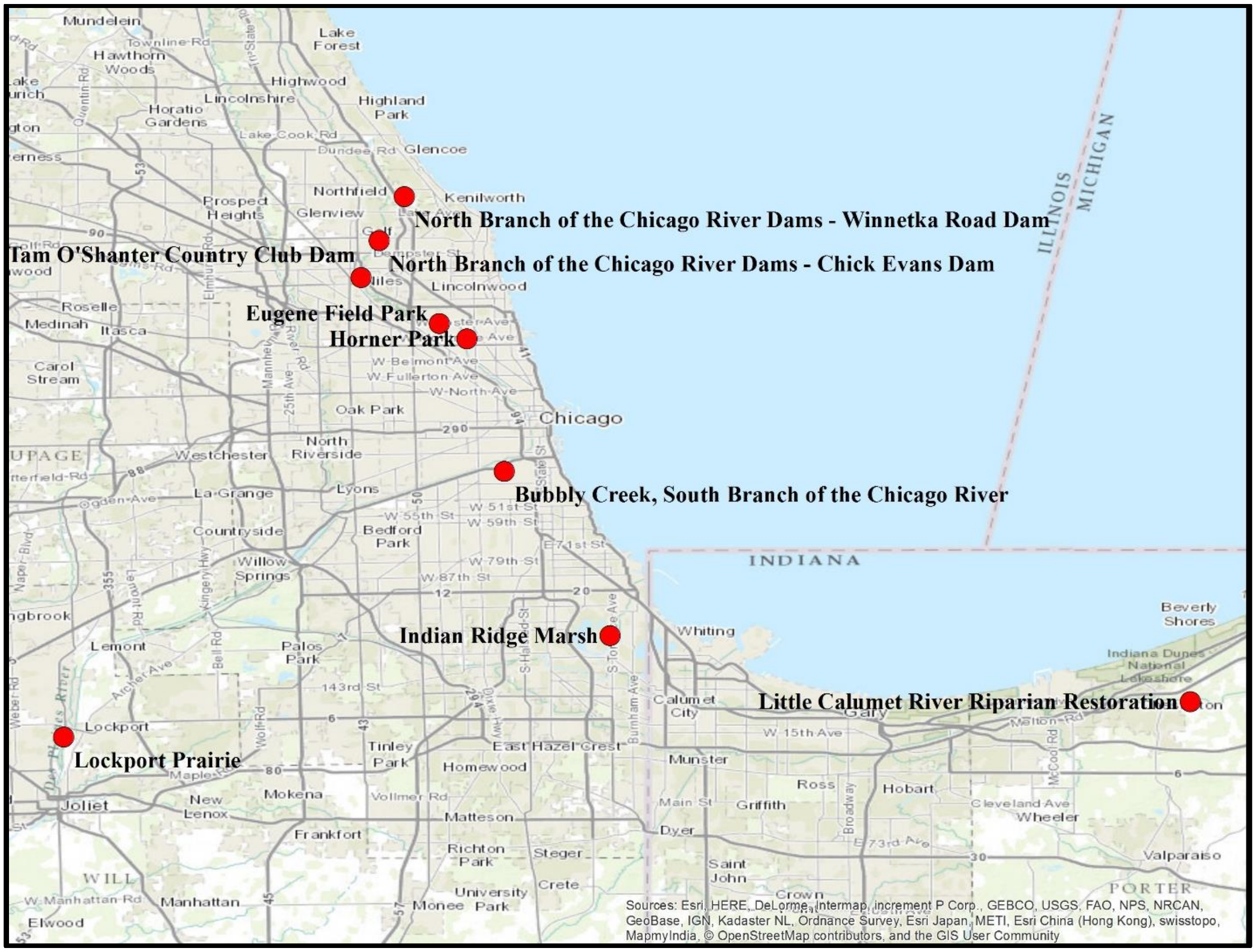


Figure 2-4 Map Detailing Selected Projects by the USACE Currently Underway within the CAWS

- *Lockport Prairie Ecosystem Restoration, Section 206 Aquatic Ecosystem Restoration, Feasibility Study and Integrated Environmental Assessment* (USACE 2015b).
- *North Branch of the Chicago River Dams – Forest Preserve District of Cook County, Section 22 Planning Assistance to States, Integrated Planning Report and Environmental Assessment* (USACE 2013d).

2.3.3 Des Plaines River

The following is a selection of projects that USACE has undertaken recently with nonfederal partners to restore aquatic habitat within the Des Plaines River and improve connectivity around low-head dams (Figure 2-5) (additional information on these studies is provided in Appendix B, Planning):

- *Upper Des Plaines River, Illinois, Interim Feasibility Report and Environmental Impact Statement* (USACE 1999a).
- *Upper Des Plaines River and Tributaries, Illinois and Wisconsin, Integrated Feasibility Report and Environmental Assessment* (USACE 2015c).

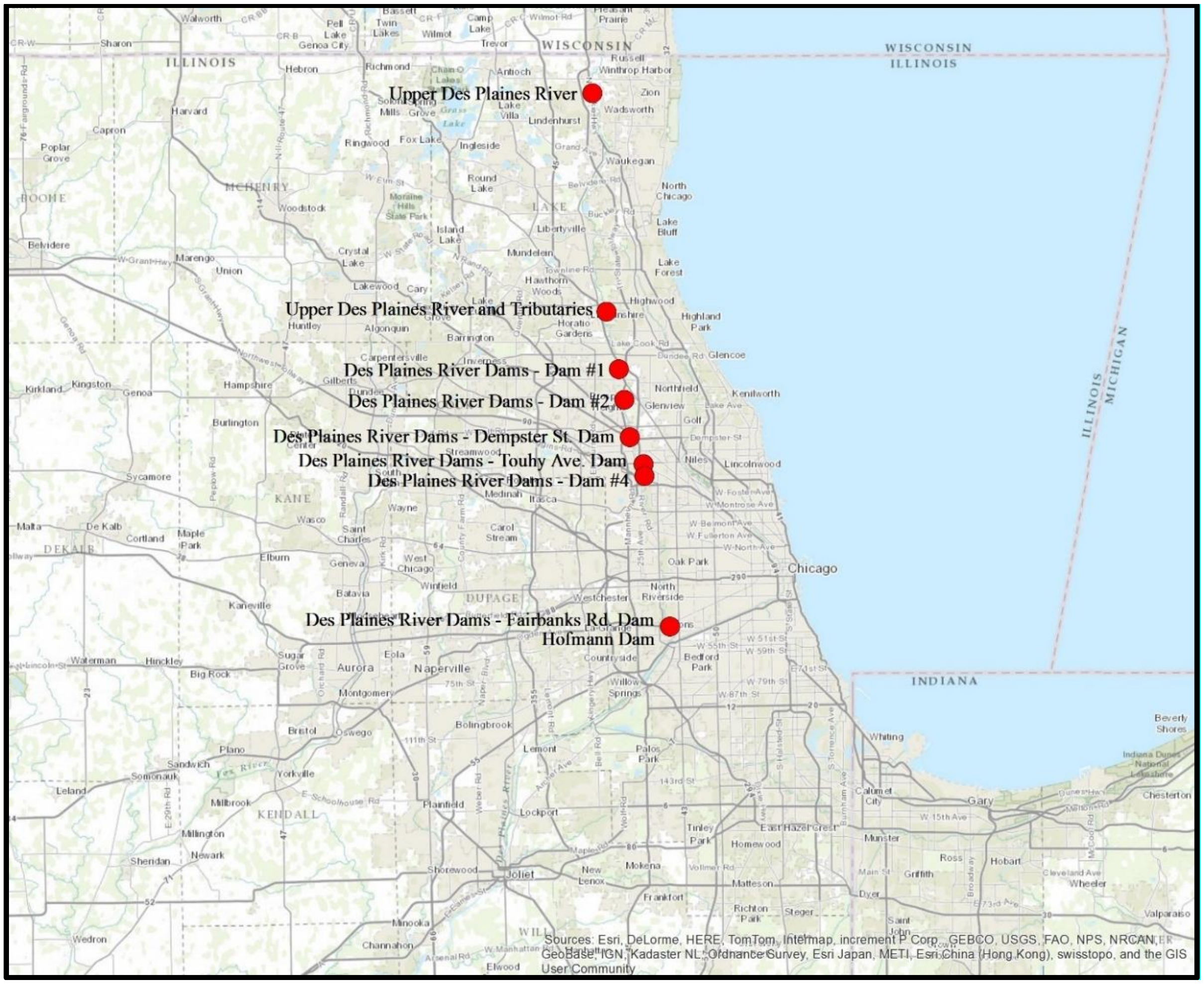


Figure 2-5 Map Detailing Selected Projects by the USACE Currently Underway within the Des Plaines River

- *Hofmann Dam Section 206 Ecosystem Restoration, Detailed Project Report* (USACE 2006a).
- *Des Plaines River Dams – Forest Preserve District of Cook County*, Section 22 Planning Assistance to States, Integrated Planning Report and Environmental Assessment (USACE 2013e).

2.3.4 Illinois River

The following is a selection of projects that USACE has undertaken recently with nonfederal partners to restore aquatic habitat within the Illinois River (Figure 2-6) (additional information on these studies is provided in Appendix B, Planning):

- *Illinois River from Henry to Naples, Illinois, Peoria Lake and La Grange Pool, Illinois River Basin, Reconnaissance Study* (USACE 1987).

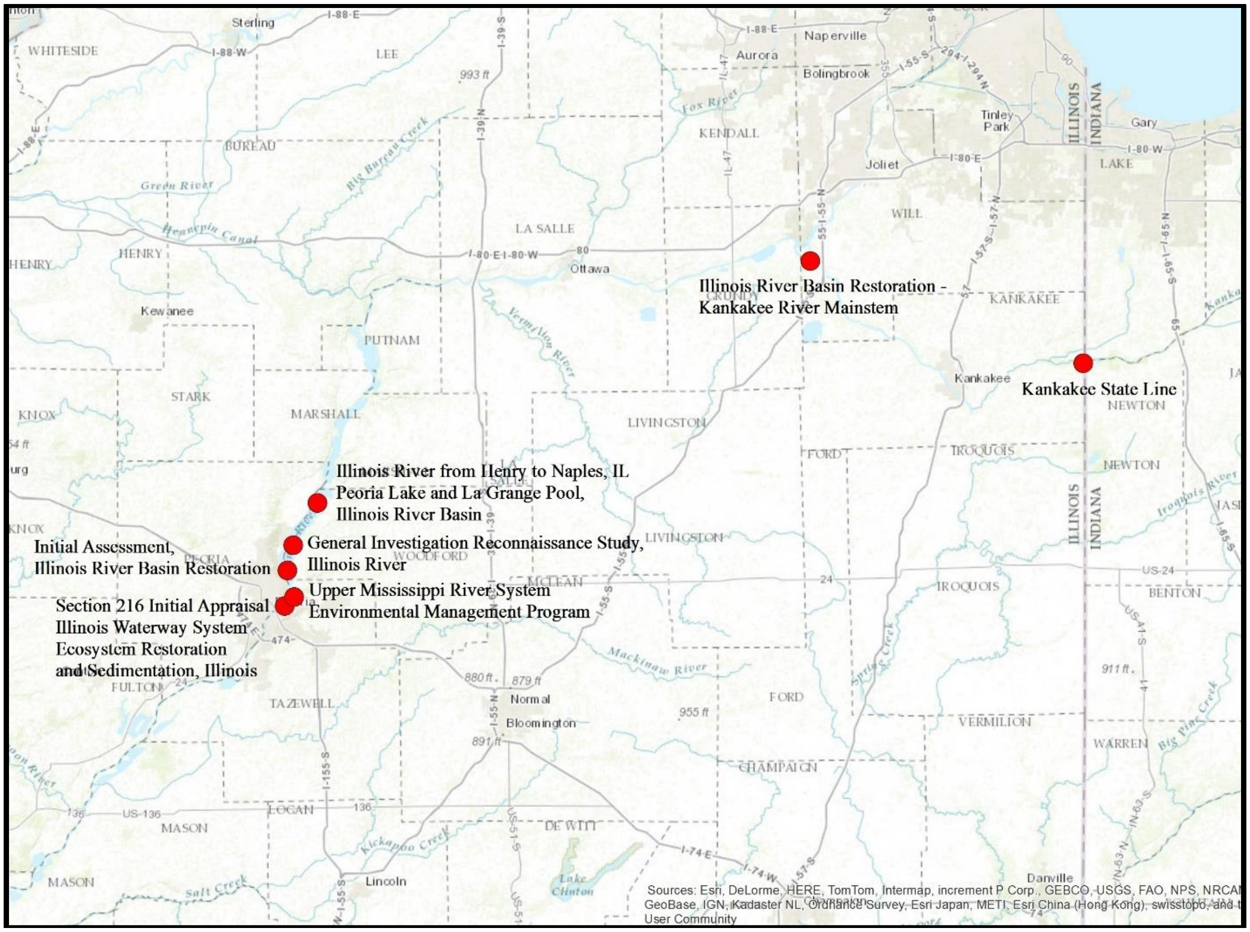


Figure 2-6 Map Detailing Selected Projects by the USACE Currently Underway within the Illinois and Kankakee Rivers

- *Upper Mississippi River System Environmental Management Program, Definite Project Report with Integrated Environmental Assessment, Peoria Lake Enhancement* (USACE 1990).

- *Section 216 Initial Appraisal, Illinois Waterway System Ecosystem Restoration and Sedimentation, Illinois* (USACE 1996a).

- *General Investigation Reconnaissance Study, Illinois River, Ecosystem Restoration, Section 905(b) Reconnaissance Analysis* (USACE 1999b).

- *Initial Assessment, Illinois River Basin Restoration, Section 519 of the Water Resources Development Act (WRDA) of 2000* (USACE 2002a).

2.3.5 Kankakee River

The following is a selection of projects that USACE has undertaken recently with nonfederal partners to restore aquatic habitat within the Kankakee River (Figure 2-6) (additional information on these studies is provided in Appendix B, Planning):

- *Illinois River Basin Restoration, Section 519, Kankakee River Mainstem, Critical Restoration Project* (USACE 2014b).

- *Draft Detailed Project Report with Integrated Environmental Assessment, Section 206 Kankakee State Line, Aquatic Ecosystem Restoration Project* (USACE 2006b).

2.4 ANS Control Efforts and Associated Studies

As a member of the Asian Carp Regional Coordinating Committee (ACRCC), USACE is committed to preventing Bighead and Silver Carp from utilizing potential aquatic pathways to transfer into the GLB. USACE is contributing to this effort through the implementation of a four-pronged strategy, which includes (1) operation of electric barriers in the CSSC, (2) conducting studies to evaluate the effectiveness of the electric barriers, (3) participating in extensive monitoring of the CSSC for Asian carp, and (4) conducting the GLMRIS-BR. Additional detailed information on USACE efforts against Asian carp can be found at www.lrc.usace.army.mil.

No currently known control efforts that allow for continued navigation would prevent *A. lacustre* from transferring through an aquatic pathway into the GLB.

2.4.1 Efficacy Studies

The USACE was authorized in Section 3061(b)(1)(D) of the WRDA of 2007, P.L. 110-114, to study a range of options or technologies for reducing impacts of hazards that may reduce the efficacy of the CSSC-EB located in Romeoville, Illinois; this study is referred to as the Efficacy Study. The USACE specifically focused the efficacy studies on efforts that could reduce the potential for Bighead and Silver Carp to enter Lake Michigan through or around the CSSC-EB in the CAWS.

The USACE developed the Efficacy Study as a series of interim reports. Complete reports include: Interim I, *Dispersal Barrier Bypass Risk Reduction Study and Integrated Environmental Assessment (EA)* (USACE 2010b); Interim IIA, *CSSC-EB Optimal Operating Parameters Laboratory Research and Safety Tests* (USACE 2011b); Interim III, *Modified Structures and Operations, Illinois & CAWS Risk Reduction Study and Integrated EA* (USACE 2010c); and Interim IIIA, *Fish Dispersal Deterrents, Illinois and CAWS Risk Reduction Study and Integrated Environmental Assessment* (USACE 2010d). The completed and approved studies are posted on the Chicago District website at www.lrc.usace.army.mil/Missions/CivilWorksProjects/ANSPortal/Efficacy.aspx. Interim IV, *CSSC Dispersal Barriers Risk Reduction Study and Integrated EA* will be released some time in the future.

The USACE may complete additional efficacy studies in the future to document modifications to the CSSC-EB project or to document additional recommendations consistent with the study authority. Summaries of the Efficacy Studies follow:

- Interim I, *Dispersal Barrier Bypass Risk Reduction Study and Integrated Environmental Assessment* (USACE 2010b) – This interim report was approved by the Assistant Secretary of the Army for Civil Works on 12 January 2010 to construct measures to prevent Bighead and Silver Carp from bypassing the electric barrier system during flood events on the Des Plaines River and through culverts in the Illinois and Michigan (I&M) Canal. Construction of the bypass barrier and I&M Canal blockage was completed in October 2010.

- Interim IIA, *Electrical Barrier Optimal Operating Parameters: Phase A, Laboratory Research and Safety Tests* (USACE 2011b) – This interim report evaluated tests conducted to determine the optimal operating parameters. The evaluation recommended an increase in the operating parameters for the CSSC-EB to make it more effective at deterring small fish. Based on this report, the operational settings were changed in October 2011. Operating parameters continue to be evaluated through laboratory and field testing. Additional efficacy studies may be required in the future if modifications to the CSSC-EB are recommended.

- Interim III, *Modified Structures and Operations, Chicago Area Waterways Risk Reduction Study and Integrated Environmental Assessment* (USACE 2010c) – This interim report evaluated the potential for risk reduction that might be achieved through potential changes in the operation of the CAWS structures (e.g., locks, sluice gates, and pumping stations) in consultation with the multi-agency working group. The report included an assessment of operational changes that could be implemented as needed by agencies that are responsible for fish population management efforts, such as electrofishing, spot piscicide application, or intensive commercial fishing efforts by the USFWS and the Illinois DNR. As part of the Interim III Study, the USFWS facilitated a risk assessment that included representatives of numerous federal and state agencies, including USFWS, USGS, USACE, and Illinois DNR. The results of the risk assessment were included in the Interim III report. This report was approved by the Assistant Secretary of the Army for Civil Works on 13 July 2010. Installation of the sluice gate screens at the Chicago River Controlling Works at the Chicago Harbor Lock, and the Controlling Works at the T.J. O'Brien Lock and Controlling Works was completed in January 2011. Sluice gate screens located at the Chicago River Controlling Works consist of two sets of four sluice gates, with each gate having a 10 ft × 10 ft (3.0 m × 3.0 m) opening.

- Interim IIIA, *Fish Deterrent Barriers, Illinois and Chicago Area Waterways Risk Reduction Study and Integrated Environmental Assessment* (USACE 2010d) – This interim report investigated and evaluated additional deterrent measures within USACE authority that could be quickly employed to potentially reduce the risk of Bighead and Silver Carp dispersing into the GLB. This report focused on readily available fish deterrent and guidance technologies that could be deployed at key locations in the CAWS and downstream in the IWW. The study included an evaluation of numerous fish deterrents including acoustic barriers, strobe barriers, bubble barrier, electric barriers, and combined technology barriers. This analysis was initially included in the scope of Interim III, but was cycled out to consider fielding a developing technology that was initially thought to be quickly deployable and relatively inexpensive. The report included a recommendation for a 2-yr demonstration of a combined acoustic-bubble-strobe fish deterrent. This report was approved by the Assistant Secretary of the Army for Civil Works on 13 July 2010. This project was not implemented.

- Interim IV, *Chicago Sanitary and Ship Canal Dispersal Barriers Risk Reduction Study and Integrated Environmental Assessment* (USACE unpublished) – This report incorporated by reference the previously completed reports, documented the results of ongoing testing and analysis related to the CSSC Electric Dispersal Barriers Project, included a systematic Risk Assessment of identified barrier failure modes, and identified upcoming risk reduction efforts for the Barriers Project. The report also included a comprehensive EA for the CSSC-EB Project. The report documented the efforts of the ACRCC and various working groups to address the risks Bighead and Silver Carp posed to the GLB. The Interim IV Efficacy Study also included a discussion of improvements to the CSSC Electric Dispersal Barriers Project that have been completed by the USACE since the enactment of WRDA 2007; these improvements serve to increase the performance of the project and reduce risk associated with barrier failure modes. The Interim IV Efficacy Study also included updates on other efforts to increase the efficacy of the CSSC-EB Project and further reduce risk related to potential bypasses of the project by Bighead and Silver Carp. These updates included work by the USACE, as well as other federal and state agencies as part of the ACRCC. Additional topics included monitoring and response actions, eDNA monitoring, other potential modes of transit including ballast water, and commercial harvesting. In addition, an update was provided regarding dual frequency identification sonar (DIDSON) used by the USFWS in conjunction with the USACE to study the behavior of fish near the CSSC-EB. The final report is expected to be released in 2017.

2.4.2 Aquatic Invasive Species Management

In 1990, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA), P.L. 101-646, codified at 16 USC §4701, et seq., to establish a broad national program to prevent the introduction and control the spread of introduced ANS; this legislation was reauthorized and amended in 1996 by the National Invasive Species Act (NISA), P.L. 104-332 (ANSTF 2012). The Aquatic Nuisance Species Task Force (ANSTF) is an interagency committee established by Section 1201 of the NANPCA. It serves to develop and implement a program for waters of the United States that (ANSTF 2012):

- Prevents the introduction and dispersal of ANS;
- Monitors, controls, and studies such species;
- Conducts research on methods to monitor, manage, control, and/or eradicate such species;
- Coordinates ANS programs and activities of ANSTF members and affected state agencies; and
- Educates and informs the general public program stakeholders about the prevention, management, and control of these species.

The ANSTF is co-chaired by the USFWS and NOAA, and consists of 13 federal agency representatives and 13 ex-officio representatives (ANSTF 2012). Federal agency representatives include USFWS, NOAA, USACE, Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Department of State (DOS), EPA, U.S. Forest Service (USFS), Department of Transportation (DOT), Maritime Administration (MARAD), National Park Service (NPS), USCG, USDA Animal and Plant Health Inspection Service (USDA-APHIS), and USGS. Ex-officio members of the ANSTF include GLFC, Lake Champlain Basin Program, Chesapeake Bay Program, San Francisco Estuary Project, American Public Power Association, American Water Works Association, Association of Fish and Wildlife Agencies, Gulf States Marine Fisheries Commission, Mississippi Interstate Cooperative Resources Association, Native American Fish and Wildlife Society, National Association of State Aquaculture Coordinators, and Smithsonian Environmental Research Center. Fisheries and Oceans Canada is an invited observer to the ANSTF. Members of the ANSTF focus their work on ANS issues of national concern that require or could benefit from collaborative solutions. Although the ANSTF has a national focus, it recognizes the tremendous importance of actions taken at the regional and local level to achieve national ANS solutions. Section 1203 of NANPCA created the Great Lakes Regional Panel to identify priorities, to coordinate ANS program activities, and to advise public and private interests on control efforts in their region (ANSTF 2012).

Section 1202 of the NANPCA authorized the ANSTF to develop and implement a program for waters of the United States to prevent introduction and dispersal of ANS; to monitor, control, and study such species; and to disseminate related information (ANSTF 2012). The ANSTF Strategic Plan for 2013–2017 carries through many of the goals and objectives established in previous ANSTF plans by remaining focused on prevention, monitoring, and control of ANS as well as increasing public understanding of the problems and impacts associated with invasive species. The Strategic Plan also calls attention to other areas of ANS management, including habitat restoration and research. The Strategic Plan establishes eight goals:

(1) Coordination – Maximize the organizational effectiveness of the ANSTF.
(2) Prevention – Develop strategies to identify and prevent the establishment of new ANS and slow the spread of existing ANS in the waters of the United States.
(3) Early Detection and Rapid Response – Identify and respond to ANS in a timely manner following introduction in order to prevent their establishment and/or spread.
(4) Control and Management – Control established ANS when feasible and when the benefits of managing the established species outweigh the costs of removing them in terms of harm to the environment, the economy, and public health
(5) Restoration – Protect and rehabilitate native species and ecosystems by conducting habitat restoration efforts on multiple scales.
(6) Education/Outreach – Increase awareness about the threats posed by ANS, emphasizing the impacts, importance of prevention and containment, and recommendations for appropriate domestic and international actions.
(7) Research – Facilitate research to address environmental, economic, and human health risks and impacts associated with ANS.
(8) Funding – Coordinate federal agency budgets to support ANSTF priorities and establish a clear process that links state and regional needs in their areas of responsibility.

There are other invasive species-focused committees and working groups besides the ANSTF, one of the larger being the National Invasive Species Council (NISC) (ANSTF 2012). The NISC was established by E.O. 13112, as amended. NISC is co-chaired by the Secretaries of Agriculture, Commerce, and the Interior and includes various member departments and their constituent agencies, as well as a small staff assigned specifically to the council. The E.O. directs the Secretary of the Interior to establish an Invasive Species Advisory Committee (ISAC) composed of nonfederal experts and stakeholders to provide advice and recommendations to NISC on invasive-species-related issues. NISC provides national leadership and oversight on both terrestrial and ANS and ensures that federal programs and activities to prevent and control invasive species are coordinated, effective, and efficient. NISC has specific responsibilities including promoting action at state, tribal, local, and ecosystem levels; identifying recommendations for international cooperation; facilitating a coordinated network on invasive species; and developing guidance on invasive species for federal agencies to use in implementing NEPA. NISC is also responsible for preparing a National Invasive Species Management Plan, which directs federal efforts to prevent, control, and minimize invasive species and their impacts (ANSTF 2012).

The USACE also has an Invasive Species Leadership Team (ISLT) that was established in 2005 to provide oversight of the USACE Invasive Species program. The ISLT provides direction to achieve the goals and objectives in the National Invasive Species Council's Management Plan that apply to USACE programs and projects in fulfillment of the 2009 Memorandum USACE Invasive Species Policy (Temple 2009) and the 2014 Memorandum Invasive Species Management in the USACE (Stockton 2014). The ISLT provides support for the exchange and sharing of information, as well as strategic recommendations to the USACE and U.S. Army Engineer Research and Development Center (ERDC). The structure of the ISLT was defined in the 2005 Memorandum Invasive Species Leadership Team Appointments (White 2005) and generally consists of one representative from each Major Subordinate Command (MSC)/Division Office and a representative from one of the district offices within each MSC. USACE headquarters (HQUSACE) proponents include a representative from Natural Resources Management, Navigation, Planning, and Military Missions, a technical proponent from ERDC, and the Armed Forces Pest Management Board. A representative from the Department of the Army has also been appointed as a member of the ISLT. ISLT responsibilities include the following:

- Providing recommendations to HQUSACE staff on fulfilling agency duties under E.O. 13112;
- Providing strategic direction to research programs that address invasive species, including the Aquatic Plant Control Research Program and the Aquatic Nuisance Species Research Program;
- Representing the USACE on regional invasive species councils;
- Coordinating and collaborating on regional invasive species councils, across federal agencies, and with nonfederal sponsors;
- Developing and implementing cost-effective strategies to address invasive species problems that affect USACE water resource management missions;
- Coordinating team initiatives with the Environmental (and other relevant) Communities of Practice;
- Coordinating with the MSC; and
- Coordinating annual cost information for USACE and provided to the National Invasive Species Council.

In addition, several agencies (e.g., USACE, USFWS, Illinois DNR, USGS) help monitor for the presence of Bighead and Silver Carp within the CAWS and upper IWW. If Bighead and Silver Carp were to become established in the GLB, they could cause declines in abundances of native and stocked fish species. In addition, studies suggest that conditions in areas of the GLB, including nearshore habitats and some tributaries, may be suitable for the feeding and reproduction of Bighead and Silver Carp (Kolar et al. 2005; Cooke and Hill 2010; Murphy and Jackson 2013). The State of Illinois has several outreach and educational initiatives to engage the public on aquatic invasive species awareness and how to prevent the spread of invasive species in Illinois that can be found on the following website: http://www.invasive.org/illinois. The State of Illinois also actively participates in the “Be a Hero – Transport Zero” (Sea Grant Illinois-Indiana undated) and “Stop Aquatic Hitchhikers!” (USFWS and USCG undated) campaigns, as well as continued work in a “Don’t Dump Bait” messaging initiative (Rosenthal 2015). In addition, a “Be a Hero – Release Zero” campaign was initiated by the Illinois DNR in the fall of 2015 to target the spread of aquatic invasive species through trade (Rosenthal 2015). Although these campaigns have been used to engage the public on aquatic invasive species prevention, additional efforts have been undertaken to address the threat of the Asian Carp.

The USACE is a member of the Monitoring and Response Work Group (MRWG) of the ACRCC. The MRWG was established by the ACRCC and is co-led by the Illinois DNR and the GLFC. Guided by the ACRCC Framework, the MRWG was assigned the task of developing and implementing a Monitoring and Response Plan (MRP) for Asian carp that were present or could gain access to the CAWS. The MRP has been released annually since the establishment of the MRWG in 2010.

The 2016 MRP includes 22 individual project plans detailing tactics and protocols to identify the location and abundance of Asian carp in the CAWS, lower Des Plaines River, and upper Illinois River, and initiate appropriate response actions to address such findings (MRWG 2016). As part of the MRPs, the USACE has participated primarily in projects listed as monitoring and barrier effectiveness evaluations. Monitoring projects include the following:

- Fixed site monitoring upstream of the CSSC-EB s (2010–2011);
- eDNA monitoring in the CAWS and upper Des Plaines River (2009–2013);
- Fixed site monitoring downstream of the CSSC-EB (2011 to present); and
- Seasonal intensive monitoring upstream of the CSSC-EB (2013 to present).

Barrier effectiveness evaluations that the USACE has participated in include the following:

- Telemetry;
- Small fish telemetry;
- DIDSON; and
- Fish-barge interactions.

Highlights of the major initiatives outlined in the 2016 MRP are listed below along with updated information and preliminary results from 2016 where appropriate; for more detailed results of efforts, refer to the 2015 Interim Summary Report (MRWG 2016). Projects that are part of the 2016 MRP are listed in Table 2-2. Additional details on the 2016 MRP and the current interim summary report can be found on the ACRCC website, http://www.asiancarp.us. Monitoring continues within the surrounding waterways as part of the annual MRP. Future MRPs, interim summary reports that analyze the previous year's monitoring data, and any new information on Asian Carp population changes are expected to be posted to the ACRCC website.

Monitoring Projects

The following are highlights of the monitoring projects conducted during 2015 by the MRWG member agencies in the upper Illinois Waterway and CAWS:

- Over 35,000 fish were collected above the CSSC-EB during seasonal intensive monitoring. On June 22, 2017, as part of the ACRCC's MRWG seasonal intensive monitoring event, a Silver Carp was captured downstream of T.J. O'Brien Lock and Dam, approximately 9 mi (14.5 km) downstream of Lake Michigan. Southern Illinois University is conducting additional analysis on the fish. In addition to this fish captured in June 2017, a Bighead Carp was captured in Lake Calumet in 2010. Examination of the otolith (e.g., small bones in the inner ear of fish) chemical composition of the Bighead Carp collected in 2010 indicated that the fish may have originated in the Illinois River and then moved or been transported to Lake Calumet.

Table 2-2 Projects Identified in the 2016 MRP

Project Plan Name	Project Plan Name
Seasonal Intensive Monitoring in the CAWS	Monitoring Fish Abundance, Behavior, and Barge Interactions at the Electric Dispersal Barrier
Strategy for eDNA Monitoring in the CAWS	Monitoring Fish Density and Spatial Distribution in Lockport, Brandon Road, and Dresden Island Pools and the Associated Lock and Dam Structures
Larval Fish Monitoring in the IWW	Assessing Population, Movement, and Behavior of Asian Carp to Inform Control Strategies
Distribution and Movement of Small Asian Carp in the IWW	Analysis of Feral Grass Carp in the CAWS and Upper Illinois River
Fixed Site Monitoring Downstream of the Dispersal Barrier	Evaluation of Gear Efficiency and Asian Carp Detectability
Response Actions in the CAWS	Gear Evaluation for Removal and Monitoring of Juvenile Asian Carp Species
Barrier Maintenance Fish Suppression	Unconventional Gear Development
Barrier Defense Asian Carp Removal	Monitoring Asian Carp Using Netting with Supplemental Capture Techniques
Identifying Movement Bottlenecks and changes in Population Characteristics of Asian Carp in the Illinois River	Barrier Defense Removal of Asian Carp Using Novel Gear
Telemetry Monitoring Plan	Alternative Pathway Surveillance in Illinois – Law Enforcement
Understanding Surrogate Fish Movement with Barriers	Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

- In 2016, there were no small Asian carp (<6 in. [<152.4 mm]) documented in the upper pools (e.g., Starved Rock through Lockport) of the Illinois River. In 2015, small Asian carp were captured progressively further upstream. Prior to the 2015 field season, the furthest upstream capture was at river mile 190 at Henry, Illinois. In 2015, small fish were captured at river mile 211 in April; river mile 223 in June; river mile 236 in July and August; and river mile 256.5 near Seneca, Illinois, in Marseilles Pool. The increases in captures during 2015 may indicate a range expansion of juvenile Asian carp upstream toward Lake Michigan. However, the increased captures may also be an artifact of increased juvenile sampling within the upper Illinois River. In addition, new sampling methodologies have been deployed that appear to be more effective at sampling juvenile Asian carp than previous methods. These enhanced monitoring tools continued to be utilized in 2016 and did not reveal small Asian carp above the Starved Rock LD. This would suggest that the small fish captured in 2015 were likely immigrants from pools lower in the river (e.g., Peoria).

- In 2016, no larval Asian carp were captured in the upper Illinois River (i.e., upstream of Starved Rock LD). In 2015, three larval Silver Carp were captured and confirmed within the Dresden Island pool at river mile 279.2. The origin of the three larvae is still unknown.

- The highest number of larval Asian carp in 6 years of sampling was observed in 2015. Asian carp spawning appears to be associated with a rising hydrograph.

- Fixed and random sampling below the CSSC-EB has resulted in the collection of more than 176,000 fish through 2015. No Asian carp have been observed in the Brandon Road or Lockport pools. The detectable Asian carp population front (the most upstream pool where adult fish are consistently caught across the pool and their detection/presence is predictable, with one or multiple individuals collected in a given day/week of sampling) is near river mile 280, approximately 6 mi (9.7 km) downstream of BRLD and approximately 47 mi (75.6 km) downstream of Lake Michigan.

- Additional effort was expended in 2015 to sample the upper pools nearer the CSSC-EB, using supplemental capture techniques including combinations of netting and electrofishing. Electrofishing was determined to be the most effective supplemental capture technique.

- Telemetry results indicate that tagged Asian carp have approached Brandon Road Lock. Two separate occasions since 2012 have shown tagged Bighead Carp approaching the lock, staying within the area 2–3 hours, and then moving back downstream. Preliminary results for 2016 indicate an Asian carp approached the Brandon Road Lock two separate times in August and stayed near the approach channel for 7 hours each time.

- In 2016, one water sample collected near Lake Calumet (i.e., near the mouth of the Little Calumet River) for eDNA tested positive for Asian carp. In 2015, no Asian carp eDNA was detected above the CSSC-EB. Prior to 2015, Asian carp eDNA has been detected above the CSSC-EB beginning in 2010 and in every sequential year up to 2014. However, research over the past several years has indicated that eDNA could be transferred by various sources other than a living fish (i.e., barges, gill nets, birds, fish markets).

Removal Projects and Evaluation

The following are highlights of the removal projects and evaluations conducted during 2015 by the MRWG member agencies in the upper Illinois Waterway and CAWS:

- In 2016, harvest efforts utilizing contracted commercial fishing removed over 1 million pounds of Asian carp from the Marseilles and Starved Rock pools.

- Between 2010 and 2015, over 1,791 tons of Asian carp have been removed from the IWW below the CSSC-EB during contracted commercial fishing efforts. This tonnage was comprised of 79,077 Bighead Carp and 325,096 Silver Carp. Contracted commercial fishing targeted the Starved Rock and Marseilles pools (downstream of BRLD).

- In 2016, a total of 495 Asian carp were captured in the Dresden Island pool (a pool downstream of BRLD); 184 Asian carp were captured in Rock Run Rookery, 7 Asian carp were captured north of Interstate 55, and 304 Asian carp were captured south of Interstate 55.

- From 2010 to 2015, a total of 2,225 Asian carp (i.e., total of 17.3 tons) have been captured within the Dresden Island pool.

- During spring of 2016, the Unified Method was deployed in a backwater lake on the upper Illinois River near Morris, Illinois. Over a 2-week period, fish present in the backwater lake were moved from one end of the lake to the other using nets, so that the fish could be harvested all at once. A total of 96,000 pounds of Asian carp was removed during the 2016 effort. The Unified Method will be repeated at Morris, Illinois, Hanson Material Services backwater slips spring 2017, and additional locations are being considered.

CSSC Electric Dispersal Barrier Effectiveness Evaluation

The following are highlights are taken from 2016 MRP of the CSSC Electric Dispersal Barrier effectiveness evaluations conducted during 2015 by the MRWG member agencies in the upper Illinois Waterway and CAWS:

- Telemetry involves surgically implanting individually coded ultrasonic transmitter tags in the fish and then monitoring movements with a series of stationary and mobile hydrophones. Telemetry studies have observed no upstream passage past the CSSC-EB by live fish. Two dead, tagged Common Carp (*Cyprinus carpio)* have been found upstream of the CSSC-EB since 2011. The tags were able to pass up to 12 receivers without being detected, which suggests the detections of the tags may have been masked via increase ambient noise within the water. Although nothing can be confirmed, the fact the tags were masked suggest the fish may have died and then been entrained by barges, thereby moving the tagged fish upstream of the CSSC-EB. Additional analysis is provided in the 2014 Asian Carp Monitoring and Response Work Group Interim Summary Report.

- Both upstream and downstream inter-pool movement was observed in pools below the CSSC-EB.

- To study movement across the CSSC-EB and through locks and dams, 2,273 surrogate fish with similar behavior to Asian carp have been tagged.

- Asian carp density in Dresden Island pool appeared to decrease consistently from 2012 to 2014. This is likely a result of commercial harvest.

- Asian carp tend to move upstream in spring and downstream in late summer and fall. Asian carp in lower pools also tend to display greater movement than Asian carp in pools closer to the CSSC-EB.

- Total fish density (non-Asian carp) near the CSSC-EB tends to be greatest during summer.

- An early study in 2012 pulled fish through the barrier in non-conductive cages and investigated whether unconfined, tethered fish were able to become entrained by barges. Certain locations of the cage (box to rake, see Figure 2-7) resulted in low fish incapacitation. Similarly, tethered fish were shown to be entrained by barges and to move through the CSSC-EB. In 2013, USFWS expounded upon the tethered fish methodology and found that all barge configurations except box to box provided

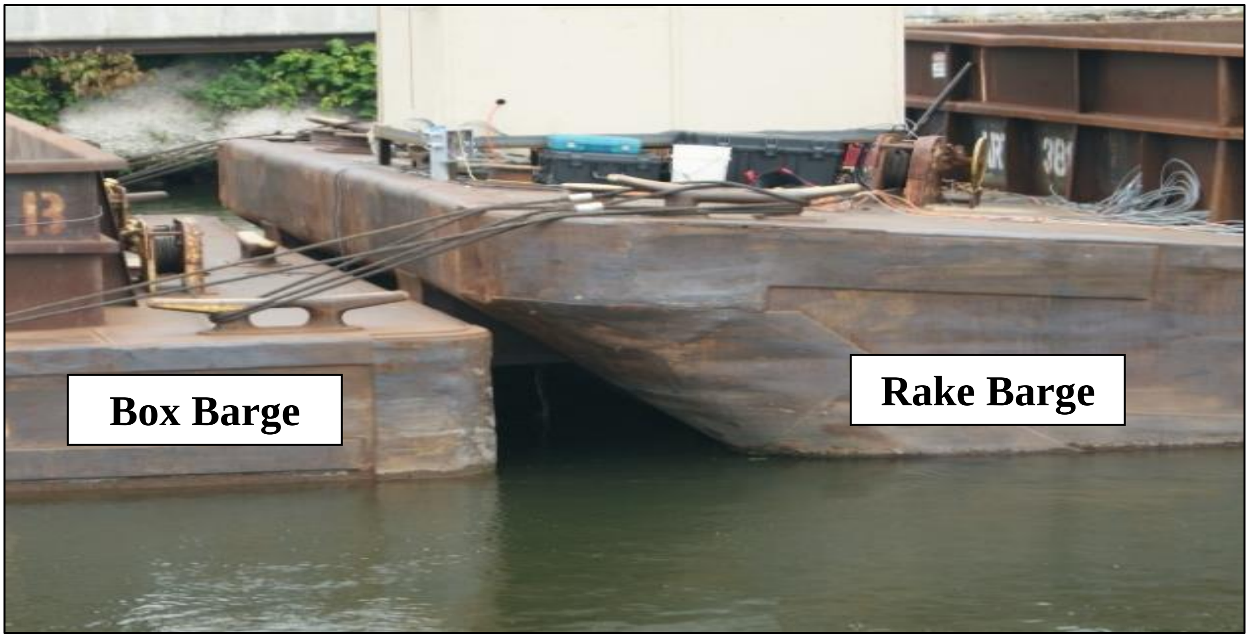


Figure 2-7 Picture of Interstitial Space Created by Tying Curved Bow of a Rake Barge to the Box Stern of Another Barge

some percentage of entrainment. In 2015, hatchery-raised Golden Shiners (*Notemigonus crysoleucas*) were planted within the rake to box junction of barges; they stayed within the junction for long distances (9.6 mi [15.5 km]) through locks and the electric barrier system. In addition, fixed DIDSON cameras were used to observe wild fish within the barrier during barge passes. During downstream passage of barges, return currents caused large numbers of fish to move upstream past the CSSC-EB.

Gear Development and Effectiveness Evaluation

The following are highlights of the gear development and effectiveness evaluations conducted during 2015 by the MRWG member agencies in the upper Illinois Waterway and CAWS:

- Modifications to the configuration and deployment of nets and electrofishing arrays were explored, resulting in new deployment techniques that increase the coverage of net deployments and electrofishing arrays.
- Pound nets (i.e., similar to fyke nets with two wings that funnel fish into a larger net that they cannot escape from) were determined to be both the most effective gear for capturing Asian carp in backwater ponds and lakes, and the most cost-effective gear.
- Field testing indicated that hydroguns (acoustic fish-pulsed pressure wave) do not create an effective barrier to Asian carp movement.

- Relationships between capture gear and Asian carp size class were determined; specific gear was determined to be optimal for targeting specific size classes and age ranges of Asian carp. This study also indicated that juvenile Asian carp tend to favor nearshore habitats, and gradually move to deeper water as they increase in size.

- A model is up and running to identify movement bottlenecks and changes in population characteristics of Asian carp in the Illinois River (Ohio State University [OSU]/USFWS [Dave Glover] modeling effort); scenario investigation took place during winter 2016–2017 utilizing input from USFWS and Illinois DNR. Initial outputs are anticipated to be shared with fishery managers by spring 2017. During winter 2016–2017, the model will continue to be tested for accuracy.

- In 2016, Illinois DNR procured a portable electric barrier system and conducted limited field testing. Additional field testing is scheduled for 2017, with the goal of working toward an in situ placement in conjunction with USCG, USACE, and other interested parties.

Alternative Pathway Surveillance

The following are highlights of the alternative pathway surveillance efforts carried out during 2015 by the MRWG member agencies in the upper Illinois Waterway and CAWS:

- Thirty-two Bighead Carp have been removed from five Chicago-area ponds using electrofishing and trammel and gill nets since 2011. Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008.

- Law enforcement conservation officers have completed inspections of five aquaculture facilities and numerous fish trucks. These and other efforts have resulted in citations and ongoing multi-agency, cross-jurisdictional investigations into the illegal trade of invasive aquatic species.

Chapter 3 Need for and Objectives of Action*

3.1 National Objectives

The USACE's planning process is based on the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* promulgated in 1983 (U.S. Water Resources Council 1983). The Principles and Guidelines provide for development of reasonable plans that are responsive to federal, state, and local concerns. Planning project benefits are quantified in this process as National Economic Development (NED) output, National Ecosystem Restoration (NER) output, or a combination of NED/NER output.

The federal objective of water and related land resources planning is to contribute to NED to protect the nation's environment, in accordance with national environmental statutes, applicable E.O.s, and other federal planning requirements (Durden and Fredericks 2009). The objective of NED is to maximize increases in the net value of the national output of goods and services. For a USACE FS, this objective is met by comparing the difference in the value (i.e., benefits) produced by the project to the value (i.e., costs) of the resources required to produce those goods and services or construct the project. Benefits are increases in the net value of national outputs (i.e., goods and services) and vary by the type of water resource project. The costs (i.e., opportunity costs) are the costs of the resources required or displaced to achieve the plan (such as concrete and steel for building a floodwall). The NED objective is to maximize the difference between monetized benefits and costs (Durden and Fredericks 2009).

Ecosystem restoration is one of the primary missions of the USACE Civil Works program. The USACE's objective in ecosystem restoration planning is to contribute to NER. Contributions to NER (i.e., NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and is expressed quantitatively in physical units or indexes (but not monetary units) (USACE 2000). These net changes are measured in the planning area and in the rest of the nation. Single-purpose ecosystem restoration plans shall be formulated and evaluated in terms of their net contributions to increases in ecosystem value (i.e., NER outputs), expressed in nonmonetary units. Multipurpose plans that include ecosystem restoration shall contribute to both NED outputs and NER outputs. In this latter case, a plan that trades off NED and NER benefits to maximize the sum of net contributions to NED and NER is usually recommended (USACE 2000).

3.2 USACE Campaign Plan

The USACE has developed a campaign plan (USACE 2015d) with a mission to "deliver vital engineering solutions, in collaboration with our partners, to secure our Nation, energize our economy, and reduce risk from disaster." This Campaign Plan shapes USACE command priorities, focuses transformation initiatives, measures and guides progress, and helps the USACE adapt to the needs of the future. This project addresses goals 2 and 4 of the Campaign Plan. Goal 2 is addressed in that this project is an integral component in the control of ANS transfer between the GLB and the MRB. Goal 4 is addressed by applying the planning process to formulate, analyze, and evaluate alternative designs in pursuit of an innovative and sustainable ANS control.

The following is a summary of the Campaign Plan Goals and Objectives:

- Campaign Plan Goal 2: Deliver enduring and essential water resource solutions using effective transformation strategies.
  - Objective 2c: Deliver quality solutions and services.

  - Objective 2d: Deliver reliable, resilient, and sustainable infrastructure systems.

- Campaign Plan Goal 4: Build resilient people, teams, systems, and processes to sustain a diverse culture of collaboration, innovation, and participation to shape and deliver strategic solutions.
  - Objective 4b: Enhance trust and understanding with customers, stakeholders, teammates, and the public through strategic engagement and communication.

3.3 Environmental Operating Principles

In 2002 and again in 2012, the USACE formalized a set of Environmental Operating Principles (EOPs) applicable to decision-making in all programs. The principles are consistent with NEPA, the Army Strategy for the Environment, other environmental statutes, and the WRDA. The EOPs inform the plan formulation process and are integrated into all project management processes. Alternatives formulated for this project are consistent with the EOPs, which are as follows:

- Foster sustainability as a way of life throughout the organization;

- Proactively consider environmental consequences of all USACE activities and act accordingly;

- Create mutually supporting economic and environmentally sustainable solutions;

- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may affect human and natural environments;

- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs;

- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner; and

- Employ an open, transparent process that respects the views of individuals and groups who are interested in USACE activities.

3.4 Problems and Opportunities

The first step in the planning process is to identify problems and opportunities. Problems are undesirable, negative conditions that the study will address. Opportunities are desirable conditions that could be achieved in the future. GLMRIS-BR System-wide Study Area problems and opportunities were drawn from the GLMRIS Report (USACE 2014a) and from public input and interagency information exchange. Through the NEPA public scoping process, input was solicited on problems and opportunities from members of the public, government resource agencies, and other stakeholders. Public comments are available on the GLMRIS-BR project website, glmris.anl.gov/Brandon-rd, as is a report that summarizes the NEPA scoping effort, the *GLMRIS-BR Environmental Impact Statement (EIS) Scoping Summary Report* (USACE 2015e).

A discussion of general GLMRIS-BR System-wide Study Area problems and opportunities follows.

3.4.1 Problems

GLMRIS-BR is the first of possible phased actions that build on the foundation of the GLMRIS Report (USACE 2014a). The following are the problems for GLMRIS-BR:

- Aquatic nuisance species cause impacts: MRB ANS may transfer through the CAWS and cause significant environmental, economic, and sociopolitical impacts within the GLB.

  The need for action to remove, contain, and prevent nonnative species from impairing native ecosystems and existing economies was realized as long ago as the 1950s, but awareness has increased over the past 20 years. As discussed in the GLMRIS Report – ANS White Paper (Veraldi et al. 2011), intentional and accidental species introductions are often associated with declines in native species richness and an overall decrease in biological diversity. In addition, when ANS are introduced to complex ecosystems in which they did not evolve, their populations can grow rapidly, resulting in further dispersal to other suitable habitats. Many consider the negative effects posed by nonnative species to be nationally and globally significant, with these effects further compounded by habitat loss, impairments to natural processes, and commercial species depletion. In many instances, the addition of one aggressive nonnative species can displace several native species that share similar ecological traits. It is estimated that over 50,000 nonnative species may have been introduced to the United States; these range from well-intentioned introductions like reed canary grass (*Phalaris aurundinacea*), to well-controlled agricultural species such as the corn cultivar (*Zea maize*), to accidental events such as the transfer of the round goby (*Neogobius melanostomus*). Asian carp were introduced into the United States to help aquaculture and wastewater treatment facilities keep retention ponds clean. Flooding allowed these fish to escape into the MRB and then migrate into the Missouri and Illinois Rivers. Asian carp are considered to be successful invaders and are now established in the Mississippi, Missouri, and Illinois Rivers.

  The introduction of ANS has had well-documented environmental, economic (e.g., agriculture, forestry, sport fishing), and sociopolitical impacts, with specific emphasis on adverse impacts. Examples of adverse environmental impacts include interspecies competition for space and resources, food chain disruption, and physical and chemical alteration of habitats as witnessed in areas such as Chesapeake Bay, the Florida Everglades, the GLB, and the upper MRB. Potential adverse economic impacts include costs associated with control and management of the effects of an established ANS. Pimentel et al. (2005) estimated that invasive species cost the United States more than $120 billion annually in economic damages associated with ANS effects and their control. In addition, time lost following amplified regulations to ensure ANS species are not spread beyond their current established range is another example of a potential economic impact. Potential adverse social impacts include those associated with recreation losses, aesthetic degradation, and public services (drinking water, food production, etc.).

- ANS transfer via aquatic pathways: MRB ANS may transfer to the GLB via aquatic pathways.

  This study defines pathways as determined by the Pathways Work Team, which is a partnership between the ANSTF and the NISC Prevention Committee. This task force defines pathways as the means by which species are transported from one location to another. Pathways may be classified as either natural pathways or manmade pathways. Natural pathways include natural migration and population spread of organisms, river and ocean currents, wind patterns, unusual weather events, and spread via migratory waterfowl. Man-made pathways include constructed channels, such as the CSSC and the Calumet-Saganashkee (Cal-Sag) Channel.

The GLMRIS Report (USACE 2014a) included an evaluation of ANS that are poised to transfer from one basin to the other via aquatic pathways. These species are identified in the Non-Native Species of Concern and Dispersal Risk for the GLMRIS (http://glmris.anl.gov/documents/docs/Non-Native_Species.pdf) and were assessed in the *GLMRIS Report, Appendix C, Risk Assessment*, in a section entitled Risks of Adverse Impacts from the Movement through the CAWS and Establishment of ANS between the GLB and MRB. The five CAWS pathways provide a complete year-round aquatic connection between the two basins that could allow the interbasin transfer of MRB ANS of Concern. This report evaluates the possibility of ANS of Concern transferring from the MRB to the GLB through the CAWS.

3.4.2 Opportunities

The opportunities of this study are specific to any advantages in ANS prevention that may be gained near BRLD. They include the following:

- Control point near BRLD: Establishment of a control point near BRLD could prevent the transfer of MRB ANS to the GLB through the CAWS.

  Prevention is the most efficient and least costly method of combating invasive species (Figure 3-1). As an ANS becomes more established, resource protection and long-term control efforts escalate exponentially; the area infested increases over time and the eradication and containment of an invasive species become less likely. If ANS pass BRLD and become established in the GLB, management efforts would be widespread throughout the Great Lakes and their tributaries in the United States and Canada. The binational Sea Lamprey (*Petromyzon marinus*) control program provides an example of a similarly scaled effort. The program costs $16 million annually and involves the application of lampricides, barriers, and traps. The GLFC, pursuant to the Convention on Great Lakes Fisheries, delivers Sea Lamprey control in partnership with the USFWS, Fisheries and Oceans Canada, and the USACE, aided by research from the USGS.

- Management zone: The CSSC-EB is a control point for swimming ANS. Establishing a second control point in the vicinity of BRLD provides an opportunity to create a management zone to augment the CSSC-EB’s effectiveness at preventing the transfer of swimming MRB ANS to the GLB. This zone between the two control points could be managed (via fish removal, piscicides, etc.) as a system for swimming ANS to prevent their transfer through the CAWS to the GLB.

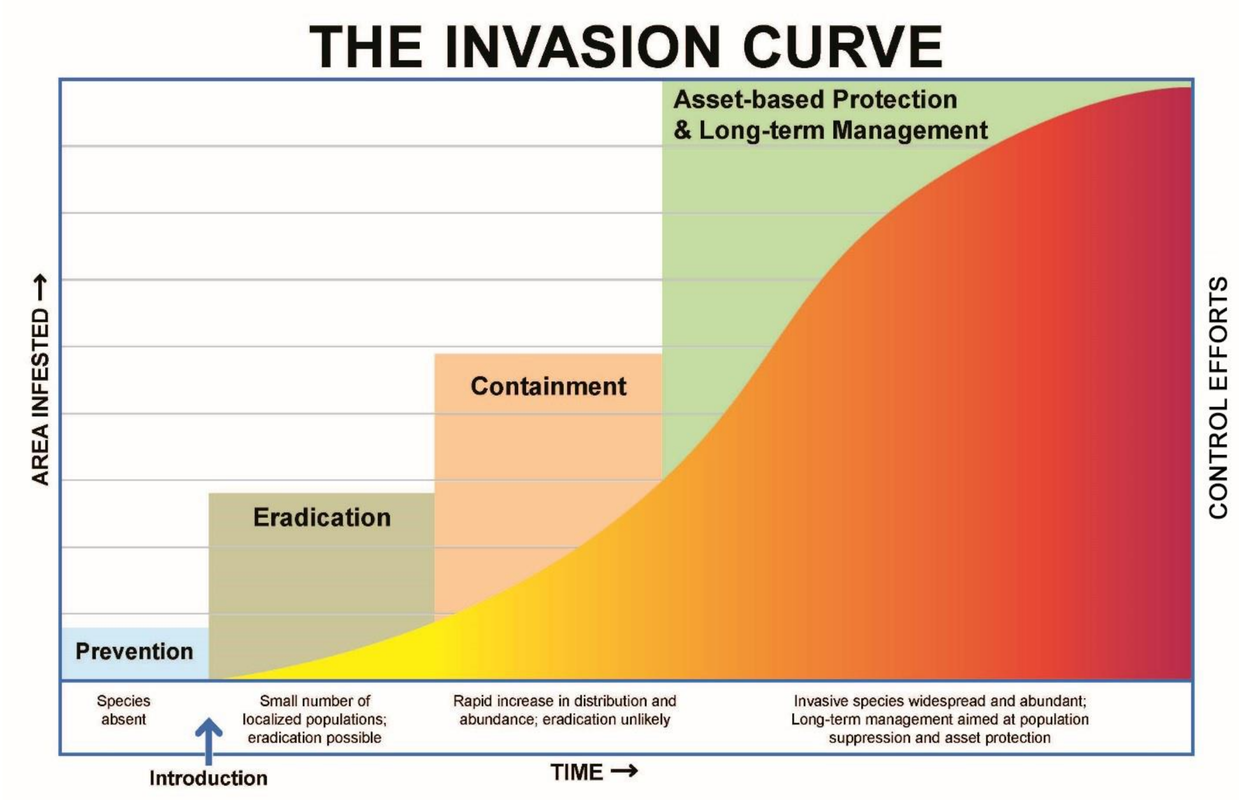


Figure 3-1 The Invasion Curve Describes How Management Changes over Time as an Invasive Species Becomes Established in New Environments

- Location minimizes flood bypass: The BRLD site is located south (downstream) of the confluence of the Des Plaines River and the CSSC. Alternatives that include implementation of a structural control point near the BRLD would minimize the likelihood of MRB ANS bypassing the CSSC-EB during flood events.

- Approach channel and lock: The approach channel and lock provide an opportunity to evaluate and optimize the operational characteristics of ANS controls, maximize the efficiency of applied technologies, and minimize the associated costs for implementation and operation. The physical lock structure also provides an additional control in the event of a temporary failure or malfunction of any potential control technologies employed downstream.

  BRLD's unique location could allow other stakeholders who are developing ANS controls to work with USACE in a field demonstration of these technologies. Several of these technologies were identified in the GLMRIS Report (USACE 2014a) but were ultimately not selected for use due to uncertainties about their effectiveness and about whether they could be implemented for full-scale field applications. Field demonstrations of these technologies could provide opportunities to inform control development and measure selection, not only for this study but also for future ANS control efforts. Field-testing of ANS controls that are in research and development (R&D) will reduce the uncertainty associated with their effectiveness and the extent to which they could be implemented.

- Maintain existing uses: Develop alternatives with control measures that allow for navigation and other waterway uses and users while effectively preventing the spread of ANS, to the extent possible.

- Future adaptability: Alternatives that include an engineered channel provide a platform for future control technologies near BRLD. Information gathered during the implementation of an alternative could be used to inform future applications of ANS controls in the CAWS and elsewhere. A concrete channel approximately 2,300 ft (701.0 m) downstream of BRLD could allow stakeholders who are developing ANS controls to work with USACE in field demonstrations of these technologies at this location. The BR Lock controls the majority of water flow in the channel (unlike a free-flowing channel, where flow is not controlled by lock and dam structures), and vessels navigate through the channel so tests can be run to inform ANS control performance with navigation. In addition, ANS controls and monitoring equipment can be attached to the walls of the engineered channel. If the ANS control shows promise as an effective control but is not ready for full-scale implementation, the control may be added to the platform in the future.

3.5 Planning Constraints

Formulation and evaluation of alternatives for the proposed project are constrained by the following factors:

- Nonaquatic pathways: The study's authorization is limited to examining ANS controls to prevent the transfer between the GLB and MRB through aquatic pathways. Non-aquatic, human, and wildlife-mediated transfers are not within the purview of the study.

  Human-mediated transfer – such as transport by persons on watercraft, bait bucket transfers, aquarium releases, pet trade, aquaculture practices, cultural practices, or overland transfer of ANS – is not within the purview of the study. In addition, the spread of ANS by attachment to non-aquatic animals (e.g., transport by migratory birds) is also outside of the scope of this study.

- Waterway user impacts: Each alternative that allows the continued use of the Brandon Road Lock for navigation will attempt to minimize disruptions to use of the waterway while maximizing the alternative's effectiveness.

  For each alternative that allows for navigation, an analysis has been completed to identify how and to what extent navigation would be affected. This analysis considered impacts on navigation during construction activities, during normal operation, and during operations, maintenance, repair, rehabilitation, and replacement (OMRR&R).

- Natural and human environment impacts: Alternative formulation for GLMRIS-BR would attempt to protect the natural and human environment by minimizing impacts on significant natural, cultural, and social resources while maximizing the effectiveness of the alternative.

  For each alternative, an analysis has been completed to identify how and to what extent natural resources (e.g., resident and migratory native species, riparian habitat, and water quality) and human resources (e.g., historic properties, stormwater management, and economic, social, and aesthetic values) would be affected. ANS controls may be nonselective, which means they could potentially have effects on nontarget species. The analysis assesses ways to minimize effects of an alternative on nontarget species to the extent practicable. In addition, to the extent possible, the alternative plans include impact analyses associated with the effects of plan implementation on all CAWS natural resources and on all current uses of the CAWS.

- Prevention: USACE defines “prevent” as the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.

- In an absolute sense, risk is not 100% preventable because this study is limited to ANS controls to prevent the transfer between the GLB and MRB through aquatic pathways. No single study or control can address all possible pathways of ANS transportation or introduction.

3.6 Project Goals and Objectives

3.6.1 Goal

Prevent the transfer of ANS from the Mississippi River Basin to the Great Lakes while considering the authorized purposes of the Illinois Waterway with the needs of multiple users and uses of the Upper Illinois Waterway, and in the spirit of shared responsibility of ANS control consistent with E.O. 13112.

3.6.2 Objectives

An objective is a statement of the intended purpose(s) of a study; it is a statement of what an alternative plan should try to achieve. Federal Ecosystem Objectives, Executive Orders pertaining to ecosystem restoration, and USACE Invasive Species Policy Goals and Objectives guided the development of the GLMRIS-BR objective.

Federal Ecosystem Objectives

The federal objective of water and related land resources planning is to contribute to national economic and/or ecosystem development in accordance with applicable national environmental statutes, E.O.s, and other federal planning requirements and policies. USACE decisions regarding invasive species prevention, control, and management are guided by E.O. 13751, Safeguarding the Nation from the Impacts of Invasive Species; E.O. 13112, Invasive Species; E.O. 13340, Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes; and the USACE Invasive Species Policy.

The nation’s environment is protected when damage to the environment is avoided or reduced and important cultural and natural aspects of the nation’s heritage are preserved. Various environmental statutes and E.O.s assist in ensuring that water resource planning is consistent with protection (see www.invasivespeciesingo.gov/laws/publiclaws.shtml). The objectives and requirements of applicable laws and E.O.s are considered throughout the planning process in order to meet this federal objective. The laws and E.O.s that are applicable to this study include, but are not limited to, the following:

- Safeguarding the Nation from the Impacts of Invasive Species (E.O. 13751)
- Invasive Species (E.O. 13112)

- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 USC §4701, et seq.)
- National Invasive Species Act of 1996 (16 USC §4701, et seq.)
- Lacey Act, as amended (18 USC §42)
- Plant Protection Act (7 USC §7712)
- Endangered Species Act of 1973, as amended (16 USC §1531, et seq.)
- Fish and Wildlife Coordination Act, as amended (16 USC §661–667d)
- Migratory Bird Treaty Act of 1918, as amended (16 USC §703, et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 USC §1251, et seq.)
- Safe Drinking Water Act of 1974, as amended (42 USC §300f, et seq.)
- National Environmental Policy Act of 1969 (42 USC §4321, et seq.)
- Resource Conservation and Recovery Act of 1976, as amended (42 USC §6901, et seq.)
- Comprehensive Environmental Response, Compensation and Liability Act, as amended (42 USC §9601, et seq.)
- Coastal Zone Management Act, as amended (16 USC §1451, et seq.)
- Clean Air Act of 1970, as amended (42 USC §7401, et seq.)
- Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes (E.O. 13340)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Protection of Wetlands (E.O. 11990)
- Wild and Scenic Rivers Act of 1968 (16 USC §1271, et seq.)
- Federal Water Project Recreation Act, as amended (16 USC §460L-12)
- National Historic Preservation Act of 1966 (P.L. 89-665; 54 USC §300101, et seq.)

Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species

This E.O. calls for actions “to prevent the introduction of invasive species and provide for their control, and to minimize the economic, plant, animal, ecological, and human health impacts that invasive species cause” utilizing the laws of the United States of America, including the NEPA of 1969, as amended (42 USC §4321, et seq.), the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 USC §4701, et seq.), the Plant Protection Act (7 USC §7701, et seq.), the Lacey Act, as amended (18 USC §42; 16 USC §3371–3378, et seq.), the Endangered Species Act of 1973, as amended (16 USC §1531, et seq.), the Noxious Weed Control and Eradication Act of 2004 (7 USC §7781, et seq.), and other pertinent statutes.

Executive Order 13112, Safeguarding the Nation from the Impacts of Invasive Species

This E.O. calls for actions “to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause” utilizing the laws of the United States of America, including the NEPA of 1969, as amended (42 USC §4321, et seq.), Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 USC §4701, et seq.), Lacey Act, as amended (18 USC §42), Federal Plant Pest Act (7 USC §150aa, et seq.), Federal Noxious Weed Act of 1974, as amended (7 USC §2801, et seq.), Endangered Species Act of 1973, as amended (16 USC §1531, et seq.), and other pertinent statutes.

E.O. 13112 established the National Invasive Species Council (NISC), a group of various federal agencies, and the Invasive Species Advisory Committee (ISAC), a group of 30 non-federal stakeholders from diverse constituencies (representing state, tribal, local, and private concerns) around the nation, to advise NISC on invasive species issues. In addition, E.O. 13112 called on NISC to prepare and issue the first national plan to deal with invasive species.

Completed in 2001, the National Invasive Species Management Plan, *Meeting the Invasive Species Challenge* (the 2001 Plan) (NISC 2001), served as a comprehensive blueprint for federal action on invasive species, as well as NISC's primary condition tool. This coordination tool provided the first comprehensive national plan for invasive species action. It called for about 170 specific actions within nine categories of activity, about 100 of which have been established or completed. Actions identified in the 2001 Plan continue to be implemented.

The 2008–2012 National Invasive Species Management Plan (the 2008 Plan) (NISC 2008) was the first revision of the 2001 Plan. The 2008 Plan focused upon five strategic goals: prevention, early detection and rapid response, control and management, restoration, and organizational collaboration. To accomplish these strategic goals, the plan included critical support for efforts such as research, data and information management, education and outreach, and international cooperation elements. The 2008 Plan identified prevention as the first line of defense, and it calls for preventing the introduction and establishment of invasive species in order to reduce their impacts on the environment, the economy, and the health of the United States.

E.O. 13112 also includes specific duties for federal agencies in regard to invasive or nuisance aquatic species. Excerpts from the order relating to federal agencies are contained in the following paragraphs:

> *Section 2. Federal Agency Duties.*
>
> *(a) Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law,*
>
> *(1) identify such actions;*
>
> *(2) subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and (vi) promote public education on invasive species and the means to address them; and*
>
> *(3) not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm cause by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.*
>
> *(b) Federal agencies shall pursue the duties set forth in this section in consultation with the Invasive Species Council, consistent with the Invasive Species Management Plan and in cooperation with stakeholders, as appropriate, and, as approved by the Department of State, when Federal agencies are working with international organizations and foreign nations.*

Executive Order 13340, Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes

E.O. 13340 identified the Great Lakes as a national treasure and defined a federal policy to support local and regional efforts to restore and protect the Great Lakes ecosystem through the establishment of regional collaboration. A number of activities have been accomplished by federal agencies working in partnership with state, tribal, and local governments in response to the E.O. The USACE has been a major participant in these activities. The E.O. established the Great Lakes Interagency Task Force, composed of the Secretary of State, the Secretary of the Army, the Secretary of Agriculture, the Secretary of Commerce, the Secretary of Housing and Urban Development, the Secretary of Homeland Security, the Secretary of the Interior, the Secretary of Transportation, the Administrator of the EPA, and the Chairman of the Council on Environmental Quality (CEQ). The task force, which worked with mayors, tribal and local governments, and the governors of the eight Great Lakes states, was officially formed in December 2004. The initial goal of the collaboration was to develop strategies for the following eight priority issues identified by the Great Lakes governors and mayors by using teams of stakeholders:

1. Toxic pollutants
2. Nonpoint-source pollution
3. Near-shore waters/coastal health
4. Habitat/species
5. Contaminated sediments/AOCs
6. Indicators/information
7. Sustainable development
8. Aquatic invasive species

USACE Invasive Species Policy Goals and Objectives

The USACE Invasive Species Management Plan was finalized in March 2009 in response to the National Invasive Species Management Plan and E.O. 13112. In executing USACE missions, districts face several issues concerning invasive species. These problems occur on USACE-managed and/or -administered lands and waters, lands and waters being proposed for Federal Civil Works projects, and USACE lands utilized for outgrants and permits. This policy is applicable to the entire spectrum of Civil Works programs and projects and complies with the spirit of the National Invasive Species Management Plan. It supports USACE Environmental Operating Principles and will be applied to invasive species issues in the execution of all Civil Works Programs including operations, civil works, regulatory actions, and engineering R&D. Specific USACE objectives to achieve the intent of the national invasive species management plan (USACE 2009) as it pertains to GLMRIS include the following:

- Leadership and coordination goal: Work strategically, using all USACE scientific, management, and partnership resources in unison to manage invasive species.
  - Partner/coordinate with local, state, and federal agencies and nongovernmental organizations (NGOs) to manage invasive species at the project, regional, and national levels; examples include the Cooperative Weed Management Areas, ANSTF, Federal Interagency Committee on the Management of Noxious and Exotic Weeds, and the 100th Meridian Initiative.

- Prevention goal: Prevent the introduction and establishment of invasive species in order to reduce their impact on the environment, economy, and health of the United States.
  - Identify pathways through which invasive species could potentially invade USACE-managed projects.
  - Take steps to eliminate pathways that are recognized as significant sources for the unintentional introduction of invasive species.
  - Implement a process for identifying high-priority invasive species that are likely to be unintentionally introduced.

  - When conducting USACE projects, develop a communication plan to share information about invasive species infestations.

- Early detection and rapid response goal: Develop and enhance the capacity to identify, report, and effectively respond to newly discovered/localized invasive species.
  - Develop monitoring plans for USACE-managed projects.
  - Take steps to improve detection and identification of introduced invasive species.
  - Each district and project should assess how their current management may be contributing to invasive species problems.
  - When conducting USACE projects, develop a program to coordinate rapid response to incipient invasions.

- Control and management goal: Contain and reduce the spread and populations of established invasive species to minimize their harmful impacts.
  - Develop and issue a protocol for ranking the priority of invasive species control projects at local, regional, and ecosystem levels.
  - Develop and implement control measures for invasive species in accordance with budget appropriations.
  - Develop partnerships to leverage funding.
  - Develop budget packages through the annual budgetary process to acquire funding to complete control measures.
  - Develop exclusion and sanitation methods for preventing spread of invasive species.
  - Develop assessment and monitoring plans for invasive species management areas.

Costs associated with Invasive Species Management for USACE projects, in accordance with the National Plan, average approximately $138 million per year (fiscal year 2015 expenditures), with the majority of those costs allocated for ANS Control and Management (Table 3-1). The NISC annually publishes funding information on invasive species activities by its member agencies. This information was reviewed for fiscal year 2016 and is provided in Table 3-1. Information for fiscal year 2017 had not been published at the time this report was written. USACE's ANS control and management expenditures are reported as Department of Defense.

GLMRIS-BR Planning Objective

Prevent the upstream transfer of ANS from the MRB to the GLB through the CAWS in the vicinity of the BRLD through the planning period of analysis.

The ultimate effect desired for this objective is the prevention of the transfer and subsequent establishment of new ANS to the GLB from the MRB through aquatic pathways. For GLMRIS, USACE has interpreted the term "prevent" to mean the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution. ("Defining 'prevent' to mean reducing the risk to the maximum extent possible is entirely reasonable" Michigan v. U.S. Army Corps of Engineers, 911 F. Supp. 2d 739, 766 [N.D. Ill. 2012], aff'd, 758 F.3d 892 [7th Cir. 2014]). Measures developed to meet this objective need to result in the protection of aquatic resources in the Great Lakes and connected tributaries including habitats and associated environmental, economic, and social resources. Effectiveness of plans developed from ANS control measures will be evaluated. This objective is to identify and evaluate alternative plans to prevent the upstream passage of ANS through BRLD.

Table 3-1 Fiscal Year (FY) 2016 Crosscut Budget for Department of Defense (DOD) (USACE) ANS Control and Management (NISC 2016)

Strategic Goal	FY 2015 Actual Expenditures	FY 2016 Enacted Expenditures	Proposed FY 2017 President's Budget
Prevention	$30,327,000	$31,850,000	$30,427,000
Early Detection and Rapid Response	$14,070,000	$15,254,000	$13,961,000
Control and Management	$57,352,000	$61,066,000	$56,141,000
Research	$9,611,000	$6,029,000	$4,915,000
Restoration	$17,318,000	$18,638,000	$12,968,000
Education and Public Awareness	$6,740,000	$7,334,000	$6,632,000
Leadership and International Cooperation	$2,075,000	$2,377,000	$1,654,000
Cumulative Total	$137,493,000	$142,548,000	$126,698,000

Chapter 4 Affected Environment (Existing Conditions)*

4.1 General Characteristics of the Great Lakes and Mississippi River Basins

4.1.1 Great Lakes Basin Ecosystem Overview

The GLB currently covers an area of approximately 29,575 mi^2 (76,598 km^2) spanning eight U.S. states and two Canadian provinces. Collectively, these lakes hold 84% of North America's fresh surface water and an abundance of natural resources used by millions of people each year (Environment Canada and EPA 2014). Formation and evolution of the Great Lakes is an ongoing process that began more than 1 million years ago and can be attributed to both natural and anthropogenic forces, including periods of glaciations, erosion and depositional processes, changing climate patterns, and human development.

Today, the Great Lakes make up the second-largest body of fresh water in the world. The basin has been categorized into 20 ecoregions, with half belonging to Canada and half to the United States. Researchers have cataloged numerous distinct coastal habitat types, including wetlands, lake plain prairies, sand, cobble and bedrock beaches, sand dunes, sand barrens, alvars, and islands. Away from the lake, many inshore habitats have also been identified, including inshore wetlands, various savanna and prairie communities, and numerous varieties of hardwood and coniferous forests.

With such a diverse assembly of habitats across the basin, the Great Lakes remain home to immensely diverse faunal communities. The natural fish assemblage of the Great Lakes originates from three sources: Arctic relicts from the northwest, warm water species infiltrating from the Mississippi and Ohio Rivers, and marine species from the Atlantic Ocean. These source populations gained access to the basin through natural connections developed during glacial retreat periods and water climatic periods. In addition, man-made connections of canals and other waterways allowed additional species to colonize when European settlers began to manipulate geomorphic features and hydrology in the GLB for the purpose of agriculture and commerce. The native fishes to the GLB have since been adversely affected in both species richness and population abundance. The loss in species richness, abundance, and genetic diversity of the Great Lakes fish assemblage has been attributed to habitat loss and fragmentation, pollution, and commercial fishing practices that once outpaced natural reproduction (Smiley 1882).

Current estimates indicate that approximately 161 native fish species (Hubbs and Lagler 2010) and 25 nonnative species (EPA 2011) reside within the basin. Amphibian and reptile populations are generally represented by salamanders, frogs, turtles, and snakes but do include a number of toads and reptiles (Edsall 1998). The Great Lakes also provide invaluable habitat for both migratory and resident bird species. Migratory flyways lace the basin along its shorelines and across island chains providing stopover points for long journeys from north to south. Wetland loss and degradation have led to the declines of many bird species that utilize this habitat for nesting and foraging (EPA 2006). In addition, more than 130 globally rare, threatened, or endangered species reside within the GLB (USFWS 2007). These species have been listed mainly because of habitat degradation and loss through human development and pollution.

In general, the status of aquatic organisms within the Great Lakes is considered fair because many areas support self-sustaining populations and a healthy food web; however, other areas are severely degraded (Environment Canada and EPA 2014). State stocking programs as well as some natural reproduction help maintain predatory fish populations, but most of these populations do not meet target relative abundance levels. The Great Lakes have an overall deteriorating trend for aquatic organisms as a result of decreasing prey fish populations, declining populations of *Diporeia* (a food source for juvenile fish), and declining populations of many coastal wetland species. The combined effects of the above have resulted in the alteration of the Great Lakes food web. In recent years, although a few new nonnative species have been detected, the effects of already established nonnative and invasive aquatic species continue to have an impact on the ecosystem (Environment Canada and EPA 2014).

4.1.2 Mississippi River Basin Ecosystem Overview

The Mississippi River is the second-longest river in the United States flowing 2,350 mi (3,782 km) from its source at Lake Itasca to the Gulf of Mexico, with the third-largest drainage in the world (DeLong 2005). The MRB's drainage basin extends from the Allegheny Mountains in the east to the Rocky Mountains in the west, and includes all or parts of 31 states and 2 Canadian provinces. The basin measures approximately 1,200,000 mi^2 (3,107,986 km^2) and covers about 40% of the lower contiguous 48 states. The upper MRB extends from the river's headwaters at Lake Itasca, Minnesota, to its confluence with the Ohio River near Cairo, Illinois, and drains approximately 20,100 mi^2 (52,058.8 km^2). The lower MRB extends from its confluence with the Ohio River to the river's mouth in the Gulf of Mexico (DeLong 2005) and drains approximately 1,130,900 mi^2 (2,929,018 km^2). The Mississippi River formed largely during the Great Ice Age when large sheets of ice began to melt and the resulting water pooled in glacial lakes in what is now Wisconsin and Minnesota. This water slowly drained towards the Gulf of Mexico, carving the Mississippi River as it flowed. Major tributaries of the Mississippi River include the Illinois, Missouri, Ohio, Tennessee, Arkansas, and Red Rivers.

The upper MRB is a biologically important resource for a variety of wildlife. The upper MRB has a rich diversity of aquatic life, supporting nearly 200 native, regularly occurring fishes, as well as an abundance of freshwater mussels, crayfish, and aquatic invertebrate species. The north–south orientation of the river provides a globally important flyway for nearly 60% of all North American bird species, while also harboring diverse amphibian, reptile, and mammal faunas. According to Theiling et al. (2000), the upper MRB supports no less than 286 state-listed or candidate species, and 36 federally listed or candidate species of threatened or endangered plants and animals endemic to the basin. Past and current adverse pressure on the biodiversity of the upper MRB is primarily related to the development of the basin for agriculture, navigation, and industry. The drastically altered landscape and channelization of the upper MRB, have led to the disruption of the physical and ecological processes of the river system, and subsequently a downward trend in flora and fauna abundance and diversity.

The MRB has been greatly affected by a number of invasive fish, plants, and mussels and continues to be threatened by new ANS introductions. Twenty-three members of the 28-member Mississippi Interstate Cooperative Resources Association (MICRA) reported 149 ANS in the MRB during a 1999 survey. These included 56 plants, 16 invertebrates, 75 fish, 1 amphibian, and 1 mammal (MICRA 2017). Bighead Carp, Silver Carp, Common Carp, zebra mussel (*Dreissena polymorpha*), purple loosestrife (*Lythrum salicaria)*, and Eurasian water milfoil (*Myriophyllum spicatum*) are among the species that are most damaging to native species and their habitats within the MRB as a whole, while giant salvinia (*Salvinia molesta*), water hyacinth (*Eichhornia crassipes*), and hydrilla (*Hydrilla verticillata*) are significant problems in the southern reaches of the MRB (MICRA 2010).

4.1.3 Illinois River Basin Ecosystem Overview

The Illinois River is the largest tributary of the Mississippi River above the mouth of the Missouri River, draining a 28,220-mi^2 (73,089-km^2) basin. The upper Illinois River arises at the confluence of its headwater basins, the Des Plaines and Kankakee Rivers, and winds southwesterly through northern Illinois. The upper river flows to Hennepin, Illinois, in Putnam County, where it encounters the "Great Bend," which marks the beginning of the middle Illinois River. Here, the Illinois turns southward and flows past Peoria to Beardstown, Illinois, with a gentle gradient through a broad, shallow valley 3 to 6 mi (4.8 to 9.6 km) wide, the ancestral Mississippi River Valley. The lower Illinois River then extends from

Beardstown to Grafton, Illinois. Major tributaries of the Illinois River include the Des Plaines, Kankakee, Fox, Vermilion, Mackinaw, Spoon, Sangamon, and La Moine Rivers. Agriculture and urban development affected and changed the landscape of the Illinois River Basin and the river itself.

Despite ecological damage and degradation, the landscape and river system remain diverse and biologically productive. The Illinois River Basin is a critical mid-migration resting and feeding area utilized by 40% of all North American waterfowl and 326 total bird species, representing 60% of all species in North America. In addition, the Illinois River system is home to approximately 35 mussel species, representing 12% of the freshwater mussels found in North America. Five mussel species are listed by the State of Illinois as threatened or endangered, one of which is a federally endangered species and another is a candidate for federal listing. Fish diversity is similarly high, with 115 species found, 95% of which are native species. Many of these species require riverine, backwater, and floodplain habitat as part of their life cycle. Eighteen fish species are listed by the State of Illinois as threatened or endangered. Many of these species are unique to the basin and/or tolerant of high silt levels. A group of aquatic organisms that is particularly representative of the Illinois River is the “Ancient Fishes” such as the Paddlefish (*Polyodon spathula*) and sturgeon (Acipenseridae family). The majority of these fish are migratory by nature and utilize a diversity of river habitats, flowing channel habitats, side channels, and backwater areas.

There are at least 15 introduced fish species in the Illinois River (USACE 2007b). In the Illinois River, the Common Carp is so plentiful and has been present for so long that few people realize it is nonnative. It has been very successful since its introduction in the 1880s and soon displaced buffalo and catfish as the major component of the commercial catch. More recently, Grass Carp have been increasing in the Long Term Resource Monitoring Program and commercial catch. Asian carp are a more recent arrival and their numbers are growing rapidly. The Asian carp compete for the same food (e.g., drifting plankton and invertebrates) as Gizzard Shad (*Dorosoma cepedianum*) and Paddlefish. Other exotic species include zebra mussel, Round Goby, European Rudd (*Scardinius erythrophthalmus)*, and at least two exotic zooplankton species that are entering the Illinois River system from Lake Michigan (USACE 2007b).

4.2 General Characteristics of Brandon Road Lock and Dam Site-Specific Study Area

Proposed in 1905 as part of the Great-Lakes-to-the-Gulf deep waterway, the BRLD (Figure 4-1) were constructed by the State of Illinois and the USACE from 1927 to 1933, with the lock being placed into operation in 1933. The lock permitted increased barge traffic along the IWW between Chicago and the Mississippi River. It also performs the vital function of maintaining water levels between Lockport and Joliet, Illinois. The lock is an Ohio River Standard Navigation main lock with 110 ft (33.5 m) by 600 ft (182.9 m) chamber and a lift of 34 ft (10.4 m). Miter gates (i.e., close-off the entrance and exit of a navigation lock) are located both upstream and downstream of the lock chamber. The chamber elevation is managed by the filling and emptying system, which consists of 10 rectangular side ports (5 ft by 3 ft 6 in [1.5 m by 1.1 m]) located along the bottom of the lock walls. Four vertical lift valves, one located at each end of the culvert, control flow through the culvert and ports for filling and emptying of the lock chamber. There are downstream guidewall extensions to both lock walls that are used for guiding barge traffic in and out of the lock chamber. The upstream guidewall extension is located on the riverward wall of the lock. An ice protection wall links this upstream guidewall to the dam. The foundation of the concrete lock structure is built on top of limestone bedrock. The miter gates are operated by electric motor-driven gear boxes. The vertical lift valves are operated by hydraulic pumps and cylinders.

Figure 4-1 Aerial View of Brandon Road Lock and Dam

The Brandon Road Dam is a 2,372-ft (723-m) long concrete and earthen dam with water control by tainter and headgates. It is composed of 822 ft (250.5 m) of fixed earthen embankment that extends from the upstream end of the lock to the concrete dam on the south and the entrance to the I&M Canal on the north. The 320-ft (97.5-m) concrete pier dam contains eight (16 ft by 15 ft [2.4 m by 4.6 m]) single-leaf vertical-lift headgates and eight (8) gate openings that have been closed with a concrete bulkhead, followed by a 30 ft (9.1 m) concrete ice chute, then 91 more ft (27.7 m) of concrete pier dam. This latter section contains six (6) (7 ft by 8 ft [2.1 m by 2.4 m]) sluice gate openings that have been closed with concrete bulkheads. Finally, a 1,110-ft (338.3-m) concrete pier dam containing 21 tainter gates (i.e., radial arm floodgate) completes the dam. The dam tainter and headgates are operated by electric motor-driven machinery and wire ropes. The tainter gates have the standard individual operators for each gate, while the headgates have three permanent and one moveable hoist for the eight gates. The gates are used to make daily pool adjustments but also have operation capability for multiple gate operations during emergency flow conditions.

Numerous upgrades and modifications have taken place at BRLD, and the following is an abbreviated list of some of the major ones:

- 1956, concrete bulkhead installed at I&M lock
- 1965, floating mooring bitts installed
- 1967, lock walls resurfaced
- 1969, lock valve machinery replaced with hydraulic operators
- 1980, dam stabilized and scour protection completed
- 1984, lock walls resurfaced
- 1985, resurfacing and stabilization of the lower guidewalls; lock electrical and lighting replacement; miter gate machinery replacement; and closure of eight head gates, six sluice gates, and small overflow section

- 1986, tainter gate rehabilitation and replacement and tainter gate machinery and electrical replacement
- 1995, downstream miter gates replaced

4.3 Physical Resources

4.3.1 Climate

Great Lakes

In general, the GLB experiences a continental to semi-maritime climate, largely determined by the prevailing winds from west to east and the modifying influences of the Great Lakes. The region is normally humid throughout the year, with cold winters and cool summers in the north and warm summers in the south. The average annual frost-free season is about four months at the northern extremity of the basin and about six months at the southern extremity. Mean annual surface air temperatures over the basin range from about 39°F (4°C) on Lake Superior to 49°F (9°C) on Lake Erie. Average temperature on each of the lakes is lowest in February and highest in July. Annual precipitation over most of the GLB ranges from less than 25 in (63.5 centimeters [cm] to more than 40 in. (101.6 cm), decreasing somewhat from the south to north and from east to west. Average snowfall over the region ranges from 40 in. (101.6 cm) to 120 in. (304.8 cm). The lakes have a seasonal effect on precipitation patterns in the basin, with spring and summer precipitation greater over the land and winter precipitation greater over the lakes and coastal areas.

Climate change resulting from the increase in greenhouse gas emissions is projected by some to significantly change climatic conditions over the next 50 to 100 years within the GLB (Pentland and Mayer 2016). Projections for the middle of the twenty-first century (i.e., 2041–2070) suggest warming of 3.5–6.5°F (1.9–3.6°C), relative to 1970–2000 temperatures, with the ranges of increased temperatures relative to the ranges of expected increases in global emissions of greenhouse gases. Projections for changes in precipitation are, in general, less certain than those for temperatures; however, if higher greenhouse gas emissions are a reality in the future, models project that precipitation within the region will likely increase by 10% to 20% later in the century (i.e., 2071–2099), relative to 1970–2000. Changes in the seasonal precipitation cycle are likely to be greater, with winter and spring rain increasing and summer rain decreasing by up to 50%. Increases in the frequency and intensity of extreme precipitation are projected across the Great Lakes region (Pentland and Mayer 2016).

CAWS/Des Plaines River/Illinois River/Kankakee River

The climate of the project area is typical of northeast Illinois and may be classified as humid continental, characterized by warm summers, cold winters, and daily, monthly, and yearly fluctuations in temperature and precipitation. The NOAA National Weather Service site was queried for summary data within the GLMRIS-BR Illinois Waterway Study Area. The station nearest the GLMRIS-BR Illinois Waterway Study Area with available data was Chicago, Illinois. Averages were calculated based on data from 1981 to 2010 (NOAA undated). The average annual high temperature within the GLMRIS-BR Illinois Waterway Study Area is 59.1°F (15.1°C), while the average annual low temperature is 40.8°F (4.9°C). The average annual temperature for the GLMRIS-BR Illinois Waterway Study Area is 49.9°F (9.9°C). Coldest average monthly temperatures range from daily lows and highs of 16.5°F (−8.6°C) and 31.0°F (−0.6°C) respectively, in January. July is the warmest month with an average daily low of 63.9°F (17.7°C) and an average high of 84.1°F (28.9°C).

Mean annual precipitation is 36.9 in. (93.7 cm) with the majority of precipitation occurring April through August. Accumulated annual snowfall averages 36.7 in. (93.2 cm) for the GLMRIS-BR Illinois Waterway Study Area. Wind speed averages 11–12 mph (17.7–19.3 km). Early spring floods may occur when snow accumulation extends into a period of increasing temperature that results in rapid melting. If this occurs when soils are already saturated or still frozen, and given the amount of impervious surfaces within the GLMRIS-BR Illinois Waterway Study Area, runoff may increase dramatically. The start of the growing season, as defined for agricultural purposes, usually occurs from late April to early May. However, in natural areas flowering plants may be found in groundwater discharge zones as early as the last week in January, although most native plants start their annual growth after cultivated and nonnative plant species. The first frost typically occurs between late September and mid-October, with the frost-free season ranging from 158 to 178 days.

Current science-based predictions indicate that climatic changes in this region will likely include higher mean temperatures in summer and winter, with measurably less average annual rainfall, but more intensive rainfall events when they do occur (Melillo et al. 2014). Higher summer air temperatures would generate greater rates of evaporation from the upper Illinois Waterway, and potentially lower mean overland and tributary flow into the waterway system. This would tend to lead to lower water levels in the upper Illinois Waterway and potentially higher water temperatures.

Decreases in winter and summer precipitation could also endanger aquatic ecosystems and lessen groundwater inflow to the upper Illinois Waterway. Ongoing research is supporting the observed trend toward more regionally intense storm and rainfall events, primarily during seasonal transition periods in the fall and spring.

4.3.2 Geologic Setting

Great Lakes

"The Great Lakes have attained their present form and connections as a result of a complicated series of events" (Hough 1958). Many of the basic attributes of the lakes, such as their locations, depths, and shapes, were indirectly influenced by events that occurred as much as a half-billion years ago, when the bedrock foundation of the region was laid down. The bedrock terrain, with various degrees of resistance to erosion, was sculptured by weathering and stream erosion over a period of some 180 million years. During the last million years, continental ice sheets invaded the region several times and scoured and molded the landscape.

The earliest known predecessors of the modern Great Lakes are relatively recent arrivals on the scene. They came into existence probably not more than 20,000 years ago, when the wasting margin of the last continental ice sheet retreated into the lake basins (Figure 4-2). The earliest lakes were narrow, ice-margin bodies of water that expanded as ice melted and that were compressed in area at various times when ice sheets temporarily readvanced. The lake waters, at first, spilled southward over the divides of the various lake basins. During the northward retreat of the border of the continental ice sheet, the lake waters found new, lower outlets in the north, and the lakes periodically drained down to lower levels – only to be returned to higher levels when uplift of the land raised northern outlets higher than the old southern outlets. The process of uplift continues today (Hough 1958).

CAWS

The geologic history of the CAWS was primarily shaped by events that occurred more than 15,000 years ago. During the Wisconsin glacial episode, a lobe of glacial ice known as the Lake Michigan lobe

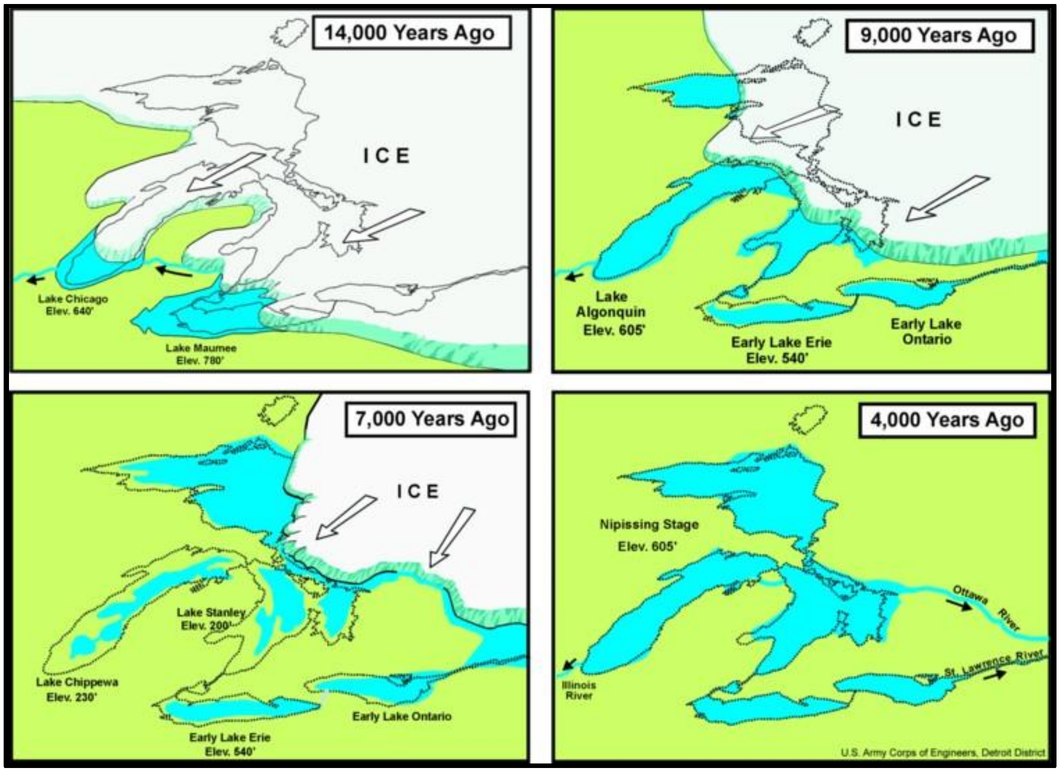


Figure 4-2 Formation of the Great Lakes

advanced southward along the Lake Michigan Basin and then turned to the southwest and extended across what is now northeastern Illinois. About 20,000 years ago the ice reached its maximum southward position, which was approximately 200 mi (321.9 km) south of Chicago. As the climate warmed, the ice margin of the Lake Michigan lobe began to recede northward. Pauses in the recession of the ice lobe resulted in the deposition of glacial sediments that formed end moraines on the margin of the receding ice. From about 15,000 to 14,000 years ago, the fluctuating ice margin was building end moraines and shaping the landscape of what is now the Chicago region. By 13,500 years ago, the receding ice had permanently withdrawn into the Lake Michigan Basin, and by 10,500 years ago, the lake basin was free of glacial ice. The remaining end moraines influenced the drainage patterns in the region that persist today, albeit also influenced by man. Bedrock located within the project area is primarily composed of dolomite and limestone with small amounts of shale present. The bedrock is covered by up to 300 ft (91.4 m) of an unconsolidated formation comprising clay, silt, sand, and gravel. Much of the material was directly deposited as glacial till and outwash from melting glaciers.

Des Plaines River

In regards to the Des Plaines River, the area has been affected by four major glaciation events, lasting from approximately 1.6 million to 10,000 years ago (USACE 2015d). The last major glacial advance was called the Wisconsinan cycle, and evidence of its existence is prominently displayed throughout the Des Plaines River Basin. Glaciers sculpted the underlying landscape by abrasion, erosion, and deposition. Continental glaciers, such as the types of glaciers that passed over the area, tended to produce a more rounded topography, by scraping away at the bedrock in some areas and depositing the accumulated debris in other areas. The deposition of accumulated materials by glaciers is referred to as glacial drift, which can be further identified by how and where it was deposited. The underlying bedrock of the GLMRIS-BR Site-Specific Study Area is covered by various depths of a complex layering of beds and lenses of outwash with different layers of till left by surging and retreating glaciers. In addition, the area is laced with clustered end moraines (ridges left by retreating glaciers), which are oriented in a north–south direction that roughly parallels the shore of Lake Michigan (USACE 2015d).

Illinois River

The landscape of the Illinois River Basin was created by geologic processes that shaped the upper Midwest over the past one and one-half million years. The ancient Mississippi River originally flowed in a now-buried valley from the northwest corner of Illinois near Galena to Tazewell and Mason Counties, south of Peoria, where it was joined by the westward-flowing Mahomet River. During the Pleistocene era, great continental-scale glaciers repeatedly entered Illinois from the northwest and northeast. These glaciers originated in central Canada more than 1,000 mi (1,609.3 km) north of the modern Illinois River (Figure 4-3). At least three major glaciations affected Illinois, and each strongly modified the landscape. Most of the lobes of glacial ice that covered Illinois emanated regionally from the Lake Michigan Basin,

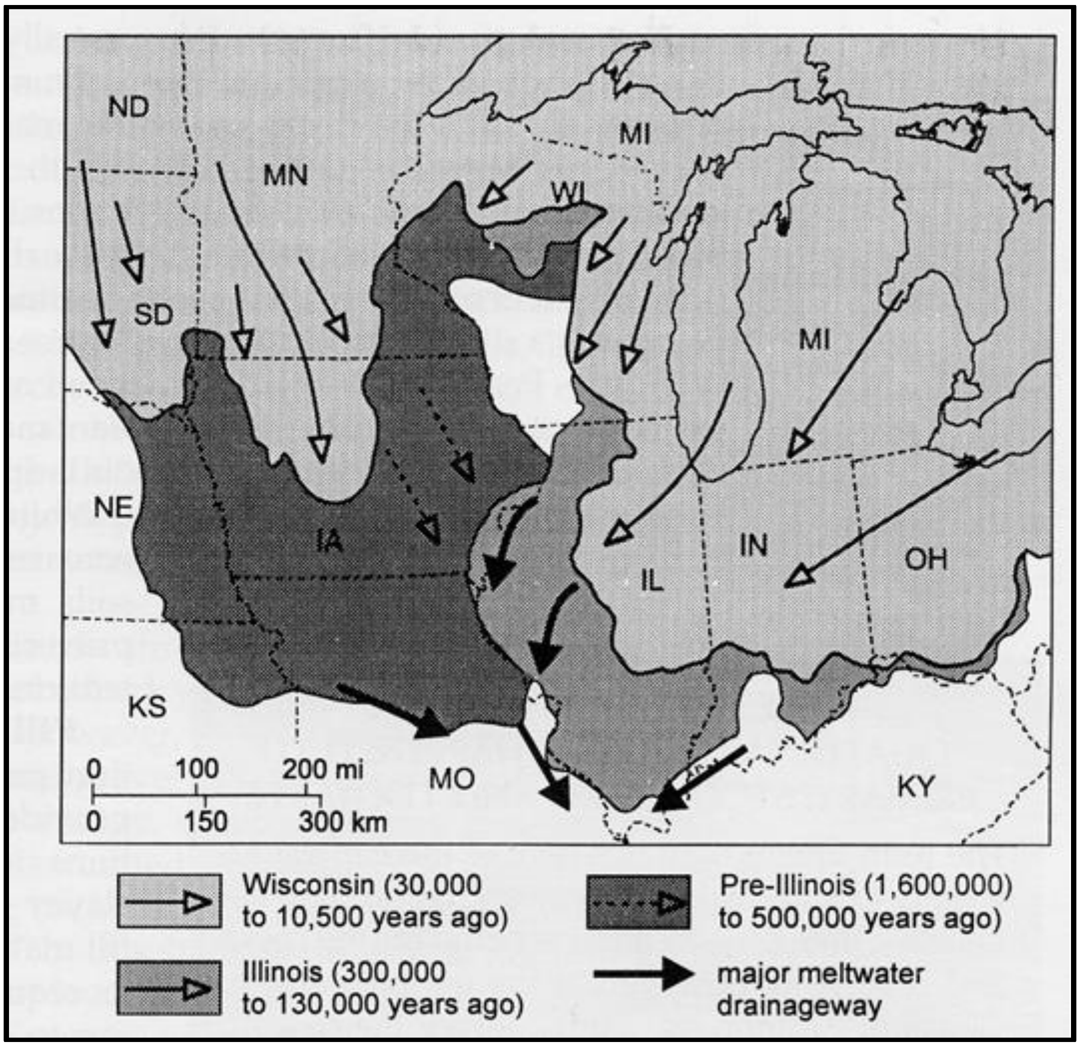


Figure 4-3 Farthest Extent of Pleistocene Ice Advances (Open arrows indicate general ice flow directions; closed arrows indicate major meltwater drainage ways.) (Source: USACE 2007b)

but there is evidence that ice also flowed in from the northwest. Flowing ice and related geologic agents, including winds and meltwater streams, sculpted the bedrock and preexisting sediments, leaving sedimentary deposits up to several hundred feet thick.

Creation of complex moraine topography, widening and incision of the Illinois Valley by huge floods, and deposition of a layer of windblown silt over most of the watershed uplands are effects of the last glacial episode. Figure 4-4 illustrates the alterations in the flow paths of the major rivers in Illinois due to glaciation.

The Mississippi River once occupied the lower Illinois Valley from above Henry to Grafton, Illinois. With the advancement of the Wisconsin glacial episode (~21,000 years ago), the Mississippi River was pushed westward to its present location. With the recession of the glacier and the ensuing warmer climate, meltwaters formed the Kankakee and Des Plaines Rivers, which converged into the Illinois River southwest of Chicago. From this confluence, the Illinois flowed westward, cutting a new channel until it reached the ancient and deep valley of the Mississippi River above Henry, Illinois. As the Illinois River turned southward in Putnam County, it followed a much wider and deeper glacial valley. As the waters of the Illinois entered this wide basin, their low volume produced a river of a gentle rate of fall, creating a floodplain river ecosystem.

Kankakee River

The general geology of the Kankakee River Basin consists of a mantle of unconsolidated, glacial deposits overlying bedrock. The glacial deposits, or drift, have been modified by melt water and wind action so that considerable variation can be observed in the surficial geology of the basin. The receding Wisconsin

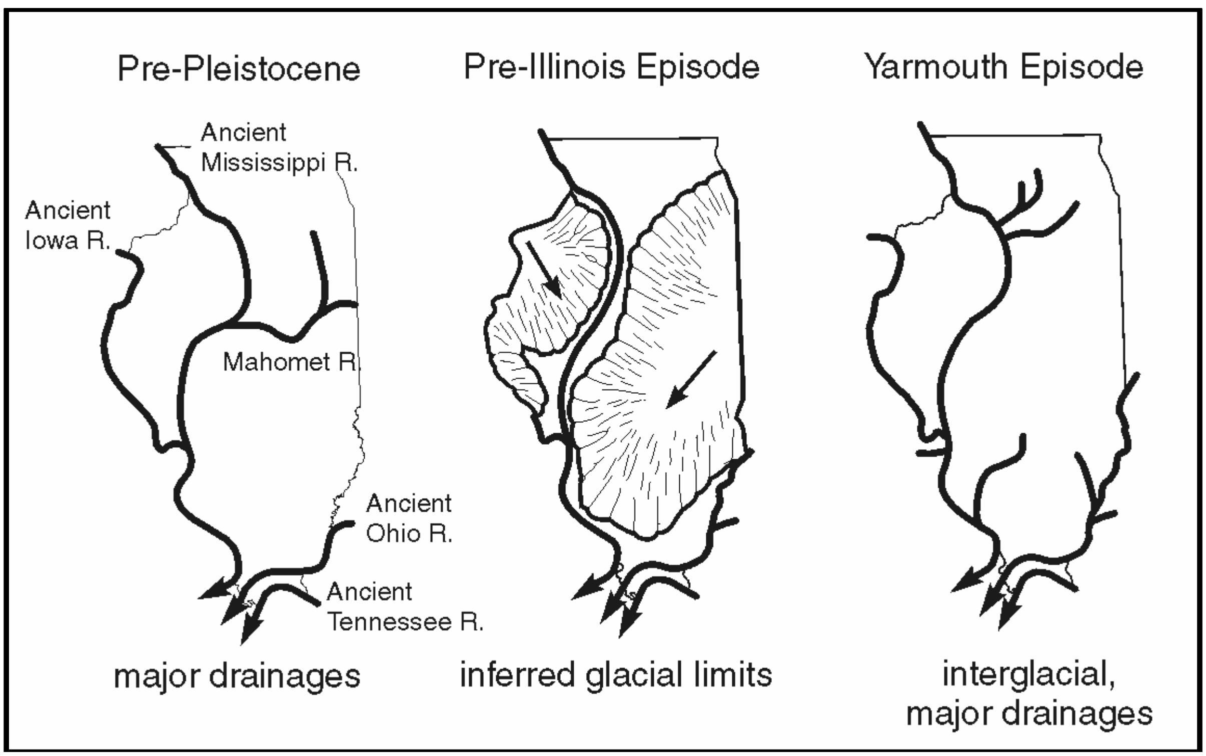


Figure 4-4 Changes in the Flow Paths of the Rivers in Illinois over Time

glacial episode, the fourth and last continental glacier to move into the basin, laid down the glacial drift comprising the surface deposits of the basin. Glacial deposits older than Wisconsin are absent over the greater part of the Kankakee River Basin. Thus, Wisconsin drift rests on bedrock in Will and Kankakee Counties as well as the north end of Iroquois County. Illinoisan drift is found beneath the Wisconsin drift in southern Iroquois County. Older Kansan deposits exist in south Iroquois County along the buried Mahomet Bedrock Valley. The bedrock in the Kankakee River Basin consists of crystalline basement rocks overlain by approximately 4,000 ft (1,219.2 m) of limestone, sandstone, and shale. These overlying rocks, known as sedimentary rocks, commonly are interbedded and grade into one another. They are visible at only a few localities since throughout most of the basin drift deposits overlie them.

4.3.3 Soils

Great Lakes

The GLB has large areas of relatively flat land with fine-textured soils of glacial origin. Included are the Iron River and Gogebic soils in Minnesota, Wisconsin, and the Upper Peninsula of Michigan. The Rubicon, Auger's, and Roscommon soils, which occupy areas in Wisconsin and much of Michigan, are level to rolling, well-drained to poorly drained sands. Southern Michigan, Indiana, western Ohio, and eastern Wisconsin include soils in rolling, calcareous glacial till and sand outwash materials. The Wooster-Mahoning soils occur in rolling, acid glacial till in eastern Ohio and Pennsylvania. The Ontario and Lordstown soils occupy much of western New York. The Ontario soils are deep, calcareous glacial till, and the Lordstown soils are thin, acid glacial till over sandstone and shale.

CAWS

Native soils within the CAWS are primarily of glacial origin. Soil type and depth vary throughout the area, but most of the soils occur within two major soil orders: Mollisols and Alfisols. Mollisols are deep, dark-colored (organically rich), soils formed mainly under grassland vegetation, and Alfisols are light-colored, predominantly forest soils with lesser amounts of organic matter. Entisols, a third soil order with a small distribution in the area, are light-colored, recently deposited alluvial (i.e., eroded loose soils deposited by water) soils that have not had sufficient time to develop recognizable horizons (i.e., layers). Entisols are typically found along rivers and streams. The original soil structure around the CAWS has been greatly disturbed by human activities.

Des Plaines River

Within the Des Plaines River Basin there are approximately 13 soil associations, the most widespread being the Morely-Markham-Ashkum (30%), Urbanland-Markham-Ashkum (18%), and Elliott-Ashkum-Varna (14%) (USACE 2015d). Typically, these soil associations are slowly permeable and can be subject to hydric conditions. Higher frequencies of wetlands and poorly drained soils, along with the most agriculturally productive soils, occur in the northern portion of the basin. The moderately slow permeability exhibited by many soils in the agricultural and urbanized portions of the area create conditions conducive to flooding and standing water during periods of high water table or heavy precipitation. Many soils, specifically within Cook County, were modified by human activities and are overlaid by a few feet of miscellaneous fill and/or regraded top soil (USACE 2015d).

Illinois River

In regard to general soil characteristics of the upper Illinois River Basin, tremendous outwash deposits developed from glacial melt-water streams carrying upland loess accumulations. Wisconsin glacial deposits created outwash plains consisting of moderately well-sorted sand and gravel. Cahokia Alluvium (deposits of poorly sorted sand, silt, and/or clay containing localized pockets of sandy gravels) overlies the glacial outwash. The alluvium is, in turn, covered by Richland loess (deposit of windblown, fine-grained clayey silt). Because of the glacial influence, silt loam and silty clay are the dominant soil types on central Illinois floodplains and bottomland prairie.

Kankakee River

The majority of the soils in the Kankakee River Basin have developed from parent materials of glacial origin (USACE 2006b). The Wisconsin glacial episode removed the previously formed soils and left till, outwash, lakebed sediments, and loess. The till has generally been covered by outwash, lake sediments, loess, and sands, or alluvial deposits of recent origin. The properties of the existing soils depend, among other things upon the type and thickness of the upper deposits as well as the composition of the underlying materials. Various combinations of surface and substrata materials are found in the Kankakee River Basin: loess on outwash, outwash on till, lake bed on till, loess on till, loess on lake bed, alluvium on outwash, and alluvium on bedrock. The underlying till is a heterogeneous mixture of clay, silt, sand, and gravel. The physical and mineral composition of the till, as well as the degree of compaction it received during the Pleistocene, affect the permeability or underdrainage of the soil developed over till. The tills vary from slowly permeable to moderately permeable. The till in southwestern Iroquois County primarily comprises compact material derived from shale and limestone rocks and is slowly permeable. The till in eastern Iroquois County associated with the Iroquois Moraine is less compact and moderately permeable.

4.3.4 Hydrology and Hydraulics

Great Lakes

Lake Superior has been regulated since 1921 by means of a series of control structures including a gated dam across the St. Marys River at Sault Ste. Marie, Michigan and Ontario. Construction of the gated dam was authorized by the International Joint Commission (IJC) as a condition to approval of the water diversion for hydropower. By operation of the gates, locks, and changes in power diversions, flows specified by the adopted plan of regulation can be achieved. The present plan of regulation is known as Plan 1977-A. In general, the plan balances the levels of Lake Superior and Lakes Michigan–Huron to maintain their levels at the same positions to each other according to their long-term monthly means, while protecting the maximum levels on Lake Superior. The plan of regulation is designed to meet criteria specified by the IJC, which requires, among other things, that the control works be operated so that the mean level of Lake Superior is retained within its normal range of stage such that the level does not exceed elevation 603.2 ft (183.9 m) (IGLD 1985) or fall below elevation 599.6 ft (182.8 m) (IGLD 1985), and is done in such a manner so as not to interfere with navigation. This regulation plan affects water levels on Lakes Superior, Michigan, and Huron and, to a lesser degree, downstream through Lake Erie.

CAWS

Natural fluvial geomorphology and processes within the CAWS are significantly altered from their natural condition because of years of anthropogenic activity. The majority of the CAWS comprises manmade canals, with remnant fragments of natural stream and slough that flow into the navigable waterway. Prior to human settlement and development, the Chicago and Calumet Rivers were composed of large wetland complexes that flowed eastward into Lake Michigan intermittently. The Des Plaines River naturally flowed west into the MRB. During periods of wet weather, the Des Plaines River would change its course and flow into the Chicago and Calumet Rivers. Wet weather periods would also cause the Chicago and Calumet Rivers to inundate flat areas, which created a surface water connection with the Des Plaines River. This occurred at two specific locations, Mud Lake (Figure 4-5) and Saganashkee

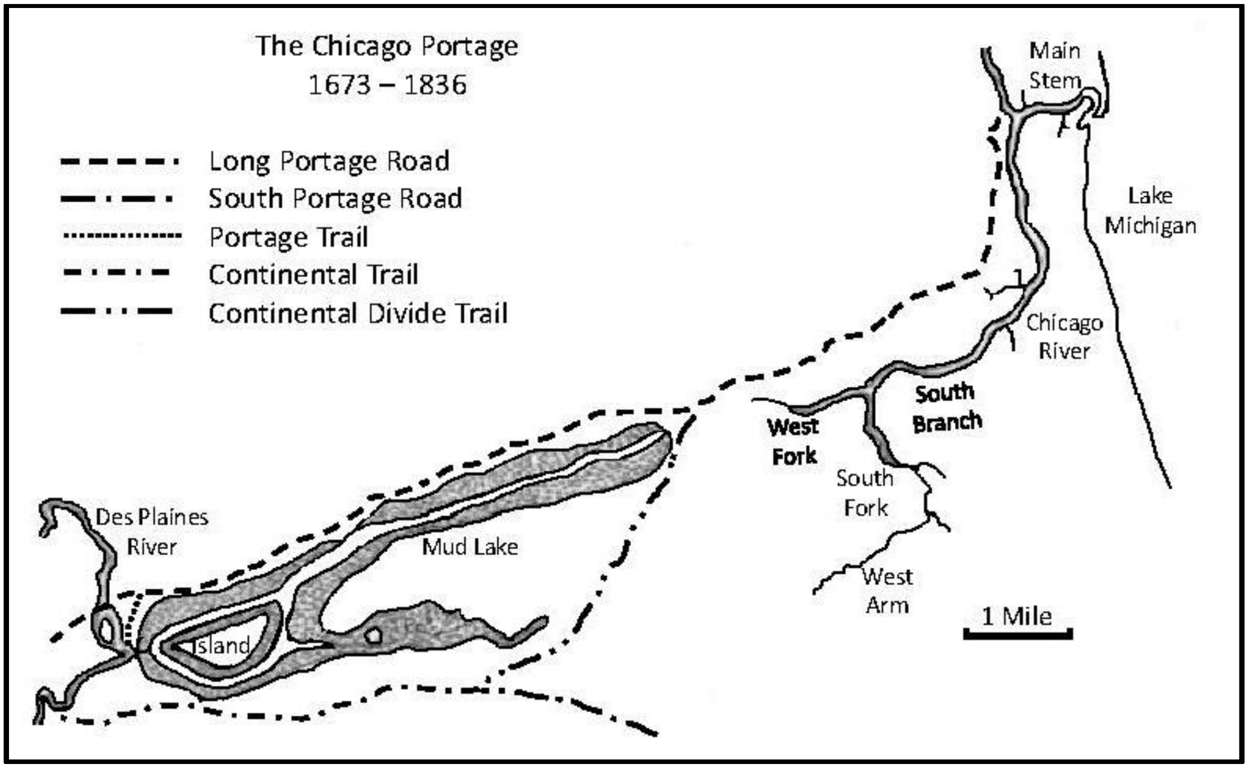


Figure 4-5 Depiction of Pre-Sanitary and Ship Canal Basin Separation

Slough. Depending on the location and quantity of rainfall, these geomorphic features would flow into each other, the West Fork of the South Branch Chicago River near Kedzie Avenue and/or the Little Calumet River near Blue Island. This interbasin flow provided a temporary connection between the respective drainage basins.

The continual or persistent connection between the GLB and the Illinois River was established in 1848 with the completion of the Illinois and Michigan (I&M) Canal (Figure 4-6). The dimensions of the original I&M Canal were 60 ft (18.3 m) wide at the surface, 36 ft (11 m) wide at the base, and 6 ft (1.8 m) deep. In the spring of 1849, the Little Calumet River was connected to the I&M Canal via the 40-ft (12.2-m)-wide and 4-ft (1.2-m)-deep Calumet Feeder Canal, which had been constructed through the Saganashkee Slough. The I&M Canal was substituted by the much larger CSSC, started in 1892, which eventually connected Lake Michigan to the IWW [remnants of the I&M Canal remain in parallel to the CSSC]. The permanent connection between Lake Michigan and the MRB was finalized with the completion of the CSSC in 1900. On the Calumet River, the USACE removed sandbars and built piers at the mouth during the period 1870–1882; between 1888 and1896, the river between Lake Michigan and Lake Calumet was straightened; between 1899 and 1916, the Calumet River was dredged to a depth of 16 ft (4.9 m); between 1911 and 1922, the Calumet Feeder Canal was eliminated by the construction of the Cal-Sag Channel, which cut through a large dolomite prairie, formerly known as the Saganashkee marshland. With the connection of the Cal-Sag Channel to the Calumet River, the Calumet region's drainage was for the most part reversed, and in 1965, the Calumet River was completely reversed by the construction of the T.J. O'Brien Lock and Controlling Works near the original confluence of the Calumet River with Lake Michigan.

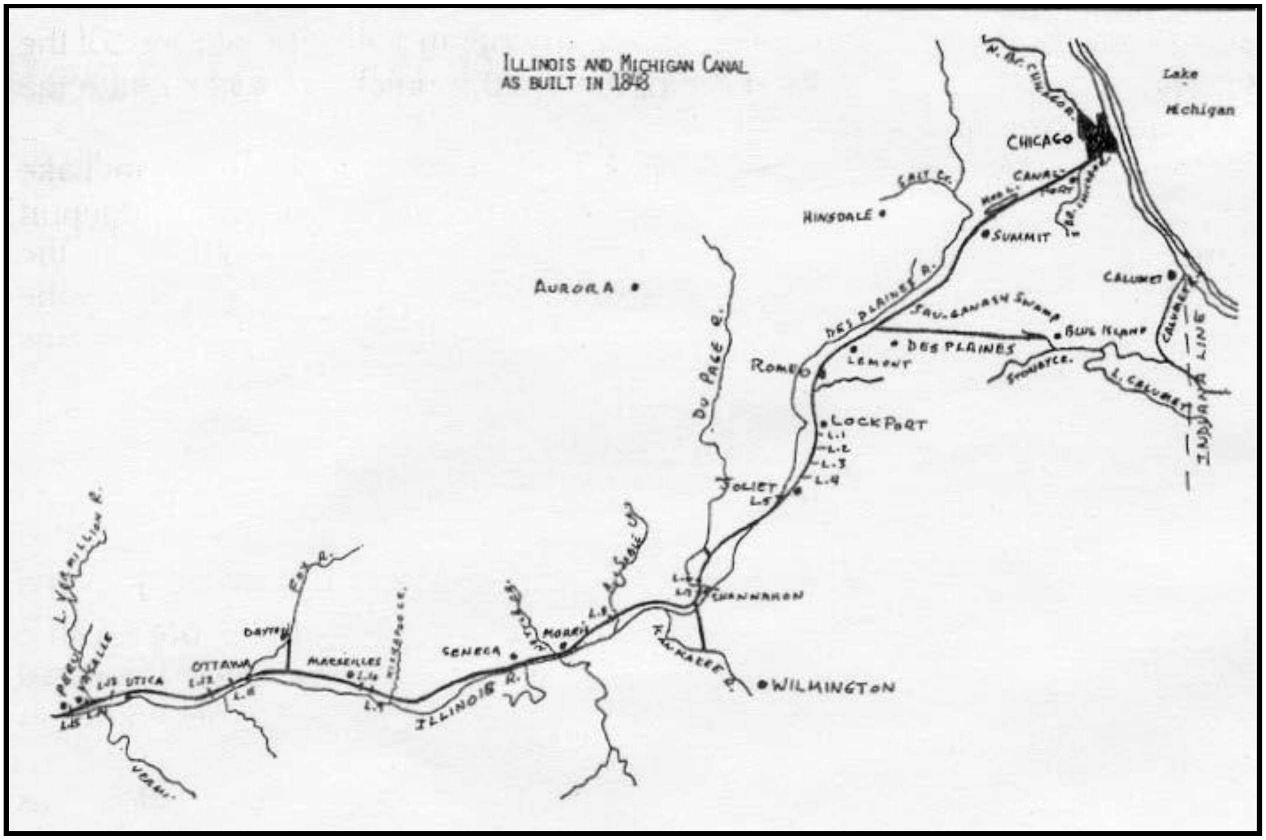


Figure 4-6 Early Configuration of the CAWS and Upper IWW circa 1848

Natural elevations of the river were altered by the construction of navigation locks to control the flow and depth of the CAWS. Under normal conditions, water levels in most parts of the system are static.

Traditionally, the CAWS has been defined as the waterways and connected rivers within the State of Illinois. For the GLMRIS Report (USACE 2014a) and the GLMRIS-BR Study, the CAWS definition has been expanded to also include the Little Calumet River, Grand Calumet River, and the connected channels in Indiana. For GLMRIS-BR, the following list provides channel definition and length of the CAWS. These routes include mileage for the most direct (shortest) point-to-point distances between the Lockport LD and the five Lake Michigan access points:

- Chicago River/CSSC
  - Main Stem: Lockport to Chicago River Controlling Works (Lake Michigan), 36.1 mi (58.1 km)
  - North Branch: Wolf Point to Wilmette Pumping Station (Lake Michigan), 15.2 mi (24.5 km)
- Cal-Sag Channel/Calumet River
  - Cal-Sag Channel: Junction of CSSC/Cal-Sag to T.J. O’Brien Lock, 22.9 mi (36.9 km)
  - Calumet River: T.J. O’Brien Lock and Controlling Works to Lake Michigan, 6.7 mi (10.8 km)
- Little Calumet River
  - Little Calumet: Cal-Sag Channel to Hart Ditch, 16.4 mi (26.4 km)
  - Little Calumet: Hart Ditch to Deep River, 11.5 mi (18.5 km)

  - Burns Ditch: Deep River to Lake Michigan, 8.3 mi (13.4 km)
- Grand Calumet River
  - West Grand Calumet: Calumet River to Indiana Harbor Canal, 6.1 mi (9.8 km)
  - Indiana Harbor Canal to Lake Michigan, 5.1 mi (8.2 km)
- Total CAWS Length: 128.3 mi (206.5 km)
- Lockport LD to BRLD: 5 mi (8 km)
- BRLD to Dresden Island LD: 14.5 mi (23.3 km)
- Dresden Island LD to Marseilles LD: 24.5 mi (39.4 km)
- Marseilles LD to Starved Rock LD: 16 mi (25.7 km)

Additional channels that may be of interest but not included in the CAWS calculation are as follows:

- Bubbly Creek: Racine Avenue Pumping Station to the SBCR, 1.6 mi (2.6 km)
- North Branch Canal: Additional channel length around Goose Island, 0.9 mi (1.4 km)
- Indiana Harbor Canal: Lake George Branch, 1.4 mi (2.3 km)

The North Branch Chicago River flows from north to south, parallel to the Lake Michigan shoreline, with its headwaters in Lake County, Illinois. In northern Cook and Lake Counties, three branches of the River (West Fork, Middle Fork, and Skokie River) combine to form the North Branch Chicago River, which flows through northern and downtown Chicago. The North Branch and much smaller South Branch join at Wolf Point in central Chicago about 2 mi (3.2 km) west of Lake Michigan. The original flow of the Chicago River was from Wolf Point eastward to the Lake but was altered in the late 1800s and early 1900s.

Historically, the Chicago River was important in the development of the city of Chicago, as it was part of an easy portage route for canoers and other small vessels between the GLB and MRB. The discharge of open sewers into the Chicago River and Lake Michigan led to severe and numerous health problems for city residents. To correct this problem, the entire city was raised 10 ft (3 m) in elevation to improve sewer drainage to the Chicago River. A system of combined intercepting sewers discharging to the Chicago River was built, and the flow direction of the river was changed by construction of the CSSC and the Chicago River Lock and Controlling Works at the old mouth of the Chicago River (Figure 4-7). This work began in 1887 and was completed in 1900. This constructed system closed off discharge to Lake Michigan and forced flow westward down the CSSC and eventually to the Illinois River. This is the current flow pattern of the river system, with wastewater treatment plants discharges making up the majority of the normal dry weather flow.

Lockport Powerhouse controls outflow of the CSSC and maintains the normal pool in the CAWS. Lockport Controlling Works is located 2 mi (3.2 km) upstream and connects the CSSC with the Des Plaines River. During wet weather conditions, the waterway is drawn down by allowing more water to leave at Lockport prior to and/or during major rainfall events. This system drawdown increases the capacity for stormwater runoff. If a storm's runoff intensity and/or volume overwhelms the capacity of the combined sewers and treatment plants, runoff and sewage is discharged into the CAWS in the form of combined sewer overflow (CSOs). Occasionally, excessive inflows threaten to cause overbank flooding in these locations. When this occurs, the sluice gates at Chicago River Lock and Controlling Works, T.J. O'Brien LD, and Wilmette Pumping Station reverse floodwaters to Lake Michigan. The lock gates at CRCW and T.J. O'Brien LD can be opened to further help relieve floodwaters in the system.

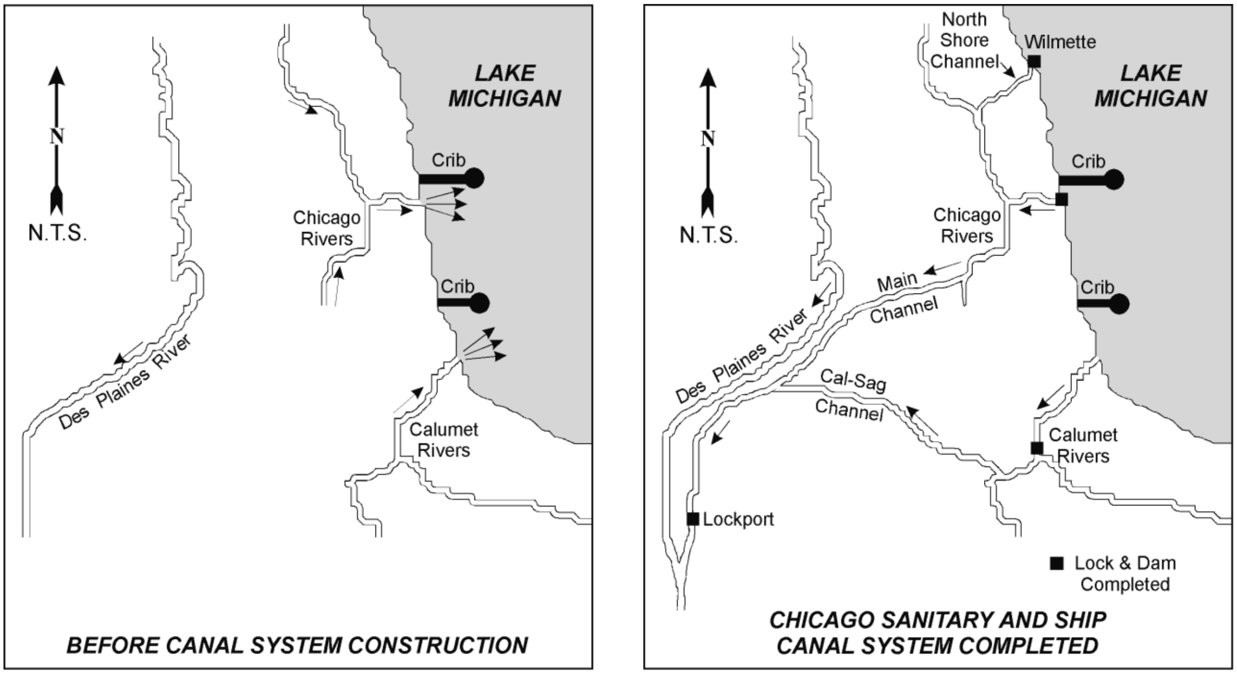


Figure 4-7 Development of the CAWS (Source: USACE 1996b)

The Tunnel and Reservoir Plan (TARP) was adopted in 1972 in order to protect Lake Michigan and the Chicago waterways from the raw sewage contained in CSOs. TARP Phase I constructed 109 mi (175.4 km) of large-diameter rock tunnels, which provided 2.3 billion gallons (8.7 billion liters) of stormwater storage. Phase I was completed in 2006 and has dramatically reduced the number of days per year that combined sewage and stormwater is released to the waterways. The Majewski Reservoir, also known as Chicago Underflow Plan (CUP) O'Hare Reservoir, was completed in 1998 and provides 350 million gallon (1.3 billion liters) of stormwater storage. Construction of the Thornton and McCook reservoirs will provide a total system storage volume of 17.5 billion gallons (66.2 billion liters) once completed. Completion of TARP Phase I delivered significant water quality benefits to the CAWS. Completion of the Phase II reservoirs will further reduce water quality degradation by preventing releases of untreated sewage and stormwater to the waterways.

The Grand Calumet and Little Calumet Rivers both have a high point in the channel that induces bidirectional flow west of the divide toward the Mississippi River and east of the divide toward Lake Michigan. The Little Calumet River flows between the Calumet River in Illinois and Lake Michigan at Burns Ditch in Indiana. The GLB/MRB watershed divide runs through the Little Calumet River near the Hart Ditch confluence. In 1922, the Cal-Sag Channel was constructed, which connected the Little Calumet River to the CSSC. This is a permanent connection.

Primarily during large storm events but also during dry weather, a portion of the water from Hart Ditch flows toward the west across the state boundary to join the Cal-Sag Channel; the other portion of floodwater flows toward the east, combining with local inflows and finally exiting to Lake Michigan through Burns Ditch at Burns Small Boat Harbor in Indiana. The Little Calumet River flows through a flood-prone watershed characterized by flat terrain that is heavily urbanized. Levees, federal and local, exist along the Little Calumet River in Illinois and Indiana. The USACE has nearly completed a levee system along the Little Calumet River between Gary and Hammond/Munster in Indiana. The project is intended to provide a 200-yr level of protection when completed.

The Grand Calumet River lies between its confluence with the Calumet River in Illinois and Lake Michigan at Indiana Harbor in Indiana. The GLB/MRB watershed divide runs through the West Branch of the Grand Calumet River, near the Hammond Wastewater Treatment Plant. The Cal-Sag Channel also connects the Grand Calumet River watershed to the MRB via the CSSC. This is also a permanent connection.

Des Plaines River

The upper Des Plaines River watershed originates in Racine and Kenosha Counties of southeastern Wisconsin. The watershed then extends south into Illinois through Lake County and then Cook County, where it converges with the Salt Creek watershed near Riverside, Illinois. The Des Plaines River then flows southwest on to its confluence with the Kankakee River, where the two rivers combine to form the Illinois River. The study area for the GLMRIS-BR project includes the entire Des Plaines River watershed. Since 2011, the following dams have been removed from the Des Plaines River watershed: Ryerson Dam (2011), Armitage Dam (2011), Hoffman Dam (2012), Fairbanks Dam (2012), Dam #1 (2014) and Dam #2 (2014) (American Rivers 2016), MacArthur Woods (2016), Captain Daniel Wright Woods (2016), and Dempster Avenue Dam (2016). The remaining two low-head dams (i.e., Dam #4 and Touhy Avenue Dam) on the mainstem of the Des Plaines River are scheduled for demolition in the near future.

Illinois River

The Illinois River begins at the confluence of the Des Plaines and Kankakee Rivers, approximately 50 mi (80.5 km) southwest of Chicago, Illinois. It then flows 273 mi (439.4 km) south–southwest where it merges with the Mississippi River 31 mi (49.9 km) northwest of St. Louis, Missouri. In total, the Illinois River watershed drains 18,500,000 ac (7,486,684 ha) of land. The first primary modification to the river came with the opening of the CSSC in 1900, which flushed untreated domestic sewage and industrial wastes away from Lake Michigan and into the Illinois River system. The original diversion increased the flow of the Illinois River by 7,200 cfs (203.9 cms), increased river stages approximately 3 ft (0.9 m), and increased water surface area over 110,000 ac (44,515.4 ha) along the length of the river (USGS 1999b). Although the amount of diverted water from Lake Michigan was reduced in 1938, river levels were further altered by the construction of navigation locks and dams during the 1930s. These dams helped maintain a 9-ft (2.7-m) channel depth for commercial navigation and had a significant impact on the river. Dams on the upper portion of the river raised water levels and created pools, thereby slowing the velocity of the river. Dams on the lower portion of the river stabilized water levels but did not create pools or slow the velocity of the river appreciably.

In general, the construction of navigation dams and diversion of flows from Lake Michigan have increased the river water surface elevation and have altered the nature of the flooding regime along certain reaches of the river. As the water surface elevation of the river increased, so did the water surface elevations of the associated backwaters and wetlands, resulting in as many as 300 long, narrow backwater or bottomland lakes. Each dam keeps the water level in the pool upstream high enough to maintain a 9-ft (2.7-m) navigation channel, and as a result, the floodplains immediately upstream of each dam are more continuously inundated than they would be under unmodified conditions. Short-term water level fluctuations on the mainstem, that is, water level changes over the course of several hours to several days, have been implicated in degradation of Illinois River ecosystem function because of the stress of rapid changes in river conditions on plants and animals. The magnitude and frequency of water level fluctuations have notably increased in portions of the river since daily water level monitoring began in the 1880s.

Excluding the CAWS, the six locks and dams on the Illinois River include BRLD, River Mile (RM) 286.0; Dresden Island LD, RM 271.5; Marseilles LD, RM 245.0;P Starved Rock LD, RM 230.0; Peoria LD, RM 157.6; and La Grange LD. RM 80.2.

Kankakee River

The Kankakee River watershed extends from South Bend, Indiana, to its confluence with the Illinois River near Wilmington, Illinois (Little and Jonas 2013). It has an approximately 5,165-mi^2 (13,377.3-km^2) drainage area and a river length of approximately 150 mi (241.4 km), reduced from its historic length of 250 mi (402.3 km). The watershed once included the Grand Kankakee Marsh, a 400,000-ac (161,874.3-ha) freshwater wetland system. The upstream portion of the river, which extends from South Bend, Indiana to the Kankakee River's confluence with the Iroquois River, was heavily modified beginning in the 1800s to improve drainage within the area. However, the portion of the river that flows through Illinois has had minimal channelization and impoundments (Suloway 1981; Kwak 1993). The width of the Kankakee River varies throughout its length but extends nearly 984 ft (299.9 m) in some reaches.

The lower Kankakee River from the mouth of the Illinois River upstream to the confluence of the Iroquois River is a fairly wide and shallow stream (Little and Jonas 2013). Two (2) low-head dams exist on this reach of river at Wilmington and Kankakee, Illinois. The lower Kankakee contains sections that are flat in gradient as well as reaches of steep gradient. The reach of stream from Kankakee to the Illinois/Indiana state line is somewhat narrower and more sinuous than the lower reach. The reach in the vicinity of the Iroquois River just upstream of Kankakee is influenced by pool effects from the Kankakee Dam. Upstream of the pool, the Kankakee River includes a pool/riffle sequence up to Momence, Illinois. Upstream of Momence, the river runs through the area known as the Momence Wetlands, and the river is narrow and sinuous with a mild gradient.

4.3.5 Limnology

Great Lakes

The surface area of Lake Superior (Table 4-1) is 31,700 mi^2 (82,102.6 km^2), and it has a volume of roughly 3 quadrillion gallons of water (2,900 mi^3 [12,100 km^3]) (Minnesota Sea Grant 2016). Lake Superior at its greatest measures 350 mi (563.3 km) long and 160 mi (257.5 km) across. The lake's surface is about 600 ft (182.9 m) above sea level, with an average depth of 483 ft (147.2 m) and a

Table 4-1 Characteristics of the Great Lakes System-Wide Study Area

Great Lake	Water Surface Area		Surface Elevation		Length		Breadth		Maximum Depth		Drainage Area	
	mi^2	km^2	ft	m	mi	km	mi	km	ft	cm	mi^2	km^2
Lake Superior	31,700	82,103	591	180	350	563	160	257	1,333	406	81,000	209,789
Lake Huron	23,000	5,957	581	177	206	332	101	163	752	229	74,800	193,731
Lake Michigan	22,300	57,757	577	176	307	494	118	190	925	282	67,900	175,860
Lake Erie	9,900	25,641	571	174	241	388	57	92	212	65	33,500	86,765
Lake Ontario	7,600	19,684	243	74	193	311	53	85	804	245	34,800[a]	90,132

[a] Includes water surface area and tributary land area downstream to the St. Lawrence Power Project at Cornwall.

maximum depth of 1,332 ft (406.0 m). The lake itself is bordered by 2,980 mi (4,795.8 km) of shoreline (University of Wisconsin Sea Grant Institute 2013). Water temperature within the lake is cold with the average temperature of 40°F (4°C). The lake is considered oligotrophic, with relatively little productivity occurring. Underwater visibility within the lake is extensive, sometimes exceeding 75 ft (23 m) (Minnesota Sea Grant 2016).

Lake Michigan's (Table 4-1) surface is approximately 579 ft (176.5 m) above sea level. The lake has a total surface area of 22,300 mi^2 (57,756.7 km^2), with an average depth of 279 ft (85.0 m) and a maximum depth of 923 ft (281.3 m). At its greatest, Lake Michigan is 307 mi (494.1 km) long and 118 mi (189.9 km) across. Only a relatively small amount of water flows out the bottleneck straits between Michigan and Huron, so Lake Michigan holds its water a long time, nearly 100 years. Lake Michigan is bordered by 1,659 mi (2,669.9 km) of shoreline (University of Wisconsin Sea Grant Institute 2013).

Lake Huron (Table 4-1) has a total surface area of 23,000 mi^2 (59,569.7 km^2). The lake measures approximately 206 mi (331.5 km) long and 183 mi (294.5 km) wide and has nearly 3,200 mi (5,149.9 km) of shoreline. Lake Huron is 579 ft (176.5 m) above sea level and has an average depth of 195 ft (59.4 m) and a maximum depth of 750 ft (228.6 m). There are 30,000 islands within Lake Huron. The watershed for Lake Huron is 51,700 mi^2 (133,902.4 km^2). A drop of water entering Lake Huron has a total retention time of 22 years (University of Wisconsin Sea Grant Institute 2013).

Lake Erie (Table 4-1) has a surface area just over 9,900 mi^2 (25,640.9 km^2). Lake Erie has a total volume of 119 mi^2 (308.2 km^2). The lake is 570 ft (173.7 m) above sea level and measures 241 mi (387.9 km) across and 57 mi (91.7 km) from north to south. There are 871 mi (1401.7 km) of shoreline surrounding Lake Erie. The average depth of Lake Erie is about 62 ft (18.9 m), with a maximum depth of 210 ft (64.0 m). The lake is naturally divided into three basins: western, central, and eastern. The western basin is very shallow, with an average depth of 24 ft (7.3 m) and a maximum depth of 62 ft (18.9 m). The central basin is fairly uniform in depth, with an average depth of 60 ft (18.3 m) and a maximum depth of 82 ft (25.0 m). The eastern basin is the deepest of the three basins, with an average depth of 80 ft (24.4 m) and a maximum depth of 210 ft (64.0 m). The central and eastern basins are deep enough to thermally stratify every year. Stratification does occur in the shallower western basin but does not last very long when it does occur (EPA 2016). Lake Erie has a total retention time of 2.6 years.

Lake Ontario (Table 4-1) is the third-deepest of the Great Lakes (after Lakes Superior and Michigan), with an average depth of 283 ft (86.3 m) and a maximum depth of 802 ft (244.4 m). Ontario sits at 245 ft (74.7 m) above sea level. The lake is 193 mi (310.6 km) long and 53 mi (85.3 km) wide and has 726 mi (1,168.4 km) of shoreline, giving it a total surface area of approximately 7,300 mi^2 (18,906.9 km^2). A drop of water entering Lake Ontario has a total retention time of about 6 years (University of Wisconsin Sea Grant Institute 2013).

4.3.6 Sediment Quality

Great Lakes

Sediment quality throughout the Great Lakes is highly variable in terms of physical, chemical, and biological characteristics. Some areas have rock outcroppings and little sediment; extensive coarse sand beaches line Lake Michigan and portions of other lakes; fine sediment from upland sources such as agricultural fields enters the lakes in large volumes via major river tributaries such as the Cuyahoga River. Atmospheric deposition of compounds such as polychlorinated biphenyls (PCBs) and mercury have affected all sediments and all lakes to some degree, with higher concentrations of these bioaccumulative compounds found near population centers.

As part of the Great Lakes Water Quality Agreement (GLWQA), the United States and Canada have designated "Areas of Concern" around the Great Lakes. These Areas of Concern are locations (typically discrete harbors, rivers or portions thereof) that have experienced extensive environmental degradation. Within the United States, 43 Areas of Concern were originally identified, and all of these included degradation to the sediment as one of the identified environmental issues. These Areas of Concern are not the only locations with chemically degraded sediment, however, because some waterways (such as the Calumet River and the Chicago River, which drain from Lake Michigan) were not included in the designation. In general, degraded sediment quality with high concentrations of metals and manmade organic compounds is found in urban centers and in the environment downstream of these centers. A number of tributaries and harbors around the Great Lakes, including the greater Chicago area, have chemically degraded sediment conditions from activities predating the Clean Water Act (CWA). Sediment quality issues within the Great Lakes are investigated and addressed on a location-specific basis.

CAWS

The CAWS is a combination of natural but highly modified and man-made waterways. As such, the sediment reflects the anthropogenic influences. Natural rivers were rerouted and channelized; the Chicago Lock was added to control water levels as part of the reversal of the flow of the river, man-made channels were added to the system. For more than 100 years, the system was a receiving basin for urban waters from all sources, including sanitary waste and industrial waste. Within the Chicago River, relatively high concentrations of metals, man-made organic compounds, and PCBs can be found. The Calumet River is similarly affected by historical industrial activities and urban discharges. The Cal-Sag Canal and CSSC are manmade and cut through limestone outcroppings. Some portions of these channels have little sediment, which is consistent with the stone bottom and banks. Other areas have sediment contributed by upstream discharges (including industrial, sanitary wastewater, and urban stormwater discharges) as well as by bank erosion and overland stormwater flows. Areas with sediment accumulation tend to have poor quality sediment, which is reflective of the urban impacts and industrial history of the waterway. Constituents found in the sediment include metals, PCBs, various organic compounds including pesticides and petroleum compounds, and nutrients such as ammonia and phosphorus. Overall, the CAWS sediment quality has been significantly affected by historical industrial activities and unregulated discharges to the waterways prior to the passage and enforcement of the CWA in 1972. No systematic remediation or other planned actions to address sediment quality in the CAWS have been identified.

Des Plaines River

Similar to the CAWS, the nearby Des Plaines River has been greatly modified over the last 100 years by the construction of the BRLD, by channelization, by urban discharges, and by other human activities. Sediment can reflect both historical and present-day activities within the watershed, since insoluble compounds (such as metals) and also constituents that attach to the sediment surface (such as large organic molecules) can be found within the sediment. The sediment quality in the lower Des Plaines River reflects the impacts of discharges to the CAWS, which have migrated downstream, as well as direct discharges to the river from historic sources. The MWRDGC conducts water- and sediment-monitoring activities within the IWW and the CAWS on a nearly annual basis. Data collected by MWRDGC were reviewed to determine sediment quality at BRLD as well as to identify trends in sediment quality. Table 4-2 shows a summary of some constituents measured in the sediment at the Brandon Road upper pool. Although these data were collected from the upper pool, it is anticipated that the lower pool would have similar sediment quality; neither the lock nor the dam prevents the downstream migration of sediment. The approach channel on the downstream side and the lock chamber themselves have very little sediment because of the discharges from the lock chamber, which flushes solids downstream.

Table 4-2 Summary of Sediment Quality in Brandon Road Upper Pool

Constituent	1984[a]	2002	2004	2006	2008	2009	2011
Ammonia, mg/kg	NA	2	79	3	296	234	59
Total phosphorus, mg/kg	NA	190	3,257	510	6,069	10,143	8,058
Total cyanide, mg/kg	0.91	0.345	1.958	0.213	0.147	1.236	NA[b]
Phenols, mg/kg	NA	0.069	0.167	0.061	1.779	0.166	0.346

[a] Source: MWRDGC website (www.mwrd.org). Monitoring and research reports for 1984, 2002, 2004, 2006, 2008, 2009, and 2011.

[b] NA = results not available.

The sediment data are quite variable, which is typical for sediment. Sediment moves in response to currents, and the sediment quality reflects the variations in water quality including spills, storm events, or other transitory disturbances. As with the water quality in the Des Plaines River, the sediment reflects the history and the current urban uses of the waterway. It is likely that the sediment quality will generally improve over time (lower concentrations of heavy metals, PCBs, and other anthropogenic species) because of improvements in water quality and the general reduction in industrial inputs that has occurred since the advent of the CWA. Any improvements in sediment quality are expected to be slow and gradual. No systematic remediation or other planned actions to address sediment quality in the lower Des Plaines River have been identified.

Illinois River

The Illinois River begins at the confluence of the Kankakee River and Des Plaines River, below where the CAWS joins the Des Plaines River. As such, the sediment reflects the quality of all the inputs. Low concentrations of man-made compounds can be found in the sediment, although in general the material is of higher quality than the sediment found upstream and closer to the urban population.

Kankakee River

The Kankakee River flows from Indiana westward into Illinois where it joins the lower Des Plaines River to become the Illinois River. The upstream end of the Kankakee River in Indiana has been channelized and used as a collective basin for discharges ranging from agricultural runoff to sanitary and stormwater waters, although overall this river has been less affected by urban and industrial activities than the CAWS and Des Plaines River. Past studies have indicated that the sediment in the Kankakee River tends towards sandier materials, particularly in the more natural portions of the river in Illinois. These materials have low levels of man-made compounds, including nutrients, pesticides, and other organic compounds associated with agricultural runoff, but in general lack the very high concentrations of industrial contaminants associated with historic discharges such as found in the CAWS. Sediment in the Kankakee River is generally of higher quality than that found in the CAWS and Des Plaines River.

4.3.7 Water Quality

Great Lakes

The Great Lakes hold approximately 21% of the earth's surface fresh water. The watershed spans more than 750 mi (1,207.0 km) from east to west, and the land within that watershed includes portions of two countries. Approximately 10% of the U.S. population and 30% of the Canadian population live within this diverse watershed. The drainage area for the Great Lakes includes urban areas, forests, wetlands, and prairies. The land is used for recreational, natural, industrial, agricultural, and residential purposes.

The opening of the St. Lawrence Seaway in 1959 provided a direct connection between the Atlantic Ocean and the Great Lakes for oceangoing vessels. Although the Great Lakes flow toward the oceans, the opportunity provided by the seaway for the transportation of both vessels and nonnative aquatic species accelerated and exacerbated changes to the lakes that began decades earlier. Human impacts on the Great Lakes over the last 200 but particularly the last 75 years include point and nonpoint discharges of contaminated water and waste; introduction (intentional or accidental) of nonnative aquatic species; hardening of the shoreline; the destruction of nearshore wetlands and shallows; and alteration of the drainage basin by changing land uses (including deforestation, introduction of agriculture, hardening surfaces). All these changes have had an impact on the water quality within the lakes either directly or indirectly by altering the biological system. Changes to the water quality of the lakes include the increase of chloride, ammonia, and phosphorus in the system, as well as measurable concentrations of metals, organic compounds, fertilizers and pesticides, petroleum-based compounds, and PCBs. These changes have led to large-scale water quality issues such as the "dead zone" or hypoxic area that develops in Lake Erie, large scale algal blooms, and beach closures caused by bacterial growth.

Although affected by human activities, the Great Lakes are still considered overall a high quality source of fresh water. The water varies from warm and eutrophic (e.g., Lake Erie) to cold and oligotrophic (e.g., Lake Superior). Temperatures can vary seasonally by more than 20ºC (68ºF), with at least portions of the lakes icing over in winter, but mild, swimming suitable temperatures near shore during the summer. The Great Lakes are used as a source of drinking water for approximately 30 million people.

CAWS/Des Plaines River/Illinois River/Kankakee River

The CWA, enacted in 1972 to restore and maintain the integrity of the nation's waterways, requires states to adopt Water Quality Standards (WQS) for waters of the United States within their jurisdictions. Section 303(c) of the CWA requires that state agencies designate uses for each water body and define the criteria necessary to protect those uses. Water Quality Standards are narrative or numeric criteria that define the maximum contamination a water body can receive and still support its designated uses. Designated uses for Illinois waters include aquatic life, fish consumption, public and food processing, water supplies, primary contact, secondary contact, indigenous aquatic life, and aesthetic quality.

Section 303(d) of the CWA requires states, territories, and authorized tribes to submit a list of impaired and threatened water bodies to the EPA. "Impaired" waters are defined as those not yet meeting WQS, and "threatened" waters are those not expected to meet WQS by the next listing cycle. The Illinois Environmental Protection Agency (IEPA) has identified that many segments of the CAWS, lower Des Plaines River, upper Des Plaines River, Kankakee River, and Illinois River are not supporting their designated uses, as shown in Table 4-3. High counts of fecal coliform indicator bacteria impair many of the waterways for recreational use, and chemical constituents such as phosphorous, mercury, PCBs, and low dissolved oxygen (DO) impair many of the waterways for aquatic life. For a discussion of impairments as identified by IEPA, refer to the IEPA Integrated Water Quality Report and Section 303(d) Lists website at http://www.epa.illinois.gov/topics/water-quality/watershed-management/tmdls/303d-list/.

Table 4-3 Water Impairments from 2014 Illinois Section 303(d) List

Waterway	Nonsupporting Designated Use	Impairment(s)
Primary Contact Recreation Use, Indigenous Aquatic Life Use		
Lower North Shore Channel from its confluence with the North Branch Chicago River upstream to the North Side Water Reclamation Plant	Fish consumption	Mercury, PCBs
North Branch Chicago River from its confluence with the NSC to its confluence with the Chicago River	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, iron, phosphorus (total), total dissolved solids (TDS)
South Branch Chicago River from Wolf Point downstream to South Fork of the South Branch Chicago River (Bubbly Creek)	Fish consumption	PCBs
	Indigenous aquatic life	DO, TDS, phosphorus (total)
Little Calumet River from its confluence with the Calumet River and Grand Calumet River to its confluence with Calumet-Sag Channel	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	Aldrin, DO, iron, phosphorus (total), TDS, silver
Little Calumet River South	Aesthetic quality	Bottom deposits, sludge, visible oil
	Aquatic life	Chlordane, chloride, DO, endrin, hexachlorobenzene, phosphorus (total), sedimentation/siltation
	Primary contact recreation use	Fecal coliform
Calumet-Sag Channel from its confluence with the Chicago Sanitary Ship Canal upstream to its confluence with Stony Creek	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, iron, oil and grease, phosphorus (total), TDS, total suspended solids (TSS)
Calumet-Sag Channel from its confluence with Spring Creek upstream to its confluence with the Little Calumet River	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, iron, TDS
Kankakee River from the Illinois/Indiana state line to confluence with the Iroquois River	Fish consumption	Mercury

Table 4-3 (Cont.)

Waterway	Nonsupporting Designated Use	Impairment(s)
Kankakee River from the confluence with the Iroquois River to the confluence with the Des Plaines River	Fish consumption	Mercury, PCBs
Illinois River	Fish consumption	Mercury, PCBs
	Primary contact recreation use	Fecal coliform
Primary Contact Recreation Use, General Use		
Chicago River	Aquatic life	DO, pH, phosphorus (total)
	Fish consumption	Mercury, PCBs
	Primary contact recreation use	Fecal coliform
Lake Michigan Nearshore (open water)	Fish consumption	Mercury, PCBs
	Aesthetic quality	Phosphorus (total)
Upper Des Plaines River from confluence with Salt Creek upstream to Wisconsin border	Primary contact recreation use	Fecal coliform
	Fish consumption	Mercury, PCBs
	Aquatic life	Arsenic, chloride, DO, iron, methoxychlor, pH, phosphorus (total), TSS, cause unknown
Upper Des Plaines River from confluence with Chicago Sanitary Ship Canal upstream to confluence with Salt Creek	Aquatic life	Aldrin, arsenic, chloride, lindane, methoxychlor, pH, phosphorus (total)
	Fish consumption	Mercury, PCBs
	Primary contact recreation use	Fecal coliform
Incidental Contact Recreation Use, Indigenous Aquatic Life Use		
South Fork of the South Branch Chicago River (Bubbly Creek)	Indigenous aquatic life	DO, phosphorus (total)
Chicago Sanitary and Ship from its confluence with the South Branch Chicago River to its confluence with the Calumet-Sag Channel	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, phosphorus (total)

Table 4-3 (Cont.)

Waterway	Nonsupporting Designated Use	Impairment(s)
Grand Calumet River	Indigenous aquatic life	Ammonia (un-ionized), arsenic, barium, cadmium, chromium, copper, DDT, DO, iron, lead, nickel, PCBs, phosphorus (total), sedimentation/siltation, silver, zinc
Lower Des Plaines River from the BRLD to Interstate 55 Bridge	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, iron, manganese, TDS
General Use		
Upper Lower North Shore Channel from the Wilmette Pumping Station to O'Brien Water Reclamation Plant	Aquatic life	DO, pH, phosphorus (total)
	Fish consumption	Mercury, PCBs
	Primary contact recreation use	Fecal coliform
Calumet River from Lake Michigan to the T.J. O'Brien Lock and Controlling Works	Fish consumption	Mercury, PCBs
	Primary contact recreation use	Fecal coliform
Secondary Contact Recreation Use, Indigenous Aquatic Life Use		
Chicago Sanitary Ship Canal from its confluence with the CSC to downstream to the Will County line	Fish consumption	PCBs
	Indigenous aquatic life	DO, phosphorus (total), TDS
Chicago Sanitary Ship Canal from the Will County line downstream to its confluence with the Des Plaines River	Fish consumption	PCBs
	Indigenous aquatic life	DO, iron, manganese, phosphorus (total), TDS
Lower Des Plaines River from its confluence with the Chicago Sanitary Ship Canal to the BRLD	Fish consumption	Mercury, PCBs
	Indigenous aquatic life	DO, iron, manganese, TDS

Source: IEPA (2014b).

The effective recreational designated use for the lower Des Plaines River is Secondary Contact Use from the confluence with the CSSC to the BRLD (see https://www.epa.gov/sites/production/files/2014-12/documents/ilwqs_part303.pdf). The lower Des Plaines River is designated a Non-Recreational Water from the confluence with the CSSC to the BRLD and is designated Incidental Contact Recreation Water from the BRLD to the Interstate 55 Bridge, approximately 8 mi (12.9 km) downstream. Since 1972, most segments of the CAWS have been designated for Secondary Contact Use, which includes fishing, boating, and other activities where water contact is minimal or incidental but excludes swimming and other Primary Contact activities. The Secondary Contact designation was reevaluated and upheld in 1985 and reevaluated again from 2002 to 2011. On the basis of information generated through a Use Attainability Analysis (UAA) conducted by the IEPA, it was determined that recreation in and on the water is attainable for many segments of the CAWS. In 2012, the Illinois Pollution Control Board adopted new and revised use designations that better protect recreation on the CAWS. Primary Contact Recreation Use designations are now in effect for 8 of 17 CAWS segments, consistent with Section 101(a)(2) recreational goal uses of the CWA. The recreational use designations in effect for the other nine segments provide for less than Section 101(a)(2) goals. The applicable federal Aquatic Life Use designations currently in effect for the lower Des Plaines River segments provide for protection and propagation of fish, consistent with Section 101(a)(2) aquatic life goal uses. The federally applicable Indigenous Aquatic Life Use designations currently in effect for the 14 other segments provide for less than Section 101(a)(2) Aquatic Life Use goals.

The changes in use designation that indicate a general improvement in water quality conditions over time will also generally benefit downstream waters including the IWW, which receives the flow from the CAWS and Des Plaines River. According to the September 23, 2015, EPA letter in response to future conditions solicitation from USACE (see Appendix K, Coordination, for correspondence), “Future water quality management activities in the CAWS and lower Des Plaines River, as guided by implementation of new and/or revised WQS, may include implementation of a total maximum daily load (TMDL), more stringent point source permit limits, better stormwater control, and/or new, holistic strategies to improve aquatic life. To the extent that stricter permit limits, installation of stormwater controls, or improved instream habitat are shown to be necessary to remedy aquatic life use impairments in order to meet the applicable designated use for a water body, improvements in treatment technologies and/or habitat may be required. Additional management activities in the CAWS could also include flow augmentation, aeration, and/or sediment removal in certain reaches (EPA letter dated September 23, 2015, p 4).”

The EPA response letter also noted several actions that are anticipated to improve water quality within and downstream of the CAWS: “IEPA issued permits in 2013 for the O’Brien (formerly known as Northside), Calumet and Stickney plants requiring phosphorus removal, with associated lengthy compliance schedules. The O’Brien, Calumet, and Stickney permits all contain a 1 milligram per liter (mg/L) phosphorous limit (EPA letter dated September 23, 2015, p 8).” In addition, the CSOs covered under the permits, which discharge untreated wastewater mixed with stormwater into the CAWS, are primarily controlled by MWRDGC’s construction and operation of the Tunnel and Reservoir Plan (TARP) system. A schedule for completing the TARP by 2029 is included in a Federal Consent Decree entered in Federal Court. Stage I of the McCook Reservoir is to be completed by the end of 2017 with Stage II of the McCook Reservoir being the final piece to be completed by 2027; the remaining TARP components are substantially complete as of 2016.

A TMDL for the Des Plaines River/Higgins Creek Watershed was finalized in May 2013; the TMDL addressed 18 impaired water bodies identified for TMDL within the Des Plaines/Higgins Creek watershed. The water bodies investigated included Buffalo and Higgins Creeks, and lakes within the watershed, but did not include mainstem reaches of the Des Plaines River. Currently, water quality problems in the Des Plaines River are being addressed through the Des Plaines River Watershed Workgroup. The Des Plaines River Watershed Workgroup will monitor water quality in the river and tributaries, prioritize and implement water quality improvement projects, and secure grant funding. Monitoring data will allow for a greater understanding of the water quality impairments, identify priority restoration activities, and track water quality improvements. The workgroup is committed to an approach for attaining water quality standards that focuses on stakeholder involvement, monitoring, and locally led decision making based on sound science.

The Kankakee and Illinois Rivers are designated for use as Primary Contact Recreation Use and as General Use waters; these designations protect primary recreational contact and aquatic life uses. However, these waterways are impaired by atmospheric deposition of mercury and PCBs and by the upstream sources of fecal coliform. The Illinois River will certainly show future improvement based on the changes to the CAWS management and the addition of disinfection at Chicago-area wastewater treatment plants. A TMDL for the Kankakee River was completed in 2009 to address the fecal coliform impairment.

Following a 1986 pilot project, the U.S. Geological Survey (USGS) began implementation of the National Water-Quality Assessment (NAWQA) Program in 1991, monitoring the surface water quality in the upper Illinois River Basin in Illinois, Indiana, and Wisconsin. The intent of the program was to provide consistent descriptions of current status of water quality in the basin, define trends in water quality, and identify relations of status and trends in water quality to land use and waste management activities. Monitoring data for several stations along the Des Plaines River were established and continued to be monitored (for example, the Des Plaines River in Joliet at route 53 from 1981 through 2015, and the Des Plaines River at Riverside from 1970 through 2013).

Historic information obtained from the USGS 1987 Surface Water Quality Assessment of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin (USGS 1987) suggests that Lake Michigan diversions in the early nineteenth century affected the water quality in the Des Plaines River. By 1912, all fish and mussels from the lower Des Plaines and Illinois Rivers were eliminated and the fishery collapsed. Increasing amounts of oxygen-demanding wastes were discharged into the upper Illinois River system as the Chicago area population grew. Early DO studies suggested that the river system contained anaerobic conditions in the Illinois River reach 146 mi (235.0 km) downstream of Lake Michigan in 1924; however, water quality conditions are noted as "recovering" since wastewater treatment practices began, TARP was introduced, and soil erosion and sediment control programs were completed.

The Upper Illinois River Basin study unit is one of 14 NAWQA studies that began in federal fiscal year 1997 (October 1, 1996). The upper Illinois River Basin extends from approximately Hennepin, Illinois, upstream to the confluence of the Des Plaines River with the Kankakee River. During the planning period, available data and results from previous studies in the study unit are reviewed to understand the primary physical, chemical, and biological factors that affect water quality in the study unit and to identify gaps in the available data. Descriptions of how land use and land cover, soils, geology, physiography, climate, and drainage characteristics may affect water quality are to be included in reports. Information obtained from reviews of previous studies, field checks of available monitoring stations and candidate sampling sites, and field reconnaissance data are used to design a sampling program for the study unit. The nutrients and suspended solids loading for the upper Illinois River Basin (1978–1997) were evaluated in the planning phase of the project (USGS 2000), summary trends and conclusions are as follows:

- Downward trend of ammonia concentration in the Des Plaines River over time. Elevated concentrations of ammonia in the Des Plaines River are attributed to municipal and industrial waste discharge.

- Upward trend of nitrite + nitrate over time. Elevated concentrations of nitrate in the Des Plaines River are attributed to agricultural practices in the watershed.

- Upward trend of dissolved phosphorous, likely due to location of sampling sites downstream of wastewater treatment plants.

- Suspended solids concentrations do not indicate any particularly strong spatial patterns among major river basins in the GLMRIS-BR Illinois Waterway Study Area. Instead, high suspended solids concentrations are observed at sites draining areas of poorly permeable, easily eroded soils in both agricultural and urban areas.

- The major contributor of total ammonia nitrogen, total Kjeldahl nitrogen, and phosphorus loads to the total study area output was the Des Plaines River Basin, the CSSC in particular. The high loads in the CSSC reflect the input from the three (3) largest wastewater treatment plants in the GLMRIS-BR Illinois Waterway Study Area.

- Loads and yields of nutrients from the upper Illinois River Basin are among the very highest in the entire Mississippi River drainage system.

Some of the identified causes of impairments, such as ammonia, phosphorus, and other parameters linked to wastewater and stormwater discharges, are likely to be mitigated in the future as suggested in the September 23, 2015, letter from EPA. The "Chicago Underflow Plan" or "Tunnel and Reservoir Plan" is nearing completion and per the consent decree will be completed by 2029. The Majewski Reservoir, also known as CUP O'Hare Reservoir, was completed in 1998 and provides 350 million gallons (1.3 billion liters) of stormwater storage. Thornton Reservoir went online in fall 2015 and provides approximately 7 billion gallons (26.5 billion liters) of stormwater storage. The first stage of the McCook Reservoir is planned to be online by January 2017 with the second stage completed before 2029; the final McCook Reservoir will provide approximately 10 billion gallons (378.5 billion liters) of storage (Stage I will provide approximately 3.5 billion gallons (13.2 billion liters) of storage, with Stage II providing the rest). These reservoirs, together with the existing deep tunnel system, capture combined sewer overflows for treatment, thereby reducing the ammonia, phosphorus, and solids loading that is released during storm events. In addition, future water quality standard changes as discussed above for the CAWS will have a beneficial downstream impact on water quality.

Section 319 of the CWA, established in 1987, provides federal grants to state agencies for the development of nonpoint source management program plans. IEPA staff work with state and local agencies, nonprofit entities, and third parties to develop and implement projects that address nonpoint sources of pollution through educational and training programs, watershed-based planning, and implementation of best management practices to protect water quality. Dozens of these projects are underway within the GLMRIS-BR Illinois Waterway Study Area and are described in the IEPA Grants Reporting and Tracking System (GRTS) and the IEPA Section 319 Biannual Reports. In addition to stormwater control and point discharge regulation changes, various entities have undertaken numerous small-dam removal and ecosystem restoration projects. These projects have a beneficial impact on water quality by reducing stagnant ponds, reducing bank erosion, and adding native plants, which capture nutrients. Although the direct impact of these small projects on water quality is not readily quantifiable, the overall change is a gradual improvement in water quality in the watershed. Based on continued improvements in nonpoint pollution control and in habitat, it is anticipated that water quality within the GLMRIS-BR Illinois Waterway Study Area will continue to gradually improve for the foreseeable future.

4.3.8 Air Quality

Great Lakes

The goals of the CAA are to establish and achieve National Ambient Air Quality Standards (NAAQS) that would address public health and welfare risks posed by air pollutants. In 1977 and 1990, the CAA was amended to set dates for achieving attainment of NAAQS and to address the emissions of hazardous air pollutants. Prior to 1990, many areas of the country, including the major population centers in the Great Lakes Region, failed to meet the established NAAQS. Air pollution is assessed on a localized level. When it is determined that the NAAQS for a given area are not met, the state will develop a State Implementation Plan (SIP) that contains measures needed to meet the NAAQS. Specific air quality issues associated with the project area are discussed below.

CAWS/Des Plaines River/Illinois River/Kankakee River

Air quality in the vicinity of the BRLD is affected by local industries, power-generating stations, and vehicle traffic. In general, the largest sources of pollution within Illinois are electrical general, mineral and metal processing, petroleum processing, and chemical manufacturing. Based on measured air concentrations, the area air quality in northeastern Illinois has been designated as nonattainment for several criteria pollutants (e.g., ozone, sulfur dioxide [SO_2], and lead [Pb]). A criteria pollutant is a pollutant for which NAAQS have been established under the CAA. A nonattainment designation is based on the exceedance or violations of the air quality standard. In areas that have been redesignated as attainment from previous nonattainment status, a maintenance period is established for 10 yr after redesignation. The maintenance plan establishes measures to control emissions to ensure the air quality standard is maintained into the future. Counties in the project area are currently in nonattainment or maintenance for a number of criteria air pollutants, and because of the urban nature of the area, it is expected that these designations will continue into the future study period. These designations are described below and summarized in Table 4-4 and Figure 4-8. The Chicago–Naperville, IL-IN-WI

Table 4-4 NAAQS Designations within the GLMRIS-BR Illinois Waterway Study Area

Pollutant	County	Status
8-hr ozone 2008 NAAQs	Cook	Designated “nonattainment” and classified “marginal” July 20, 2012.
	DuPage	
	Grundy (Aux Sable, Goose Lake Townships)	
	Kane	
	Kendall (Oswego Township)	
	Lake	
	McHenry	
	Will	
1-hr SO_2 2010 NAAQS	Cook (Lemont Township)	Designated “nonattainment” October 4, 2013.
	Will (DuPage, Lockport Townships)	
Pb	Cook (Chicago)	Designated “nonattainment” December 31, 2010.

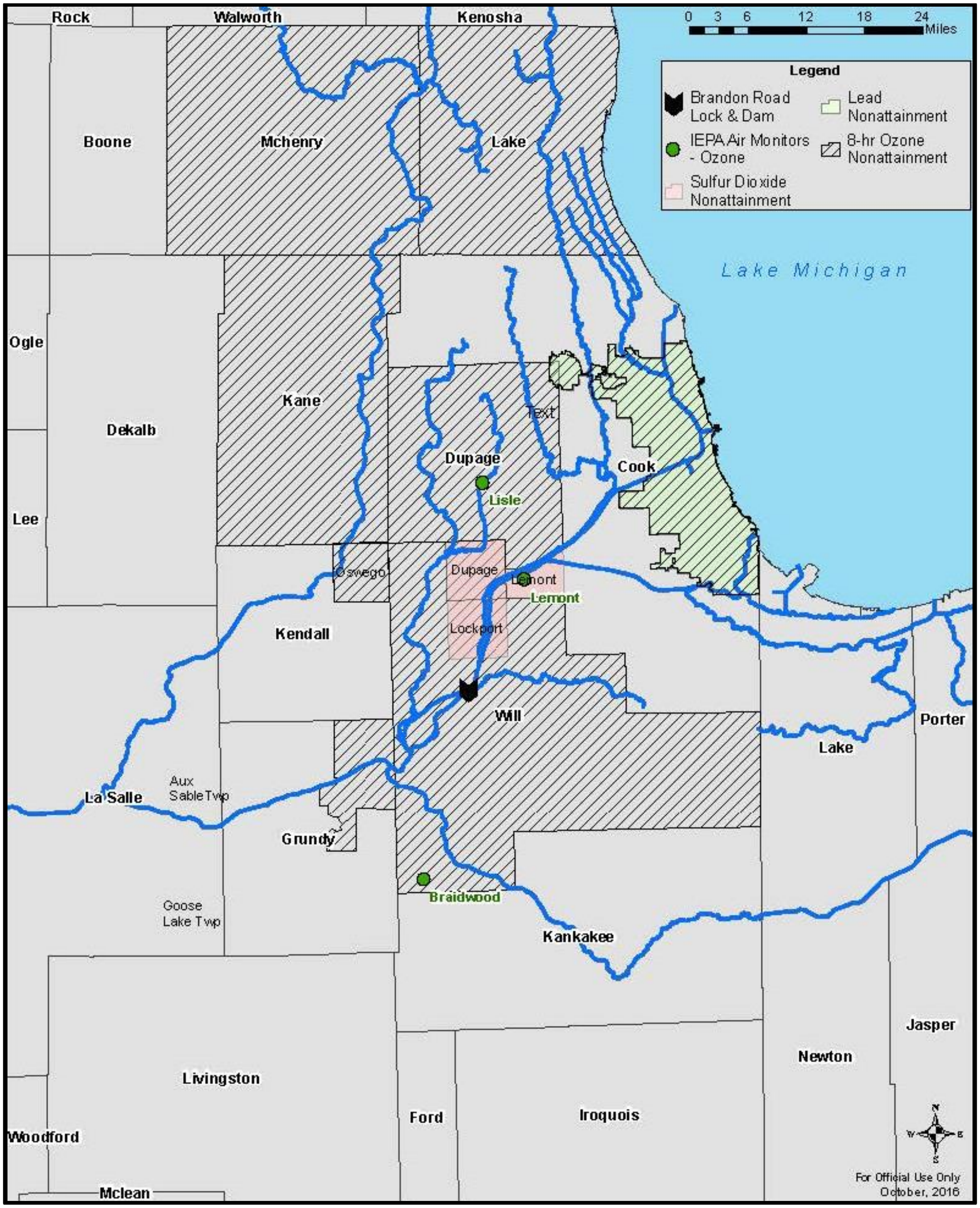


Figure 4-8 NAAQS Designations within the GLMRIS-BR Illinois Waterway Study Area

nonattainment areas for the 8-hr ozone standard include the counties of Cook, DuPage, Grundy (i.e., Aux Sable and Goose Lake Townships only), Kane, Kendall (i.e., Oswego Township only), Lake, McHenry, and Will in Illinois (EPA 2015). The Chicago–Naperville, IL-IN-WI area has a "marginal" classification, meaning ozone levels are closer to the standard; therefore, there are fewer and/or less stringent mandatory air quality planning and control requirements. In addition, two partial counties (i.e., Lemont Township, Cook County and DuPage and Lockport Townships, Will County) were designated as nonattainment areas for sulfur dioxide and one partial county (i.e., within the City of Chicago, Cook County) was designated as nonattainment for n-propyl bromide (NPB). The SO_2 and Pb nonattainment areas have been updated in recent years. The listings described here are current as of October 1, 2015. There are currently no areas in northeastern Illinois in nonattainment for particulate matter (PM), carbon monoxide (CO), or nitrogen dioxide (NO_2).

The State of Illinois establishes air quality standards, which limit concentrations of pollutants to protect the public health and welfare. Illinois standards reflect consideration of effects of pollution on crops, vegetation, wildlife, visibility, and climate. The state sets primary and secondary air quality standards for six pollutants: fine particulate matter (both PM_{10} and $PM_{2.5}$, which refer to particles 10 micrometers [µm] in diameter or less and 2.5 µm in diameter or less, respectively), SO_2, CO, NO_2, ozone, and Pb. These standards are listed in Table 4-5. The state also uses the national standard method for reporting air pollution levels to the public, the Pollution Standard Index (PSI). This PSI is based on the short-term federal NAAQS, the federal episode criteria, and the federal significant harm levels for "critical pollutants; ozone, SO_2, CO, particulate matter, and NO_2." The PSI categories are in Table 4-6.

The IEPA maintains a number of air-monitoring stations; however, no ozone-monitoring stations are located in Joliet, Illinois. The three air-monitoring stations for ozone located closest to the project area are at Lemont, in southwest Cook County; at Lisle, in DuPage County; and at Braidwood, in southern Will County. During 2013, the Lemont station exceeded the ozone 8-hr primary standard once (with a level of 0.077 parts per million [ppm]), but the other two stations did not have any exceedances.

Table 4-5 Summary of National and Illinois Ambient Air Quality Standards (IEPA 2013)

Pollutant	Primary/Secondary	Averaging Time	Level
CO	Primary	8 hr	9 ppm
		1 hr	35 ppm
Pb	Primary and Secondary	Rolling 3-month average	0.15 µg/m^3
NO_2	Primary	1 hr	100 ppb
	Primary and Secondary	Annual	53 ppb
Ozone	Primary and Secondary	8 hr	0.075 ppm
Particle Pollution $PM_{2.5}$	Primary	Annual	12.0 µg/m^3
	Secondary	Annual	15.0 µg/m^3
	Primary and Secondary	24 hr	35 µg/m^3
PM_{10}	Primary and Secondary	24 hr	150 µg/m^3
SO_2	Primary	1 hr	75 ppb
	Secondary	3 hr	0.5 ppm

Note: All standards with averaging times of 24 hr or less are to have not more than one actual or expected exceedances per year. $PM_{2.5}$ standards are referenced to local conditions of temperature and pressure rather than standard conditions (760 mm Hg and 25°C).

Table 4-6 PSI Categories (IEPA 2013)

PSI Range	Descriptor
0–50	Good
50–100	Moderate
101–199	Unhealthful
200–299	Very unhealthful
300+	Hazardous

The nearest SO_2 air-monitoring station is in Lemont, in Cook County. This station had 3 exceedances of the 1-hr primary standard of 75 parts per billion (ppb). Lemont is considered nonattainment based on the monitoring results for 2013 and previous years; the "design value" calculated for Lemont is 90 ppb, which is above the NAAQS of 75 ppb.

An air-monitoring station for particulates ($PM_{2.5}$ only; PM_{10} has few monitoring stations) is located in Joliet, in Will County. This station had no $PM_{2.5}$ exceedances in 2013. There are no Pb air-monitoring stations near the project area, and there were no exceedances at any monitors in 2013. There are no CO-monitoring stations near the project area, and only three in the state since there are no nonattainment areas for that pollutant. Similarly, there are no NO_2-monitoring stations near the project area; all of the NO_x monitoring locations are in Cook County (within the Chicago Metropolitan area) or East St. Louis. There was only a single exceedance of NO_2 at any station within the last several years.

In 2013, Joliet/Will County had a "good" PSI rating 68.2% of the time and "moderate" PSI rating for 31.5% of the time. For 0.3% of the time the air quality was unhealthy. In general, air-quality-monitoring trends for the criteria pollutants show downward or stable trends well below the national standards (Table 4-5).

4.3.9 Land Use

Great Lakes

Shorelands are the focus of development in the Great Lakes region for waterborne commerce, water supply, and recreation. Primary factors determining the type of shoreland use and development in a given area are geographical location, accessibility, ownership, topography, and historical development.

Developed land (e.g., industrial, commercial, and permanent residential) is predominant along lower Lakes Michigan and Huron, and Lakes Erie and Ontario (Figure 4-9). Industrial and commercial developed land is concentrated primarily in urban areas. Seasonal residential developed land is located primarily along the northern shorelands of northern Michigan, Wisconsin, and Minnesota, away from the metropolitan concentrations of the lower lakes.

Natural areas occupy approximately 17.1% of the GLB with the majority being located around Lake Superior (Figure 4-9). Large tracts of wildlife and game preserves are located along many of the isolated lakeshore areas of Michigan, Wisconsin, and Minnesota. Both public and private interests administer these areas to provide habitat and cover for wildlife and to promote better hunting opportunities in the Great Lakes region.

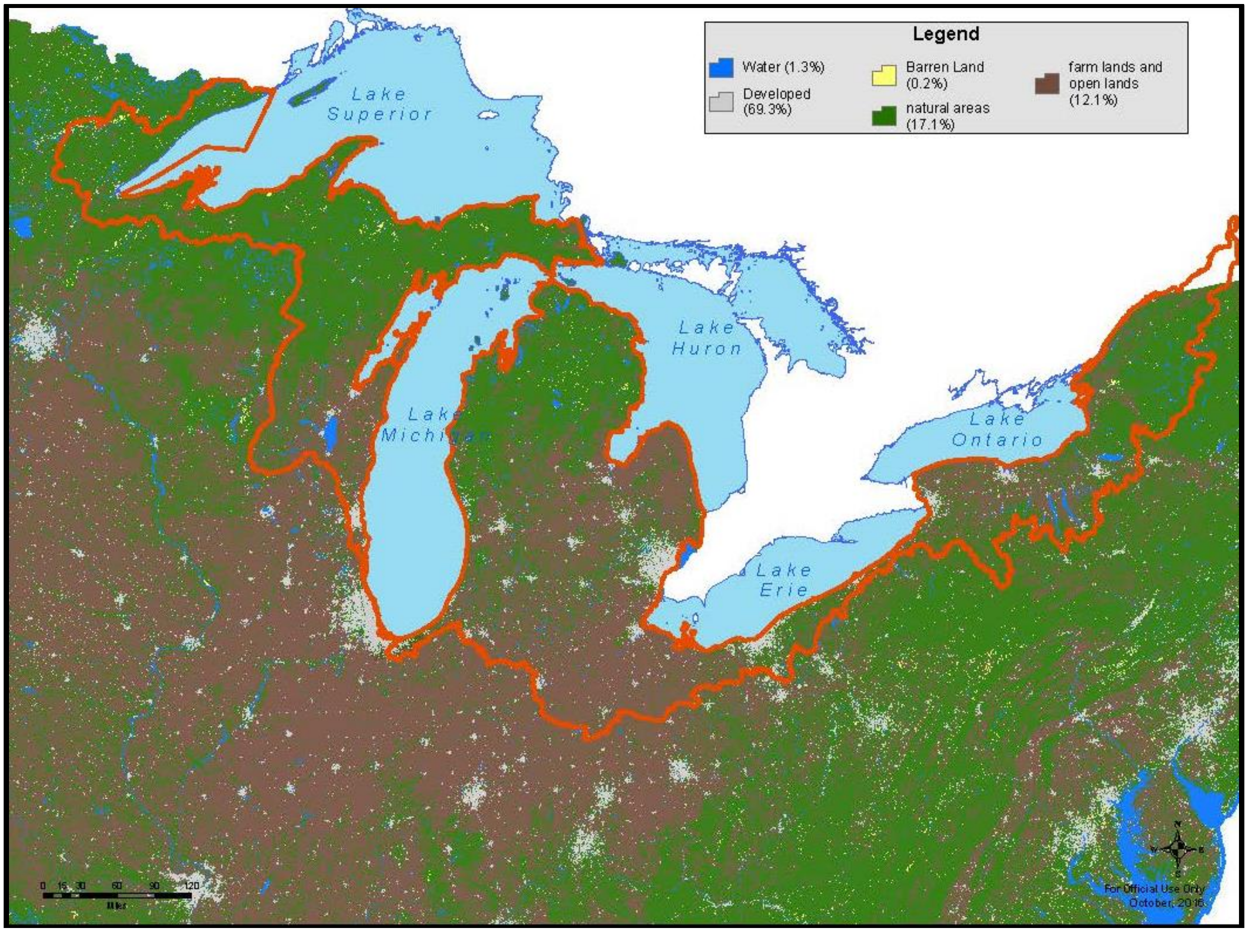


Figure 4-9 Land Use Surrounding the Great Lakes

Located along the shores of the Great Lakes are major recreational areas. The U.S. Department of Interior National Park Service oversees 1,969 mi^2 (5,099.7 km^2) in the Great Lakes states, including one National Park, one National Historic Park, four National Lakeshores, and numerous other areas. Environment Canada oversees 1,211 mi^2 (3,136.5 km^2) of National Parks in the region. In addition, the states and provinces have extensive park land holdings.

CAWS/Des Plaines River/Illinois River/Kankakee River

Presettlement land cover of the GLMRIS-BR Illinois Waterway Study Area was primarily prairie, with pockets of dolomite prairie and wetland depressions. The riparian zones of the Chicago and Calumet River systems flowed through vast marshes and, more often than not, had an undefined channel. The riparian zone of the Des Plaines River was much different than that of the Chicago and Calumet Rivers. Along the riparian zones of the Des Plaines River and confluent streams, hardwood forest most likely occurred.

Today, land use within the CAWS Basin is generally urban with extensive industrial development. Many of the drainage areas of the CAWS, such as the upper CSSC, Chicago River, and Calumet River, are fully developed with little change in the land use over the last few years (Figure 4-10). Basin stakeholders include the City of Chicago and 31 suburban municipalities. Flow in the CAWS is dominated by treated wastewater from five million residents and an additional industrial load of approximately 4.5 million

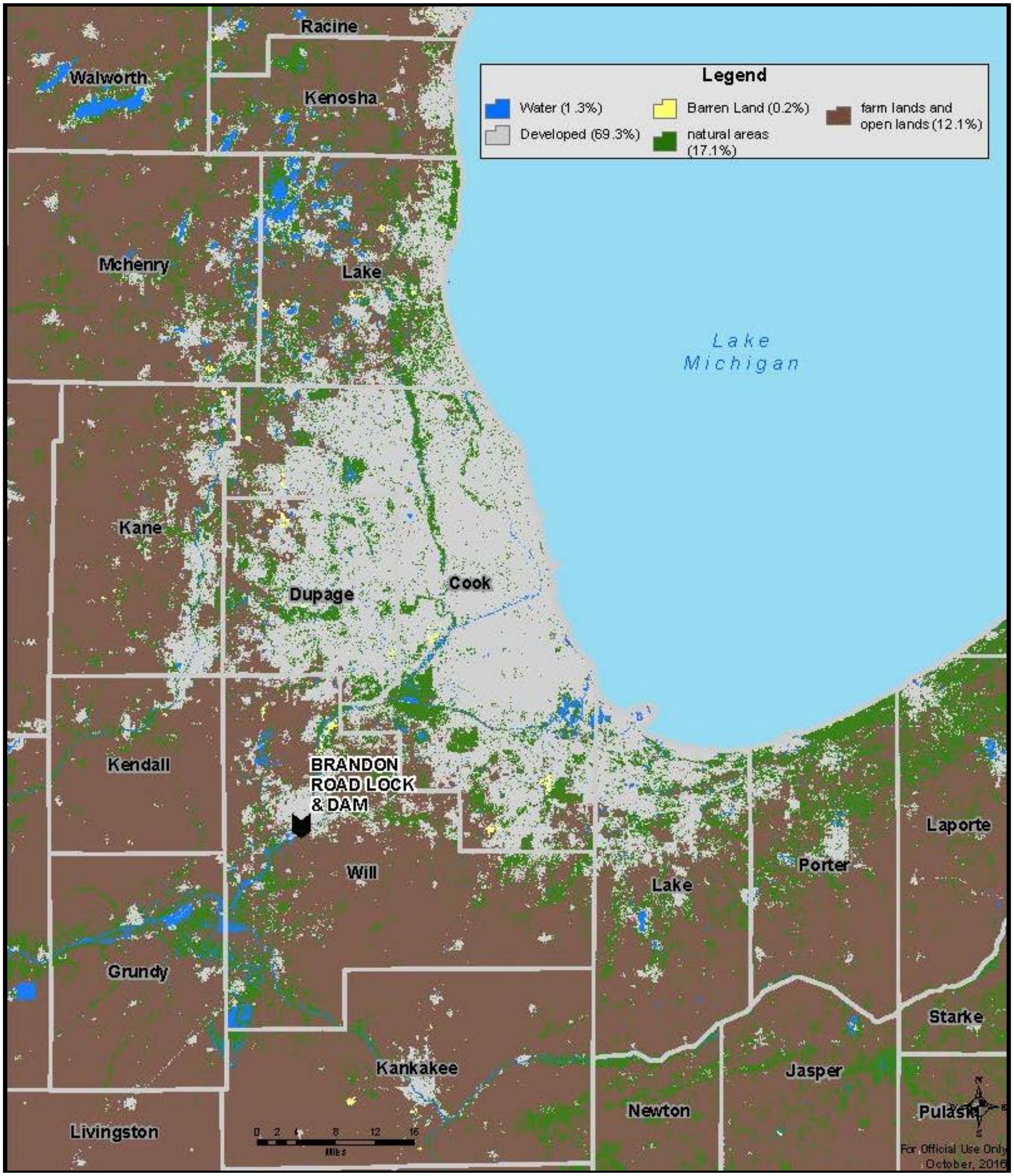


Figure 4-10 Land Use for the CAWS Study Area

population equivalents. Land use has been converted from these natural types to industrialized and residential grounds with intermittent pockets of highly disturbed forest and wetland. Much of the land adjacent to the rivers and canals is owned by the MWRDGC; certain parcels are leased to the Cook County and Du Page County Forest Preserves and are set aside for recreational purposes. Based on National Land Cover Data (NLCD) datasets, small relative changes in land use of the CAWS occurred between 1992 and 2001, and leveling off of land use or basically no change occurred between 2001 and 2006. This would indicate that the overall land use trend of the CAWS watershed appears to be stabilizing with little relative change expected in the near future, based on extrapolation of the latest observed data.

Within the Illinois River Basin, the predominant land use is row crop agriculture. In contrast to presettlement land cover distribution (which was primarily prairie), today the landscape is approximately 64% agriculture, 17% grassland, 10% forest, 5% urban or developed, and 4% open water and wetlands as evaluated from satellite imagery (Table 4-7).

Table 4-7 Land Uses in the Illinois River Basin

Land Use	Area		
	Square Miles (mi^2)	Square Kilometers (km^2)	Percentage (%)
Row crop	14,671	37,997.7	60.05%
Rural grassland	3,621	9,378.3	14.82%
Woodland/forest, deciduous/closed canopy	1,980	5,128.2	8.10%
Small grains	984	2,548.5	4.03%
Urban grassland	620	1,605.8	2.54%
Urban/built-up, medium density	518	1,341.6	2.12%
Woodland/forest, deciduous/open canopy	354	916.9	1.45%
Urban/built-up, high density	351	909.1	1.44%
Forested wetlands	344	891.0	1.41%
Urban/built-up, low density	305	789.9	1.25%
Open water	260	673.4	1.06%
Shallow water wetlands	142	367.8	0.58%
Shallow marsh/wet meadow	108	279.7	0.44%
Urban/built-up, medium high density	106	274.5	0.43%
Deep marsh	31	80.3	0.13%
Barren	15	38.8	0.06%
Woodland/forest, coniferous	12	31.1	0.05%
Orchards/nurseries	9	23.3	0.04%
Swamp	0	0	0.00%
Total	**24,431**	**63,265.9**	

[a] Sum of urban classes not included = 1,279 mi^2 (3,312.6 km^2).

Row crops are widely distributed, but occur in the highest density in the central portion of the Illinois River Basin. The area of row crops is four times greater than the next most abundant land cover class, rural grassland, which includes pasture, hay fields, conservation set asides, grass waterways, roadside grasses, and other grasses. Rural grasslands are widely distributed throughout the basin, especially along waterways. Closed-canopy forests occur along the main stem river bluffs and are also relatively abundant in the northeast region of the basin in county forest preserves. Urban/built-up classes are widely distributed, but there are several large clusters, particularly in the greater Chicago area, Springfield, and Peoria (Figure 4-10).

In addition to the losses of natural habitats in all classes, the remaining areas are highly fragmented and degraded to various degrees. It is uncommon to find continuous natural land cover along the riparian corridor of an entire stream. Construction of roads, fields, and dams and losses of movement corridors have resulted in habitat fragmentation and the creation of small, isolated areas of forests, wetlands, prairies, and riparian corridors. Modern agriculture and the development of cities and towns have also contributed to habitat fragmentation.

In the Kankakee River Basin, agriculture is the major land use. Farming accounts for 71% and 94% of the total acreage in the Illinois Counties (Kankakee and Iroquois Counties, respectively) portion of the watershed, and 75% of the total acreage in the Indiana portion of the watershed (Knapp 1992). The major nonagricultural land uses are woodlands (9%), urban land (8%) and water, wetlands, and barren land. Land use percentages are based on the Kankakee River Basin, which is a total area of approximately 5,800 mi^2 (15,021.9 km^2) (Knapp 1992).

4.3.10 Natural Areas

Great Lakes

Within the GLB are 1 National Park, 1 National Historic Park, 4 National Lakeshores, 6 National Forests, 3 National Wilderness Preserves, and 20 National Wildlife Refuges. Isle Royale National Park located in Lake Superior, is a remote island cluster near Michigan's border with Canada that encompasses 571,790 ac (231,400.2 ha). Isle Royale was also designated as a National Wilderness Area in 1976 and an International Biosphere Reserve in 1980. It is the largest island in Lake Superior. Keweenaw National Historical Park was established in 1992 and celebrates the life and history of the Keweenaw Peninsula, part of the Upper Peninsula of Michigan located on Lake Superior. National Lakeshores within the GLB include Apostle Islands, Pictured Rocks, Indiana Dunes, and Sleeping Bear Dunes. The Apostle Islands National Lakeshore consists of 21 islands and 12 mi (19.3 km) of mainland encompassing a total of 69,372 ac (28,703.9 ha) on the northern tip of Wisconsin in Lake Superior. Pictured Rocks National Lakeshore hugs the south shore of Lake Superior in Michigan's Upper Peninsula and encompasses 73,236 ac (29,637.6 ha). Indiana Dunes National Lakeshore, located on the southern shore of Lake Michigan in Indiana, encompasses 15 mi (24.1 km) of lakeshore and a total acreage of 15,067 ac (6,097.4 ha). Natural features include dunes, wetlands, prairies, rivers, and forests. Last is Sleeping Bear Dunes National Lakeshore located along the northwest coast of Michigan's Lower Peninsula and encompassing 71,198 ac (28,812.8 ha). The area provides miles of sand beach, bluffs that tower 450 ft (137.2 m) above Lake Michigan, lush forests, clear inland lakes, and unique flora and fauna.

The six National Forests located within the GLB are Chippewa National Forest, Superior National Forest, Chequamegon-Nicolet National Forest, Ottawa National Forest, Huron-Manistee National Forest, and Finger Lakes National Forest. Located in Minnesota are Chippewa and Superior National Forests, which were established in 1908 and 1909, respectively. Chippewa National Forest covers approximately 666,623 ac (269,772.8 ha) of which approximately 75% is within the Leech Lake Indian Reservation. The Superior National Forest encompasses approximately 3,900,000 ac (1,578,274.0 ha), which includes some

2,000 lakes and rivers, more than 1,300 mi (2,092.1 km) of coldwater stream, and 950 mi (1,528.9 km) of water streams. In addition, there is a small true boreal forest and mixed conifer-hardwood forest located there. Chequamegon-Nicolet National Forest was established in 1933 and is located along the southern shoreline of Lake Superior in Wisconsin. Chequamegon-Nicolet encompasses approximately 1,530,647 ac (619,430.9 ha) and includes remove areas of uplands, bogs, wetlands, muskegs, rivers, streams, pine savannas, meadows, and numerous glacial lakes. The Ottawa National Forest covers approximately 993,010 ac (401,856.9 ha) of Michigan's Upper Peninsula and was established in 1931. The Huron and Manistee National Forests were combined in 1945, with the Huron Forest having been established in 1909 and the Manistee Forest having been established in 1938. The combined forest encompasses a total of 978,906 ac (396,149.2 ha), which includes 5,786 ac (2,341.5 ha) of wetlands extending across the northern portion of Michigan's Lower Peninsula. Last is the Finger Lakes National Forest in located near Lake Ontario in New York. It was established in 1985 and encompasses 16,259 ac (6,579.8 ha).

The three National Wildlife Refuges within the GLB are Michigan Islands, Seney, and West Sister Island. Michigan Islands National Wildlife Refuge was established in 1943 and encompasses 744 ac (301.1 ha). The eight islands within this refuge are scattered between Lake Michigan and Lake Huron. They were originally set aside as resting habitat for migratory birds traversing the Great Lakes Flyway. The Seney National Wildlife Refuge was established in 1935 and encompasses 95,265 ac (38,552.4 ha). Similar to Michigan Islands National Wildlife Refuge, Seney was set aside for migratory bird habitat, but also provides habitat for North American river otters, beavers, moose, black bears, and gray wolves. Last is the West Sister Island National Wildlife Refuge established in 1937 and encompassing 77 ac (31.2 ha) in the western basin of Lake Erie.

There are 20 National Wilderness Preserves within the GLB with a combined acreage of 1,283,590 ac (519,450.5 ha). In addition to National Parks/Historic Parks/Lakeshores/Forests/Wildlife Refuges/ Wilderness Areas, there are also approximately 127 state parks, wayside areas, nature preserves, fish and wildlife management areas, and forests within the GLB (Figure 4-11); for a list refer to Appendix B, Planning.

CAWS/Des Plaines River/Illinois River/Kankakee River

Eleven Nature Preserves were identified within the area of the CAWS (Krohe 2004). Illinois Beach State Park is the only state park within the watershed, extending for 6.5 mi (10.5 km) along the southeastern shore of Lake Michigan and covering 4,160 ac (1,683.5 ha). The area also includes Indiana Dunes, a National Lakeshore that runs along 15 mi (24.1 km) of the southern shore of Lake Michigan. In addition, there are 16 county forest preserves that cover nearly 8,500 ac (3,439.8 ha). Last are 35 natural areas constituting approximately 1% of the area, or about 2,300 ac (930.8 ha) (Figure 4-12).

Portions of the Des Plaines River that lie between southwest Chicago and Joliet, Illinois, have been designated as the Des Plaines River Resource Rich Area (RRA) (Suloway et al. 1996). Within the RRA there are 61 Illinois Department of Natural Resources (Illinois DNR) Heritage Sites representing 15 significant community types, 8 plant species, 10 animal species, 1 large forest tract, and a rookery. Nine Nature Preserves are present in the area. Cap Sauers Holdings Nature Preserve is one of the largest preserves in northeastern Illinois at 1,548 ac (626.5 ha). Principal natural features found in the Nature Preserves are river bluffs, ravine forests, springs, sedge meadows, marshes, fens, prairies, savannas, floodplain, and upland woods. In addition, there are four other natural areas within the RRA: Little Red Schoolhouse Nature Center, Material Services Prairie, Santa Fe Prairie, and Waterfallot 1996) (Figure 4-12).

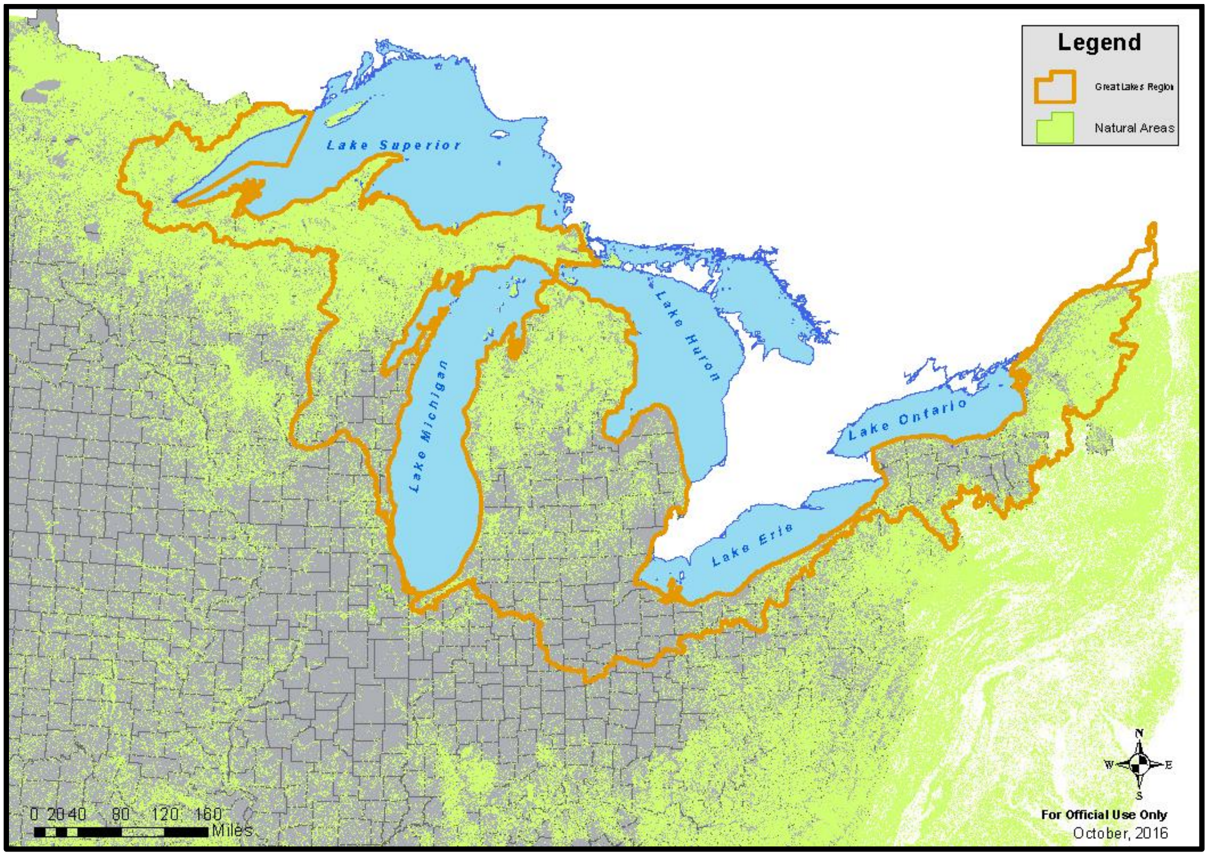


Figure 4-11 Locations of Natural Areas within the GLB

Portions of the mainstem Illinois River that lie between Peoria and Florence, Illinois, have been designated as the Middle Illinois River RRA (Suloway et al. 1996). Within the RRA there are 134 Illinois DNR Natural Heritage Sites representing 9 significant community types, 19 plant species, 22 animal species, 3 large forest tracts, and 3 rookeries. There are six Nature Preserves present in the area: Henry Allen Gleason Nature Preserve, Long Branch Sand Prairie, Manito Prairie, Matanzas Prairie, Meredosia Hill Prairie, and Sand Prairie-Scrub Oak. Principal natural features protected by the RRA include sand prairie, hill prairie, wet prairie, and savanna communities. The largest Nature Preserve in the Middle Illinois RRA is the Sand Prairie-Scrub Oak Nature Preserve, which contains 1,400 ac (566.6 ha) of sand prairie, sand savanna, and sand forest. In addition, there are 38 Natural Area sites (Figure 4-12) containing prominent features such as sand prairies, hill prairies, springs, seeps, savannas, ponds, lakes, woods, and habitat for herons, eagles, and the Illinois Mud Turtle (*Kinosternon flavescens spooneri*). The Meredosia Refuge Natural Area contains 43% of the total Natural Area acreage within the Middle Illinois RRA.

Portions of the Kankakee River that lie near the northern part of east-central Illinois and near the Indiana border have been designated as the Kankakee–Iroquois RRA. Within the RRA are 67 Illinois DNR Heritage Sites, 14 significant community types, 17 plants species, and 9 animal species. The RRA ranks fifth in the state of Illinois in terms of total biologically significant stream miles (63 mi [101.4 km] total), of which approximately half of the mileage is the Kankakee River. There are three Nature Preserves present in the area: Hooper Branch Savanna, Kankakee River, and Momence Wetlands. Principal natural features include large sand savanna with dune and swale topography, and upland and bottomland forest. In addition, there are 17 Natural Areas (Figure 4-12) within the RRA, several of which are associated with the Kankakee River.

Figure 4-12 Natural Areas, Parks, Greenways, and Other Open Spaces in the Chicagoland Area

4.4 Biological Resources

On September 16, 2016, the USFWS provided the USACE with a Draft FWCA Report on the GLMRIS-BR effort. Significant resources were identified in the draft report and are presented in the following sections. The entire Draft FWCA Report is available in Appendix A, Fish and Wildlife Coordination Act Report.

4.4.1 Summary of Area Habitat

Great Lakes

The Great Lakes region contains a diversity of habitat types starting with boreal forests in the north and transitioning to mixed and deciduous forest and tall grass prairie to the south (USACE 2008). Other vital habitats, including wetlands, bogs, marshes, swamps, fens, and approximately 5,000 tributaries, provide important habitat (e.g., breeding and rearing areas) for fish and wildlife (USFWS 2016). Other communities are transitional, from the lake to upland (coastal shore habitats); these can comprise sand dunes, low-lying swales, or forest. There are more than 1,000 mi (1,609.3 km) of shoreline, and the dune and swale habitat is the largest collection of this freshwater ecotype on the planet. The open/littoral habitats within the lakes support numerous fish and other aquatic species. Currently, there are 46 species of plants and animals unique to the Great Lakes. In addition, there are 279 species and habitat types documented as globally rare within the Great Lakes watershed. Although the Great Lakes are considered a national treasure, human settlement and growth of the population around the Great Lakes has reduced the ecological integrity of the lakes. The Great Lakes region alone has lost more than half of its original wetlands and 60% of forest lands. In addition, the region has lost a large majority of other habitat types such as savannah and prairie, with only small remnants remaining. Conversion of these habitats for human uses has contributed to numerous plant and animal eradications throughout the Great Lakes watershed (USACE 2008). General habitat descriptions of each of the lakes are provided below.

CAWS

The CAWS consists of approximately 128 mi (206.0 km) of waterways in the Chicago Metropolitan area used for conveyance of stormwater runoff and municipal wastewater, commercial navigation, and flood control. Many of the waterways are man-made canals and channels, while others are natural streams, many of which have been dredged, realigned, widened, and straightened. The absence of gradual sloping banks, shallow littoral zone habitat, and bends results in a limited habitat for aquatic biota. Homogenous silt sediments that restrict macroinvertebrate and fish populations are deposited throughout much of the CAWS because of the unnatural stream flow dynamics and the inflow of suspended sediments from wastewater treatment plants, urban runoff, and other discharges (MWRDGC 2008).

Des Plaines River

Historically, the Des Plaines River was a narrow elongated depression within the late Wisconsinan Age glacial drift. The upper Des Plaines River was very shallow and averaged about 30 ft (9.1 m) wide with banks of terraced alluvium covered with hydrophytic vegetation. As European settlement increased, the watershed was stripped of natural plant communities, initially because of agricultural practices. Streams became more entrenched and began to exhibit signs of altered hydrology with increased peak flows and reduced base flows. Today, the river valley can be as wide as 1 mi (1.6 km), with the river channel itself on the order of 200 to 250 ft wide (61.0–76.2 m). Habitats within the Des Plaines River Basin vary. Some reaches are lower gradient and exhibit abundant backwater and side stream wetland habitats (near Channahon, Illinois), while some reaches are higher gradient where the channel braids and exhibits swift currents over bedrock, thus forming many riffles (e.g., near Lockport and Romeoville, Illinois). The

Des Plaines River below Lockport, Illinois, is deeper and wider, a result of modification for commercial navigation.

Illinois River

Historically, the watershed of the Illinois River comprised floodplain forests, backwaters, wetlands, wet prairies, and savannas. The highly productive environment supported abundant and diverse fisheries, migratory waterfowl and resident birds, as well as other wildlife. In the 1800s, settlers began rapidly converting the watershed to agriculture, and floodplain forests were cleared for lumber and fuel. The floodplain of the Illinois River was also modified with the construction of levees to protect agriculture fields within the floodplain. Levees effectively constricted the floodplain to the edge of the river in many places, forcing moderate river flows to rise higher as they flowed downstream through the modified valley. Large-scale hydrologic modifications were implemented at approximately the same time as levee construction within the watershed expanded. Dams on the upper river effectively raised water levels and created slow flowing pools, while dams on the lower river primarily stabilized water levels. Overall, construction of lock and dam structures on the Illinois River resulted in increased mainstem water surface elevations as well as increased water surface elevations of associated backwater and wetland habitats, resulting in the creation of numerous long, narrow backwater and bottomland lakes.

Kankakee River

The Kankakee River Basin formerly meandered from its headwaters near South Bend, Indiana, into Illinois for a distance of 240 mi (386.2 km) where it conjoined with the Des Plaines River to form the Illinois River near Channahon, Illinois. In the late 1820s and again in 1920, the river was channelized and straightened in Indiana, truncating it to 99.5 mi (160.1 km). A 12-ft (3.6-m)-high dam at Kankakee creates what is called the Six-mile Pool (although only being 4.7 mi [7.6 km] long). An 11-ft (3.3-m)-high dam at Wilmington, Illinois, creates a pool that is 2 mi (3.2 km) long. The basin consists largely of small ditches and creeks that, along with the main stem Kankakee, Iroquois, and Yellow Rivers, total 25,313 mi (40,737.3 km) of perennial stream. The substrates of the streams within this basin include bedrock, boulder, cobble, gravel, sand, and silt. Habitat within the streams consists of woody debris, tree roots, overhanging vegetation, undercut banks, aquatic vegetation, rocky riffles, sand/gravel runs, and sand- to silt-laden pools. Riparian zones may include timbered swamp, open prairie, grazing fields, row crops, or residential area. The Indiana portion of the basin is characterized by having the majority of its natural streams channelized into drainage ditches, while a greater number of natural meandering streams may be found in Illinois portions of the basin.

4.4.2 Plant Communities

Great Lakes

Following European colonization, much of the original tallgrass prairies, dolomite prairies, oak savannas, woodlands, and wetlands of the GLB were lost to agriculture, urban development, logging, and industry. More than two-thirds of the GLB natural wetlands have been lost to agriculture, urban uses, shoreline development, and recreation.

Another influence on the flora in the region has been the introduction of nonnative, or nonindigenous, plants. Diverse plant communities that once populated an area and supported a large animal community are often choked out by nonnative plants, like the purple loosestrife, which took over riverbanks and wetlands.

Several plant species are unique to the Great Lakes. Their existence and evolution result from the physical processes of the lakes. The Michigan monkey flower (*Mimulus michiganensis*), a federally endangered species, is found in mucky soil and sand that is saturated or covered by cold, flowing spring water. Nearly all known populations of the Michigan monkey flower occur near present or past shorelines of the Great Lakes. The federally threatened dwarf lake iris (*Iris lacustris*) grows near the northern shores of lakes Michigan and Huron. Houghton's goldenrod (*Solidago houghtonii*), a federally threatened species, grows only along the Great Lakes shoreline, primarily along the northern shores of Lakes Michigan and Huron, and nowhere else in the world. The federally threatened lakeside daisy (*Hymenoxys acaulis* var. *glabra*) is unique to the Great Lakes area, naturally occurring at only a handful of sites (e.g., northern Ohio, northern Illinois, and the Michigan Upper Peninsula). Pitcher's thistle (*Cirsium pitcheri*), a federally threatened species, is a native thistle that grows on the beaches and grassland dunes along the shorelines of Lakes Michigan, Superior, and Huron. Globally imperiled plant species occurring within the Great Lakes include Houghton's goldenrod and the federally threatened eastern prairie fringed orchid (*Platanthera leucophaea*). Besides the aforementioned species, the GLB also includes seven additional species that are listed as threatened federally: Mead's milkweed (*Asclepias meadii*), Hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*), prairie bush clover (*Lespedeza leptostachya*), Fassett's locoweed (*Oxytropis campestris* var. *chartacea*), eastern prairie fringed orchid, western prairie fringed orchid (*Platanthera praeclara*), and Leedy's roseroot (*Rhodiola integrifolia* ssp. *leedyi*). The dwarf trout lily (*Erythronium propullans*) is also found within the GLB and is listed as federally endangered. In regard to state-listed species, there are approximately 908 threatened and endangered plant species within the GLB. For a list of state-listed plant species refer to Appendix B, Planning.

In addition to individual species, there are also entire plant communities within the Great Lakes region that may be considered critically imperiled (Reid and Holland 1997). These include tallgrass prairies, oak savannahs, alkaline shoredunes/cliffs, and alvars. The general plant communities that are found within the shorelines of the individual Great Lakes are described by ecoregion in Appendix B, Planning.

CAWS

The CAWS lies within the Central Corn Belt Plains ecoregion (Woods et al. 2006). The portion of the CAWS nearest Lake Michigan is now dominated by the Chicago metropolitan area but was originally part of glacial Lake Chicago. Today, nearly all the natural vegetation has been replaced by urban development. The southern portion of the CAWS that flows into the lower Des Plaines River was studded with small lakes and marshes. Because of draining and urban sprawl, marsh land has been converted to agriculture use or development. However, remnant wooded areas, lakes, and wetlands are still found throughout the area. Overall, the area is highly disturbed with cottonwood (*Populus* spp.), maple (*Acer* spp.), and ash (*Fraxinus* spp.) dominating the forests and invasive Japanese bush honeysuckle (*Lonicera maackii*) dominating the shrub layer. Within the remaining wetland areas, cattails (*Typha* spp.) are usually dominant along with common reed (*Phragmites* spp.), which is indicative of chronic disturbance (Woods et al. 2006). Federally listed species that could occur within the CAWS include the threatened eastern prairie fringed orchid, lakeside daisy, Mead's milkweed, Pitcher's thistle, and prairie bush clover. In addition, there are approximately 132 state-listed threatened and endangered plant species that could occur within the vicinity of the CAWS. For a list of state-listed plant species potentially occurring within the CAWS refer to Appendix B, Planning.

Des Plaines River

The upper Des Plaines River in Illinois where it meets the Wisconsin state line is within the Southeastern Wisconsin Till Plains ecoregion (Woods et al. 2006). The lower Des Plaines River in Illinois is within the Central Corn Belt Plains ecoregion. Wetlands within these areas have primarily been drained for agricultural purposes and urbanization has also affected plant communities in the area; however, wooded areas, lakes, and wetlands are still common (Woods et al. 2006). The only federally listed species known to occur within the watershed is the threatened eastern prairie fringed orchid, a tallgrass prairie species. However, Mead's milkweed (threatened) and prairie bush clover (threatened) could also occur within the watershed. State-listed species potentially occurring within the watershed include small sundrops (*Oenothera perennis*), mountain blue-eyed grass (*Sisyrinchium montanum*), ear-leaved fox glove (*Tomanthera auriculata*), white lady's slipper (*Cypripedium canadidum)*, queen of the prairie (*Filipendula rubra*), pale vetchling (*Lathyrus ochroleucus*), northern grape fern (*Botrychium multifidum*), pretty sedge (*Carex woodii*), millet grass (*Milium effusum)*, black-seeded rice grass (*Rubus pubescens*), American dog violet (*Viola conspera*), hairy white violet (*Viola incognia*), swollen sedge (*Carex intumescens*), Tuckerman's sedge (*Carex tuckermanii*), downy willow herb (*Epilobium strictum*), purple fringed orchid (*Platanthera psycodes*), dwarf raspberry (*Rubus pubescens*), beaked sedge (C*arex rostrata*), marsh speedwell (*Veronica scutellata*), mosquito bulrush (*Scirpus hattorianus*), Crawford's sedge (*Carex crawfordii*), larch (*Larix laricina)*, high-bush blueberry (*Vaccinium corymbosum)*, dwarf birch (*Betula pumila)*, three-seeded bog sedge (*Carex trisperma*), rusty cotton grass (*Eriophorum virginicum*), alder buckthorn (*Rhamnus alnifolia*), inland shadbush (*Amelanchier interior*), red-berried elder (*Sambucus pubens*), white beak rush (*Rhynchospora alba*), large cranberry (*Vaccinium macrocarpon*), round-leaved sundew (*Drosera rotundifolia*), cord root sedge (*Carex chordorrhiza*), bog bedstraw (*Galium labradoricum*), common bog arrow grass (*Triglochin maritimum*), slender bog arrow grass (*Triglochin palustris*), little green sedge (*Carex viridula*), grass-leaved pondweed (*Potamogeton gramineus*), fern pondweed (*Potamogeton robbinsii*), white-stemmed pondweed (*Potamogeton praelongus*), and American slough grass (*Beckmannia syzigachne*).

Illinois River and Kankakee River

Similar to the lower Des Plaines River, the upper Illinois River and the Kankakee River lie within the Central Corn Belt Plains ecoregion (Woods et al. 2006). The area is characterized by tall-grass prairie plant communities, in addition to marshes and wet prairies in depression areas, and forest plant communities that grew on the moraines and river floodplains. Extensive portions of the Kankakee and upper Illinois River areas were tiled, ditched, and tied into the existing drainage system to make land more suitable for agricultural purposes and development (Woods et al. 2006). The lower portion of the Kankakee River where it begins to flow into Indiana is characterized by disjunctive sand outwash plains and is distinguished from adjacent ecoregions by its extensive sand plains and relict dunes.

Managed areas along the Illinois River include Spunky Bottoms and Emiquon National Wildlife Refuge, which was drained over several years to allow for agricultural practices. The Nature Conservancy (TNC) began restoration activities at the site in 1998 by reducing the amount of water pumped out of the area, thereby reestablishing wetlands and open water habitats. A Section 1135 study was initiated for Spunky Bottoms that recommends the construction of a reconnection structure that would allow fish passage and controlled interior water level management. For more information, refer to *Spunky Bottoms Ecosystem Restoration, Continuing Authorities Program, Section 1135 of the Water Resources Development Act of 1986, Ecosystem Restoration Report with Integrated Environmental Assessment* (USACE 2013f). Emiquon National Wildlife Refuge was established in 1993 to restore and protect wetland habitats at the confluence of the Illinois and Spoon Rivers. The refuge includes 2,600 ac (1,052.2 ha) and when seasonally flooded contains over 1,500 ac (607.0 ha) of floodplain wetland that supports a wide range of biological diversity.

Kankakee Sands is 25,000 ac (10,117.1 ha) of remnant and restored lands managed by TNC along the Kankakee River in northwest Indiana and northeast Illinois (TNC 2017). Prior to European settlement, the Kankakee Sands area was a mosaic of rich habitat, including large marshes and lakes, oak barrens, prairies, and sedge meadows. Development of the land since the 1800s has caused fragmentation and changed the natural processes of these systems. Since 1997, TNC, its volunteers, and partners have worked together to restore nearly 6,500 ac (2,630.5 ha) in the Kankakee Sands area, turning land previously used for agriculture back to the unique prairie, savanna, and wetland habitats that thrived there 300 years ago. The area's sandy soils support globally significant oak barrens, prairies, and sedge meadows and offer rich habitat for rare species such as wild yellow indigo (*Baptisia tinctoria*) (TNC 2017).

Historically occurring along the Illinois River floodplain was the now federally threatened decurrent false aster (*Boltonia decurrens*). The combination of water level manipulation and channelization has drastically altered the historic hydrologic cycle and has isolated from the river many areas that formerly provided habitat for this species (USFWS 2016). Populations are now restricted to a narrow band of floodplain along a 248-mi (399.1-km) reach of the lower Illinois River system. Other federally listed species that could occur within the upper Illinois River and lower Kankakee River Basins include the threatened eastern prairie fringed orchid, lakeside daisy, and Mead's milkweed. State-listed species potentially occurring within the upper Illinois River Basin include the decurrent false aster, queen-of-the-prairie, tall sunflower (*Helianthus giganteus),* broomrape (*Orobanche ludoviciana)*, jack pine (*Pinus banksiana*), forked aster (*Aster furcatus*), Oklahoma grass pink orchid (*Calopogon oklahomensis*), grass pink orchid (*Calopogon tuberosus*), narrow-leaved sundew (*Drosera intermedia*), false mallow (*Malvastrum hispidum*), slender sandwort (*Minuartia patula*), red pine (*Pinus resinosa*), shadbush (*Amelanchier sanguinea*), fibrous-rooted sedge (*Carex communis*), plantain-leaved sedge (*Carex plantaginea*), bunchberry (*Cornus canadensis*), golden corydalis (*Corydalis aurea*), pink corydalis (*Corydalis sempervirens*), small yellow lady's slipper (*Cypripedium parviflorum*), hemlock panic grass (*Dichanthelium portoricense*), long beech fern (*Phegopteris connectilis*), weak bluegrass (*Poa languida*), red-berried elder, cliff goldenrod (*Solidago sciaphila*), snowberry (*Symphoricarpos albus* var. *albus*), American brooklime (*Veronica americana*), yellow monkey flower (*Mimulus glabratus*), American bur-reed (*Sparganium americanum*), buffalo clover (*Trifolium reflexum*), old plainsman (*Hymenopappus scabiosaeus*), shore St. John's wort (*Hypericum adpressum*), Kankakee mallow (*Iliamna remota*), two-flowered melic grass (*Melica mutica*), orange fringed orchid (*Platanthera ciliaris*), pink milkwort (*Polygala incarnata*), Carey's heartsease (*Polygonum careyi*), bristly blackberry (*Rubus schneideri*), Hall's bulrush (*Schoenoplectus hallii*), Pursh's bulrush (*Schoenoplectus purshianus*), Muhlenberg's nut rush (*Scleria muhlenbergii*), Carolina whipgrass (*Scleria pauciflora*), eastern blue-eyed grass (*Sisyrinchium atlanticum*), green-fruited bur-reed (*Sparganium emersum*), storax (*Styrax americana*), high-bush blueberry, corn salad (*Valerianella umbilicata*), marsh speedwell, primrose violet (*Viola primulifolia*), Mead's milkweed, American slough grass, little green sedge, spotted coral-root orchid (*Corallorhiza maculata*), leafy prairie clover (*Dalea foliosa*), northern panic grass (*Dichanthelium boreale*), beaked spike rush (*Eleocharis rostellata*), northern cranesbill (*Geranium bicknellii*), hedge hyssop (*Gratiola quartermaniae*), quillwort (*Isoetes butleri*), Richardson's rush (*Juncus alpinoarticulatus*), running pine (*Lycopodium clavatum*), hairy umbrella-wort (*Mirabilis hirsute*), wood orchid (*Platanthera clavellata*), tubercled orchid (*Platanthera flava*), eastern prairie fringed orchid, grass-leaved pondweed, blue sage (*Salvia azurea*), American burnet (*Sanguisorba canadensis*), mosquito bulrush, yellow-lipped ladies' tresses (*Spiranthes lucida*), lakeside daisy, common bog arrow grass, slender bog arrow grass, flat-leaved bladderwort (*Utricularia intermedia*), large cranberry, corn salad (*Valerianella chenopodifolia*), and Canada violet (*Viola canadensis*).

4.4.3 Wildlife Resources

Terrestrial Invertebrates

Great Lakes

Federally listed endangered terrestrial invertebrates include American burying beetle (*Nicrophorus americanus*), Hine's emerald dragonfly (*Somatochlora hineana*), Karner blue butterfly (*Lycaeides melissa* *samuelis*), Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*), and Poweshiek skipperling (*Oarisma poweshiek*). The rattlesnake master borer moth (*Papaipema eryngii*) is a federal candidate species, while the rusty patched bumble bee (*Bombus affinis*) is proposed as endangered. There are also 103 state-listed threatened and endangered species present within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS/Des Plaines River/Illinois River/Kankakee River

There are potentially two federally endangered terrestrial insects occurring within the GLMRIS-BR Illinois Waterway Study Area: the Hine's emerald dragonfly and the Karner blue butterfly.

Reptile and Amphibian Communities

Great Lakes

The Great Lakes region is a transition zone between the boreal coniferous forests north of Lake Superior, the mixed-hardwood forests to the south, and the drier prairie and savanna to the west (Harding 1997). Many amphibian and reptile species reach their distributional limits in the region, and in general, the number of species increases from north to south. The Great Lakes have a moderating effect on both winter and summer temperatures, and this is why several "southern" species reach their northern distribution limits along the shorelines of the Great Lakes. Aquatic communities of the Great Lakes offer habitat to numerous amphibians and reptiles.

There are three federally listed species within the GLB: the threatened eastern massasauga (*Sistrurus catenatus*), threatened copperbelly water snake (*Nerodia erythrogaster neglecta*), and threatened bog turtle (*Clemmys muhlenbergii*). There are also approximately 26 state-listed threatened and endangered reptiles and amphibians within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS/Des Plaines River/Illinois River/Kankakee River

Similar to other taxa within the Chicago region, the richness of amphibian and reptile species has been in decline since European settlement began in the early 1800s. Of the 50 amphibians and reptile species that have historically occurred in the Chicago region, approximately 18 species are considered common in the region currently (Pope 1944; Mierzwa 2000). For a complete list of the amphibian and reptilian community within the Chicago and Calumet River Systems, refer to *The GLMRIS Report, Appendix B, Affected Environment* (USACE 2014a). The only federally listed species within the region of the CAWS/Des Plaines River/Illinois River/Kankakee River are the threatened eastern massasauga and copperbelly water snake. The federally threatened copperbelly water snake is found within the upper Kankakee River Basin in Indiana. Within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR Site-specific Study Area, state-listed endangered, threatened, or species of concern include the Jefferson salamander (*Ambystoma jeffersonianum*), four-toed salamander (*Hemidactylium scutatum*), common mudpuppy (*Necturus maculosus*), ornate box turtle (*Terrapene ornata ornata*), Kirtland's snake (*Clonophis kirtlandii*), eastern massasauga, spotted turtle (*Clemmys guttata*), and Blanding's turtle (*Emydoidea blandingii*).

Mammalian Communities

Great Lakes

There are approximately 78 kinds of mammals in the GLB. Large mammals within the basin include elk (*Cervus canadensis*), black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), coyote

(*Canis latrans*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*). Small mammals include beaver (*Castor canadensis*), river otter (*Lontra canadensis*), American marten (*Martes americana*), fisher (*Martes pennanti*), muskrat (*Ondatra zibethicus*), American mink (*Neovison vison*), raccoon (*Procyon lotor*), eastern cottontail rabbit (*Sylvilagus floridanus*), snowshoe hare (*Lepus americanus*), striped skunk (*Mephitis mephitis*), and squirrels (Sciuridae).

Federally listed species include the endangered gray wolf (*Canis lupus*) and Indiana bat (*Myotis sodalis*). Federally threatened species include the northern long-eared bat (*Myotis septentrionalis*) and Canada lynx (*Lynx canadensis*). There are approximately 20 state-listed threatened and endangered mammal species within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS/Des Plaines River/Illinois River/Kankakee River

The mammalian community within the GLMRIS-BR Illinois Waterway Study Area has been degraded because of hydrologic and geomorphic alterations and fragmentation of habitats by industrialization. The majority of the area is covered in human altered bottomland forest and industrial parcels. Aquatic dependent mammals as well as other species of mammals may be found utilizing the GLMRIS-BR Illinois Waterway Study Area. For a complete list of the mammalian community within the Chicago and Calumet River Systems, refer to *The GLMRIS Report, Appendix B, Affected Environment* (USACE 2014a).

Federally listed species include the endangered gray wolf and Indiana bat and the threatened northern long-eared bat. State-listed species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR Site-Specific Study Area include the Indiana bat, hoary bat (*Lasiurus cinereus)*, northern long-eared bat, red bat (*Lasiurus borealis*), Franklin's ground squirrel (*Poliocitellus franklinii*), river otter, American badger (*Taxidea taxus*), and gray wolf. Populations of the Indiana bat and northern long-eared bat are not known within the GLMRIS-BR Site-Specific Study Area; the gray wolf is considered extirpated from the Chicago region with only solitary animals entering primarily the northern portion of the area sporadically.

Avian Communities

Great Lakes

Of the four major flyways (i.e., corridors for migrants similar to highways) for migratory birds in North America, two of them (i.e., Atlantic and Mississippi Flyways) travel through the Great Lakes region. It has been estimated that 100 million birds use stopover sites throughout the Great Lakes as they head toward breeding and wintering grounds (TNC 2016). Migrants depend on stopover habitat, which is typically found along the shorelines of the lakes. Between 2012 and 2014, the Great Lakes Commission (GLC) surveyed and mapped open water bird use within areas of Lakes Michigan, Huron, and Erie and observed over 1.8 million individual birds, representing at least 53 different species and at least 40 open water bird species. In addition, at least 17 species of birds that are protected by state or federal law in the Great Lakes region were also observed (GLC 2016).

According to the National Audubon Society Important Bird Area (IBA) database, there are 102 IBAs along the shorelines of the Great Lakes and many more IBAs located within the GLB. Of the 102 IBAs along the shorelines of the Great Lakes, 8 are considered Global IBAs, while the remainder are State IBAs (Table 4-8).

Table 4-8 Number of IBAs Found along the Shorelines of the Great Lakes

Lake	Number of IBAs	Global IBAs
Superior	12	Hawk Ridge Nature Reserve IBA
Michigan	51	Chicago Lakefront
		Lake Michigan
		Cowles Bog–Indiana Dunes National Lakeshore
		Sleeping Bear Dunes National Lakeshore Mainland
		Lake Michigan Long-tailed Duck IBA
Huron	16	Saginaw Bay
Erie	15	Lake Erie Central Basin
Ontario	8	Braddock Bay

Federally listed species include the endangered Kirtland's warbler (*Setophaga kirtlandii*), piping plover (*Charadrius melodus*), and whooping crane (*Grus americana*). One federally threatened species, the rufa red knot (*Calidris canutus rufa*), regularly uses the shorelines of Lake Michigan and Lake Erie in Michigan and Ohio, respectively. In addition to the federally listed species, there are also approximately 62 state-listed threatened and endangered birds within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS/Des Plaines River/Illinois River/Kankakee River

Although the Chicago and Calumet River Systems have become highly degraded and riparian habitats have been fragmented by industrialization, the river systems still provide limited habitat for migratory neotropical bird species as well as resident species. These fragmented refuges are important to numerous migratory song birds as well as other bird families (e.g., hawks, owls, and waterfowl) that follow the Lake Michigan Flyway. This important flyway provides a visual north–south sight line, the coast of Lake Michigan, for which the birds have evolved to follow as they undergo migration. During the typical migration periods, March to May and September to mid-October, more than 5 million neotropical songbirds will pass through the area. Since 1970, over 300 species of birds have been recorded from the Chicago region (Schilling and Williamson 2012).

Common species inhabiting the area include marsh birds, nesting and migrant waterfowl, and woodland birds. For a complete list of the avian community within the Chicago and Calumet River Systems, refer to *The GLMRIS Report, Appendix B, Affected Environment* (USACE 2014a). Federally listed species that could occur within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR Site-Specific Study Area include the endangered piping plover and the threatened rufa red knot. Of the species common in the area, the black-crowned night-heron (*Nycticorax nycticorax*), common tern (*Sterna hirundo*), Forster's tern (*Sterna forsteri*), and little blue heron (*Egretta caerulea*) are listed as state endangered by the State of Illinois. Two species within the area, the golden-winged warbler (*Vermivora chrysoptera*) and the wood thrush (*Hylocichla mustelina*), are regarded as species of concern by the National Audubon Society. In addition, the common tern, eastern meadowlark (*Sturnella magna*), and little blue heron are 3 of 20 common declining birds in North America (Butcher 2007).

4.4.4 Aquatic Resources

This section describes the aquatic communities in the GLMRIS-BR System-wide Study Area. Throughout the descriptions of the aquatic communities, one consistent theme is the significant impact of successive

ANS introductions on biological communities and ecosystem processes in the Great Lakes. In the past, most ANS have entered the Great Lakes by transoceanic shipping or by swimming to the Great Lakes through waterways connected to the Atlantic Ocean. In this way, the threat posed by the potential movement of Asian carp and *A. lacustre* from the MRB into the GLB is unique. As described below, aquatic invasive species that have significantly affected native species or fundamentally altered Great Lakes ecology include fish such as Sea Lamprey (*Petromyzon marinus*), Alewife (*Alosa pseudoharengus*), and Round Goby, and more recently invertebrate species like fishhook waterflea (*Cercopagis pengoi*) and dreissenid mussels (*Dreissena spp.*). In addition, newly established species like the Grass Carp as well as future ANS introduced by traditional aquatic or non-aquatic pathways make it likely that the Great Lakes will continue to experience ecosystem stress from ANS.

Plankton and Benthic Invertebrate Communities

Great Lakes

Invertebrates in the water (plankton) and in sediments (benthic) play a vital role in aquatic ecosystems by providing a food source and acting as bioprocessors of coarse and fine particulate organic matter. In addition, certain invertebrate species may provide insight into the quality of the habitat they occupy. Historically, the base of the food web of the Great Lakes was phytoplankton. Phytoplankton was consumed by zooplankton and the benthic amphipod *Diporeia* spp., and in turn, these organisms were eaten by a host of small and important prey fish species (Bunnell et al. 2014; USFWS 2016). Today, the Great Lakes have undergone food web changes in which the phytoplankton biomass in Lakes Superior, Michigan, and Huron have experienced a decline, much of which can be attributed to reductions in nutrient loading and the invasion of dreissenid mussels (Bunnell et al. 2014). For example, both the phytoplankton and zooplankton communities of Lake Michigan have seen notable decreases in size and extent during the spring season (Environment Canada and EPA 2014). Larger sized zooplankton species, typically located in water of low biotic productivity, are making up an increasing proportion of the community during the summer, while smaller zooplankton decline. In addition, spiny waterflea (*Bythotrephes longimanus*) and fishhook waterflea (*Cercopagis pengoi*), two predatory nonnative waterfleas, have established in the Great Lakes and have also contributed to the declines or displacement of native zooplankton in some lakes (Bunnell et al. 2014).

The overall decline of zooplankton has strong implications for the food web because these organisms are an important link between phytoplankton and healthy fish populations. Benthic invertebrate communities have also been altered by invasive species introductions. For example, zebra mussels, a native of Russia, were found in Lake Erie in 1998, and now zebra mussels are found in each of the Great Lakes. Zebra mussels have inflicted tremendous damage to native ecosystems and to facilities using water, such as power plants and municipal water suppliers. Hundreds of millions of dollars have been spent by water users to control and eradicate zebra mussels. Their establishment and proliferation within the Great Lakes and tributaries have also influenced the decline of native mussel species.

Chironomidae, *Diporeia* spp. (Amphipoda), Oligochaeta (worms), and Sphaeriidae (bivalves) are the dominant native nearshore benthic macroinvertebrate species in all five Great Lakes (Lozano et al. 2001; Garza and Whitman 2004; Nalepa et al. 1998, 2007; Scharold et al. 2009, 2015). However, nonnative dreissenid mussels are also abundant in all the Great Lakes except Lake Superior (Bunnell et al. 2014). For example, 63% of total macroinvertebrate organisms collected in Lake Erie were *Dreissena* spp. (Scharold et al. 2015). In general, studies suggest that the total density of *Diporeia* spp., Oligochaeta, Sphaeriidae, and Chironomidae declined between the early 1970s and the present (Nalepa et al. 2007; Lozano et al. 2001; Bunnell et al. 2014). *Diporeia* spp. were historically the dominant benthic invertebrate in all the Great Lakes, but because of dreissenid mussels, *Diporeia* spp. has almost entirely disappeared from Lake Erie and from shallow (<295 ft [90 m]) sites in Lakes Ontario, Huron, and

Michigan. *Diporeia* spp. is still found in deep (>295 ft [89.9 m]) sites in these lakes, and *Diporeia* spp. populations in Lake Superior appear to be relatively stable. The *Diporeia* spp. decline represents a loss of a food source resulting in a reduction in small fish weight and energy. See Appendix B, Planning, for a complete description of macroinvertebrate communities in each of the Great Lakes.

Federally endangered aquatic invertebrates include Hungerford's crawling water beetle (*Brychius hungerfordi*). State-listed endangered and threatened species include five aquatic snails: broadshoulder physa (*Physella parkeri*), acorn ramshorn (*Planorbella multivolvis*), an aquatic snail (*Planorbella smithi*), deepwater pondsnail (*Stagnicola contracta*), and Petoskey pondsnail (*Stagnicola petoskeyensis*). In addition, there are 36 state-listed endangered and threatened aquatic invertebrates (e.g., caddisflies, mayflies, dragonflies, and so on) within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

Native mussels also inhabit riverine areas within the GLB, of which numerous are federally or state-listed species. Federally endangered species include the clubshell (*Pleurobema clava*), northern riffleshell (*Epioblasma torulosa rangiana*), rayed bean (*Villosa fabalis*), snuffbox (*Epioblasma triquetra*), spectaclecase (*Cumberlandia monodonta*), scaleshell (*Leptodea leptodon*), fat pocketbook (*Potamilus capax*), white cat's paw pearlymussel (*Epioblasma obliquata perobliqua*), and Higgins eye pearlymussel (*Lampsilis higginsii*). Rabbitsfoot (*Quadrula cylindrica*) is the only federally threatened species. State-listed species include purple wartyback (*Cyclonaias tuberculata*), black sandshell (*Ligumia recta*), threehorn wartyback (*Obliquaria reflexa*), hickory nut (*Obovaria olivaria*), round hickorynut (*Obovaria subrotundra*), round pigtoe (*Pleurobema sintoxia*), kidney shell (*Ptychobranchus fasciolaris*), fawnsfoot (*Truncilla donaciformis*), lilliput (*Toxolasma parvum*), paper pondshell (*Utterbackia imbecillis*), wavyrayed lampmussel (*Lampsilis fasciola*), and salamander mussel (*Simpsonaias ambigua*) (USFWS 2016). In addition to federally listed freshwater mussel species, there are also 43 state-listed threatened and endangered freshwater mussel species with the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS

The MWRDGC samples the benthic invertebrate community within the Calumet River System and Chicago River System as part of the Ambient Water Quality Monitoring program. Benthic invertebrate data for 2010 have been published by MWRDGC (MWRDGC 2012), and data from this 2010 report indicated that Oligochaeta, Gammarus, Turbellaria, *Dicrotendipes lucifer*, and *Hyalella azteca* were common species in the Chicago River System, the Calumet River System, and the CSSC. In the Calumet River System, quagga mussels (*Dreissena bugensis*) were abundant. Based on the abundance of highly tolerant taxa, the invertebrate community within the Calumet River, Chicago River, and CSSC were considered moderately to highly stressed. For a complete list of the benthic invertebrate community within the Chicago and Calumet River Systems as well as the CSSC, refer to Appendix B, Planning.

No native mussels have been found during sampling of the CAWS by the MWRDGC, only the nonnative Asian clam (*Corbicula fluminea*) and zebra mussel (Appendix B, Planning). No surveys specifically targeting freshwater mussels within the CAWS were found.

Des Plaines River

The invertebrate assemblage in the Des Plaines River is a mix of intolerant (e.g., Coleoptera, Ephemeroptera, Megaloptera, and Tricoptera) and tolerant (e.g., Oligochaeta, Chironomids, and Gastropods) species. Samples were collected by the Upper Des Plaines River Ecosystem Partnership and the MWRDGC Ambient Water Quality Monitoring Program, and it was found that a larger number of sites in the upper Des Plaines River had greater abundances of intolerant macroinvertebrate species than sites in the lower Des Plaines River. For a detailed list of the macroinvertebrate community found within the Des Plaines River system, refer to Appendix B, Planning.

Critical habitat for the federally endangered Hine's emerald dragonfly has been designated along the Des Plaines River. Life history requisites include groundwater-fed marsh habitat dominated by grasses, rushes, and sedges as well as the presence of devil crayfish (*Cambarus diogenes*) burrows, which are used for overwintering and larvae development. Critical habitat was designated for the species in 2007 and revised in 2010 (50 CFR Part 17) (Figure 4-13). The nearest designated critical habitat is at Lockport Prairie Nature Preserve, which is approximately 6 mi (9.7 km) north of BRLD.

In addition to aquatic insects, freshwater mussels are also relatively abundant within the Des Plaines River. Freshwater mussels provide a good indicator of ecosystem health because they are very susceptible to habitat disturbance. During 2009 and 2011, freshwater mussel surveys were conducted by the Illinois Natural History Survey. During the survey, a total of 19 freshwater mussel species were collected in the Des Plaines River Basin. Commonly occurring species were giant floater (*Pyganodon grandis)*, white heelsplitter (*Lasmigona complanata*), cylindrical papershell (*Anodontoides ferussacianus*) and fatmucket (*Lampsilis powelli*). The slippershell mussel (*Alasmidonta viridis*) was also collected during the survey and is listed as endangered in Illinois and threatened in Wisconsin. In addition, a relict shell of a pond

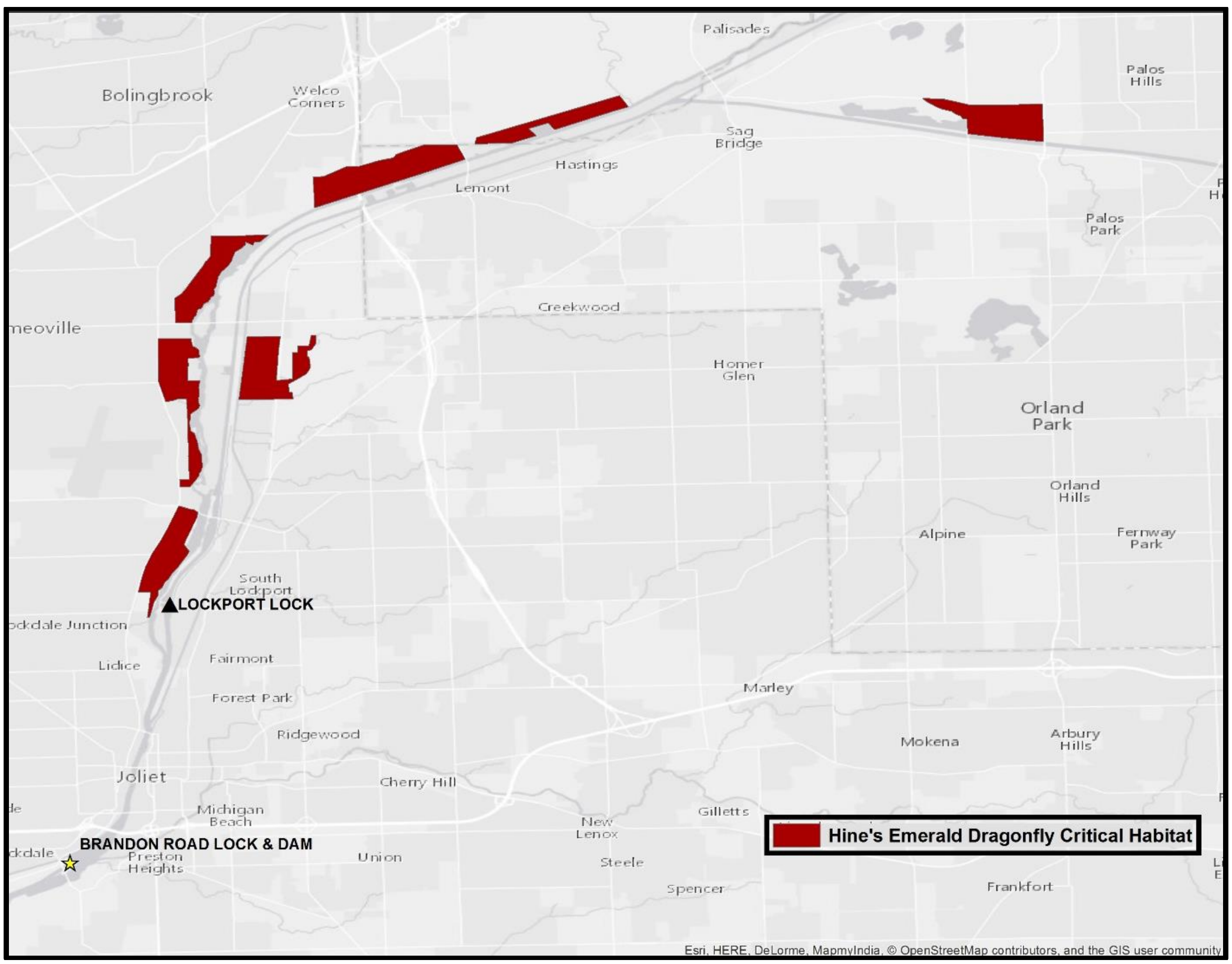


Figure 4-13 Map of Hine's Emerald Dragonfly Critical Habitat within Illinois (Red Polygons)

mussel (*Ligumia subrostrata*) was found during the survey, a species that had never been documented in the Des Plaines River Basin. For a detailed list of the mussel assemblage within the Des Plaines River system, refer to Appendix B, Planning.

Illinois River

In 2004, the USGS collected macroinvertebrates from the Illinois River at Ottawa, Illinois (USGS 2004a). Approximately 40 taxa were collected during the survey. Abundant taxa included *Glyptotendipes* sp., *Polypedilum* sp., *Rheotanytarsus* sp., *Tricorythodes* sp., *Hydropsyche bidens*, *H. orris*, *Cyrnellus fraternus*, *and Hydroptila* sp. The Hine's emerald dragonfly is the only federally endangered aquatic insect that may occur within the upper Illinois River watershed.

In the early 1900s, the Illinois River was considered one of the most productive mussel streams in America (Danglade 1914). By 1960, 25 of the 49 species recorded in the river were extirpated (Starrett 1972), but limited recovery has been detected in the upper reaches of the river. From 2009 to 2012, Illinois Natural History Survey (INHS) surveyed freshwater mussel species within tributaries of the upper, middle, and lower Illinois River (Stodola et al. 2013). A total of 31 species of freshwater mussels, of which 27 species were known historically, were observed in the Illinois River tributaries. Common species across all drainages included the fragile papershell (*Leptodea fragilis*) and white heelsplitter.

Two state-listed species (e.g., slippershell mussel and a relict shell of the state-threatened spike [*Elliptio dilatata*]) and three species of conservation concern (e.g., rock pocketbook [*Arcidens confragosus*], creek heelsplitter [*Lasmigona compressa*], and ellipse [*Venustaconcha ellipsiformis*]) were also observed.

In 2013, a single scaleshell mussel was collected in the mainstem of the upper Illinois River between Marseilles and Morris, Illinois (INHS Mollusk Database #44305) (Kanter 2013). The species is federally endangered and, prior to the 2013 collection, had not been collected within the state of Illinois for more than a century (Kanter 2013). The scaleshell mussel typically occurs in medium to large rivers with low to moderate gradients in a variety of stream habitats (USFWS 2010). The species is host specific, requiring freshwater drum for successful glochidia transformation (USFWS 2010).

Kankakee River

In 1999, the USGS surveyed macroinvertebrates from the Kankakee River at Momence, Illinois (USGS 1999a). More than 70 taxa were collected. Abundant taxa included *Tricorythodes* sp., Heptageniidae, Hydropsychidae, *Hydropsyche rossi*, *H. bidens*, *H. orris*, *Macrostemum* sp., *Macronychus glabratus*, *Polypedilum* sp., *Rheotanytarsus* sp., *Cricotopus/Orthocladius* sp., *Cricotopus* sp., and *Hemerodromia* sp. The Hine's emerald dragonfly is the only federally endangered species that may occur within the Kankakee River Basin.

A total of 30 species of freshwater mussels, from the 40 species historically known from the basin, were observed in the Kankakee River Basin during a survey by the INHS in 2009 (Price et al. 2012b).

During the survey, one federally listed and several state-listed species were found at mainstem sites on the Kankakee River. Listed species included the federally endangered sheepnose (*Plethobasus cyphyus*), state-threatened black sandshell, state-threatened purple wartyback, and state-threatened spike. The sheepnose mussel is typically found in larger streams and rivers with shallow shoal habitats and moderate to swift currents. The cited host for the sheepnose is the Sauger (*Sander canadensis*), although successful transformation has not been confirmed. The only stable population of sheepnose mussels within the Illinois River Basin is considered to be the Kankakee River population. Overall, the Kankakee River

Basin has a relatively high proportion of reaches that are classified as moderate, highly valued, or unique mussel resources compared to other basins within Illinois.

Fish Communities

Great Lakes

There are more than 150 native fish species (including federally and state-listed species) in the GLB. There are three major thermal groupings for fish communities based on their preferred summer temperature preference: warmwater (e.g., shad [Clupeidae family], catfishes [Ictaluridae family], basses and sunfishes [Centrarchidae family], and Drum [Sciaenidae family]); coolwater (e.g., Yellow Perch [*Perca flavescens*], Walleye [*Sander vitreus*], Sturgeon, and Pikes [*Esox* spp.]); and coldwater (e.g., trout and salmon [Salmonidae family], whitefishes [*Coregonus* spp.], and Deepwater Sculpin [*Myoxocephalus thompsonii*]) (Magnuson et al. 1979; USFWS 2016).

Given these temperature tolerances, fish species diversity, composition, and production differ to various degrees among the five Great Lakes in part because of the latitudinal temperature gradient from Lake Superior to Lake Erie. In Lake Erie, warm-water species like Walleye are common, while salmonids predominate in the rest of the four cooler lakes. Within the lakes, abundance and diversity are generally highest in nearshore habitats because of the higher plankton productivity and complex habitat structure. Year-round species in nearshore waters are typically warm- or cool-water species, although nearshore waters used seasonally for spawning by fish that primarily inhabit cold, deep water (USFWS 2016). Examples of deepwater species using nearshore waters for spawning are Lake Trout (*Salvelinus namaycush*), Lake Whitefish (*Coregonus clupeaformis*), Burbot (*Lota lota*), and sculpins (Corridae family). Commercially and recreationally important species can be found in all these lake habitats. Economically valuable native fishes in the Great Lakes include Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*), Yellow Perch, whitefish, and Walleye. Nonnative species, like the Pacific salmonids (*Oncorhynchus* spp.), Brown Trout (*Salmo trutta*), and Rainbow Trout (*Oncorhynchus mykiss*) are also economically important. See Appendix B, Planning, for a detailed description of fish species in each of the Great Lakes.

There are several well-documented changes in fish communities of the Great Lakes related to the introduction of nonnative species, such as Common Carp, Alewife (*Alosa pseudoharengus*), Sea Lamprey, and Round Goby. Historically, Lake Herring (*Coregonus artedi*) and deepwater coregonids were the most abundant fish in the pelagic community, while Lake Trout were the top piscivore. Overfishing and parasitism by nonnative Sea Lamprey essentially wiped out the Lake Trout population by 1956, but because of stocking and a successful lamprey control program, there is evidence that Lake Trout are returning. However, in Lake Huron, Lake Trout populations remain at depressed levels, likely because of increasing Sea Lamprey numbers in the northern part of the lake.

The invasion of Rainbow Smelt (*Osmerus mordax*) and Alewife contributed to the decline of the Lake Herring, although as Rainbow Smelt have become the preferred food of salmonid predators, Lake Herring populations have rebounded since the early 1980s. Today, the predator mix has been expanded by the intentional introduction of nonnative Pacific salmon. Introductions of Coho Salmon (*Oncorhynchus kisutch*), Chinook Salmon (*Oncorhynchus tshawytscha*), and Rainbow Trout have been successful, but the long-term stability of this sport fish community is likely to depend on the lower trophic levels (i.e., prey species such as other fish and/or zooplankton/phytoplankton), which provide a forage base for the higher trophic levels (i.e., predatory fish) (USACE 2002b). Recently, prey fish species, such as Alewife, Rainbow Smelt, and Deepwater Sculpin, have declined in Lakes Superior, Huron, Michigan, and Ontario (Environment Canada and EPA 2014; Bunnel et al. 2014). Consequently, stocking efforts are being reevaluated in light of the changing abundance of various prey species.

In addition to nonnative fish, recent invasions by invertebrate ANS such as zebra mussel, quagga mussel, and spiny water flea (a predatory zooplankton [*Bythotrephes longimanus*]) appear to have had negative impacts on some fish species. For example, following dreissenid mussel invasion there has been a decrease in abundance and condition of Lake Whitefish and Pacific salmon in part likely because of mussel-related decreases in *Diporeia* amphipods and small forage fish, respectively. Changes in nutrient input, phytoplankton growth, overfishing, habitat loss, and degradation in the chemical environment have also reduced many of the valuable commercial and recreational species in the Great Lakes. For example, marked changes in the species composition, productivity, and energy flow dynamics occurred in Lake Ontario, which experienced significant declines in productivity in the 1980s as a result of reduced nutrient loadings. This resulted in lower forage fish production and biomass. Similarly, in Lakes Erie, Huron, Michigan, and Ontario, reduced nutrient loading resulting from water quality initiatives and the spread of zebra mussels appears to be resulting in a shift toward a more oligotrophic (i.e., unproductive) lake in which the majority of energy flows through the benthic community. Fish species composition and abundance appear to be responding to this change in the food web. The return to a more oligotrophic system may make the reestablishment of some native species more feasible (USACE 2002b). Species composition and abundance can be expected to continue to shift as the full effects of changes in nutrient loadings, nonindigenous species, and management efforts are realized (USACE 2002b).

There are no federally listed threatened or endangered fish species present within the Great Lakes; however, there are 58 state-listed threatened and endangered fish species present within the GLB. For a list of state-listed species, refer to Appendix B, Planning.

CAWS

The Chicago and Calumet River Systems largely support tolerant fish species that colonized from the Des Plaines River, Lake Michigan, and several small streams that flowed into the man-made channels and canals. Intensive monitoring in fixed locations by federal and state agencies as part of the MRWG has occurred since 2010. In 2015, a total of 63 species and 2 hybrid groups were recorded from the CAWS (MRWG 2016) and a combined total of 43 species and 1 hybrid group were recorded from Lockport and Brandon Road pools (MRWG 2016). Common native species collected were Gizzard Shad (*Dorosoma cepedianum*), Freshwater Drum (*Aplodinotus grunniens*), White Sucker (*Catostomus commersonii*), Largemouth Bass, Pumpkinseed (*Lepomis gibbosus*), and Yellow Perch. Common nonnative species included Common Carp, Alewife, Round Goby, Goldfish (*Carassius auratus*), White Perch (*Morone americana*), Carp x Goldfish hybrid, Coho Salmon, Oriental Weatherfish (*Misgurnus anguillicaudatus*), Rainbow Trout, Chinook Salmon, Grass Carp, Tilapia (*Oreochromis niloticus*), and Threadfin Shad (*Dorosoma petenense*). In addition, the state-threatened Banded Killifish (*Fundulus diaphanus*) was collected in four of the five Chicago and Calumet River Systems reaches sampled and in the Lockport and Brandon Road Pools.

Similar species were collected in USFWS studies in the lock chamber of BRLD (USFWS 2016). Common Carp, Northern Pike (*Esox lucius*), Smallmouth Buffalo (*Ictiobus bubalus*), Emerald Shiner (*Notropis atherinoides*), and Gizzard Shad were collected. Fish densities in the lock chamber were higher than those in Brandon Road Pool, and hydroacoustic survey data suggested that fish heavily use the lock chamber and that fish likely transit the lock in an upstream direction (USFWS 2016).

For a complete list of fish species collected during fixed and random sampling within the Chicago River System, Calumet River System, Lockport Pool, and Brandon Road Pool, refer to Appendix B, Planning.

Des Plaines River

In general, the fish assemblage within the Des Plaines River contains a wide array of tolerant to intolerant species and is noted to be affected by the presence of low-head dams within the system (Slawski et al. 2008). However, since 2011, the following dams have been removed from the Des Plaines River: Ryerson Dam (2011), Armitage Dam (2011), Hoffman Dam (2012), Fairbanks Dam (2012), Dam #1 (2014) and Dam #2 (2014) (American Rivers 2016), MacArthur Woods (2016), Captain Daniel Wright Woods (2016), and Dempster Avenue Dam (2016). The remaining two low-head dams (i.e., Dam #4 and Touhy Avenue Dam) on the mainstem of the Des Plaines River are scheduled for demolition in the near future.

In 2012 (the most recent year with published data), MWRDGC sampled 4 stations in the upper Des Plaines River and 4 stations in the lower Des Plaines River, during which a combined total of 28 species were collected including 4 nonnative species. Native species comprised Golden Shiner, Spotfin Shiner (*Cyprinella spiloptera*), Bluntnose Minnow (*Pimephales notatus*), Mosquitofish (*Gambusia affinis)*, Blackstripe Topminnow (*Fundulus notatus*), Green Sunfish (*Lepomis cyanellus*), Orangespotted Sunfish (*Lepomis humilis*), and Bluegill (*Lepomis macrochirus*). Nonnative species included Goldfish, Common Carp, Oriental Weatherfish, and Round Goby. For a complete list of fish species collected during sampling within the Des Plaines River, refer to Appendix B, Planning.

The Illinois DNR Basin Study data indicate improving habitat in the Des Plaines River, with an increase in the proportion of intolerant species and greater species richness between 1983 and 2013. The improvement was attributed to the ecosystem restoration of the Des Plaines River (USFWS 2016). In addition, the Des Plaines River is now considered to have an excellent sportfish community with high catch rates for Northern Pike, Walleye, Channel Catfish (*Ictalurus punctatus*), Smallmouth Bass, Rock Bass (*Ambloplites rupestris*), Crappie (*Pomoxis* spp.), Largemouth Bass, and Bluegill (USFWS 2016). For a discussion of fish usage of the BRLD for movement between the lower Des Plaines River and upper Des Plaines River, refer to Section 4.9.3, Summary of Future Without-Project Condition.

Illinois River

Intensive monitoring (i.e., electrofishing and netting) in fixed locations within the Dresden Island (Figure 4-14) and Marseilles Pools within the upper IWW has been carried out since 2010 by federal and state agencies as part of the Monitoring and Response Workgroup. In 2015, a total of 70 species and 3 hybrid groups were recorded from the Dresden Island and Marseilles Pools (MRWG 2016). The majority of the total catches were comprised of Gizzard Shad, Emerald Shiner, and Smallmouth Buffalo. Nonnative species included Bighead Carp, Common Carp, Common Carp x Goldfish hybrid, Goldfish, Grass Carp, Oriental Weatherfish, Round Goby, Silver Carp, Threadfin Shad, and White Perch. In addition, the state-threatened Banded Killifish was collected in both pools, and the state-threatened River Redhorse (*Moxostoma carinatum*) was collected in Marseilles Pool. For a complete list of fish species collected during fixed and random sampling within the Dresden Island and Marseilles Pools, refer to Appendix B, Planning. A detailed discussion of the location and abundance of Bighead and Silver Carp within the upper Illinois River is in Section 4.9.3, Summary of Future Without-Project Condition.

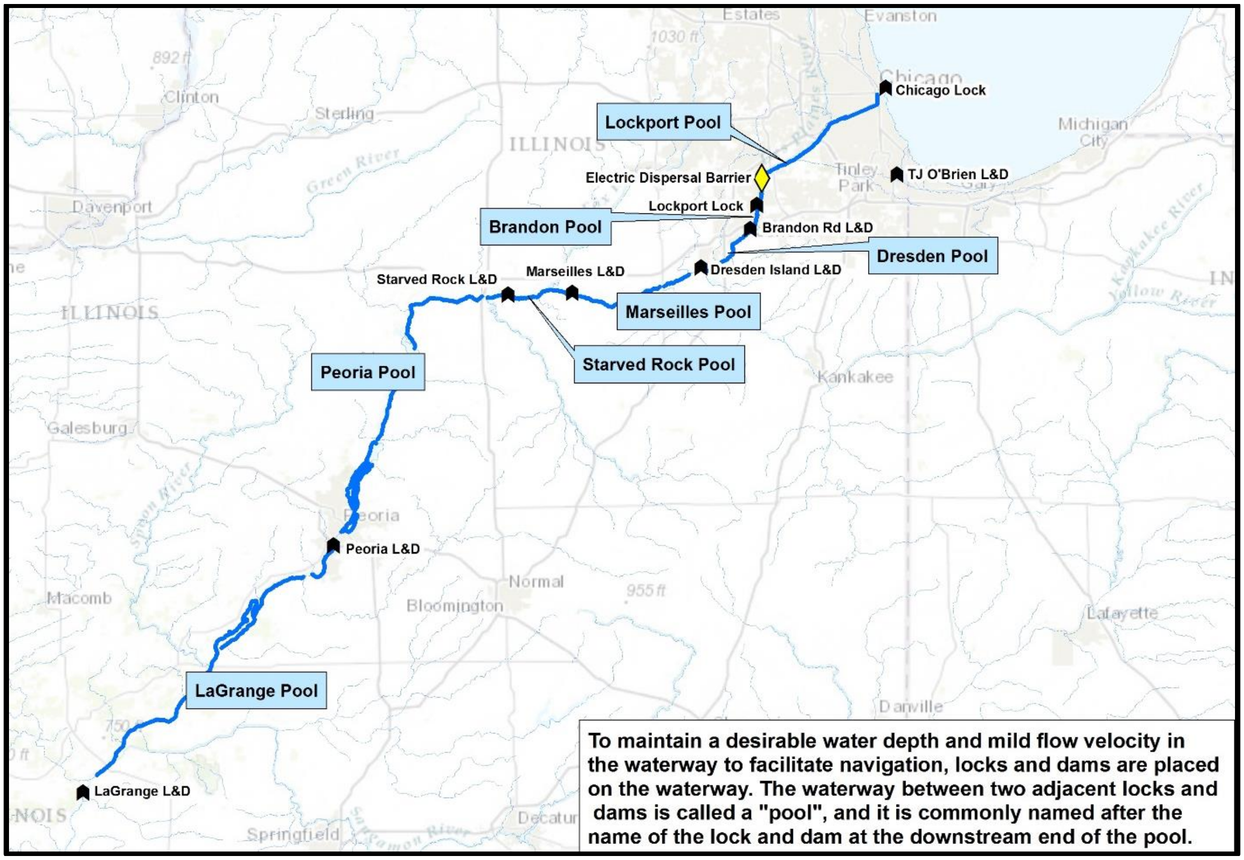


Figure 4-14 Pools within the CAWS and Upper Illinois Waterway

Kankakee River

The fish assemblage within the Kankakee River at Momence, Illinois, was sampled by the USGS in 1999 as part of the National Water-Quality Assessment Program in the lower Illinois River Basin (USGS 1999a). A total of 32 species were collected during the electrofishing survey. Native species collected included Shorthead Redhorse (*Moxostoma macrolepidotum*), Smallmouth Bass, and Channel Catfish. The following native species were also considered to be relatively abundant: Spotfin Shiner, Bluntnose Minnow, Rock Bass, Longear Sunfish (*Lepomis megalotis)*, and Logperch (*Percina caprodes*). Common Carp was the only nonnative species collected during the sampling event. For a complete list of fish species collected during sampling within the Kankakee River, refer to Appendix B, Planning.

Aquatic Nuisance Species

As part of an initial risk screening for the GLMRIS Report, a risk assessment was conducted on 10 nonnative ANS currently established in the MRB (USACE 2014a). Of the 10 species evaluated in the report, the Bighead Carp, Silver Carp, and *A. lacustre* were considered medium risk, and for GLMRIS-BR, alternatives were developed to prevent the entry of these three species into Lake Michigan through the CAWS. Basic information on life history and current population status in the MRB for the Bighead and Silver Carp and *A. lacustre* follows.

The 10 species evaluated previously as well as other nonnative species established in the MRB (Veraldi et al. 2011) were evaluated in 2016 to determine whether their population status had changed to a degree that would warrant their inclusion in the GLMRIS-BR alternative evaluation. After a review of the available literature, it was determined that no significant change in species status had occurred and that it was not necessary to add new species to the GLMRIS-BR study. See Appendix B, Planning, for a detailed description of the species evaluations.

Although the GLMRIS-BR alternative evaluation was conducted specifically for Asian carp and *A. lacustre*, the GLMRIS-BR alternatives were purposely formulated to be generally effective against any species with similar mechanisms for interbasin transfer. In this way, the GLMRIS-BR alternatives will address possible future ANS. For example, structural and nonstructural alternatives for preventing the movement of Silver and Bighead Carp will also be effective against Black Carp, another Asian carp species currently spreading in the MRB.

A 2011 ANS white paper (Veraldi et al. 2011) in support of GLMRIS identified a total of 62 alien or endemic aquatic species within the MRB as having the potential to disperse to the GLB. Of these, 9 species were identified as having a high level of risk of both transferring from the MRB to the GLB and having moderate to severe ecosystem effects (Veraldi et al. 2011).

Since the 2014 risk assessment, new information may have been found regarding the location, population status, and habitat specifications for the ANS identified as medium to high risk. In addition, the 200+ species initially evaluated in the ANS White Paper (Veraldi et al. 2011) have not been re-evaluated since the release of that document in 2011. Argonne National Laboratory reviewed the most recent data on invasive species in the MRB that have the potential to disperse via the CAWS to the GLB and determined whether a formal risk assessment was warranted for these species. The species review included

(1) The list of 10 ANS of Concern for the GLB evaluated in the GLMRIS risk assessment (Hlohowskyj et al. 2014);

(2) The additional alien or native aquatic species established in the MRB that may spread to the GLB by aquatic pathways based on Veraldi et al. (2011); and

(3) Any new species that may have established in the MRB that have the potential to transfer to the GLB via the CAWS.

A formal qualitative risk assessment would be conducted if new ANS were identified or if there was new information that could change the risk rating of previously evaluated species.

The 46 ANS not analyzed for the formal GLMRIS Risk Assessment (Hlohowskyj et al. 2014) were re-reviewed, but only 28 of those species spread primarily by aquatic pathways. The distribution and population status of these 28 species were updated using the USGS Nonindigenous Aquatic Species (NAS) (http://nas.er.usgs.gov/default.aspx), the Midwest Invasive Species Network (http://www.misin.msu.edu/), and state documentation for invasive species in the MRB. In addition to these sources, plants were updated using the U.S. Department of Agriculture (USDA) plant database (http://plants.usda.gov/java/noxiousDriver). Following Veraldi et al. (2011), the need for a new or revised formal risk assessment for these species under GLMRIS-BR was determined based on a preliminary evaluation of a species' climatological tolerance, historical spread rates, invasion success, and documented impacts to previously invaded systems.

One coelenterate (i.e., Australian Jellyfish [*Phyllorhiza punctate*]), 15 fish, 2 mollusks, and 10 plants were reviewed (Table 4-9). After a review of the available literature, it was determined that no additional

Table 4-9 MRB ANS Re-reviewed for Formal Risk Assessment under GLMRIS-BR[e]

Taxon	Reason for Rejecting for Formal Risk Assessment		Taxon	Reason for Rejecting for Formal Risk Assessment
Coelenterate			**Mollusks**	
Australian Spotted Jellyfish (*Phyllorhiza punctata*)	Marine[a]		Red-rim Melania (*Melanoides tuberculatus*)	Does not appear to be spreading or spreading very slowly[a]
Fish			Island Applesnail (*Pomacea insularum*)	Tropical/subtropical distribution; GLB climate not suitable[a]
Great Snakehead (*Channa marulius*)	Not established in MRB[a]		**Plants**	
Convict Cichlid (*Cichlasoma nigrofasciatum*)	Tropical/subtropical; GLB climate not suitable[a]		Brazilian Waterhyssop[b] (*Bacopa egensis*)	Only found in lower MRB[b]; does not appear to be spreading or spreading very slowly
Jack Dempsey (*Cichlasoma octofasciatum*)	Does not appear to be spreading[a]		Horsefly's Eye (*Dopatrium junceum*)	Only found in lower MRB[b]; does not appear to be spreading or spreading very slowly
Threadfin Shad (*Dorosoma petenense*)	GLB climate not suitable[a]		Peruvian Watergrass (*Luziola peruviana*)	Only found in lower MRB[b]; does not appear to be spreading or spreading very slowly
Blue Catfish (*Ictalurus furcatus*)	Native to MRB; does not appear to be spreading[a]		White Egyptian Lotus (*Nymphaea lotus*)	Only found in lower MRB[b]
Redbreast Sunfish (*Lepomis auritus*)	Native to MRB; does not appear to be spreading[a]		Torpedo Grass (*Panicum repens*)	Only found in lower MRB[b]
Nile Tilapia (*Oreochromis niloticus*)	Tropical/subtropical; climate not suitable[a]		Hydrilla (*Hydrilla verticillata*)	Spread by aquarium sales; fragments dispersed by waterfowl and boats[b]; established in Cayuga Lake, New York[b,c]
Shortfin Molly (*Poecilia mexicana*)	Does not appear to be established in MRB[a]		Brazilian Elodia (*Egeria densa*)	Spread by aquarium sales; fragments dispersed by waterfowl and boats[c]
Vermiculated Sailfin Catfish (*Pterygoplichthys disjunctivus*)	Spread through aquarium releases[a]		Parrot Feather (*Myriophyllum aquaticum*)	Common water garden and aquarium plant[c]; spread by aquarium trade; likely established in GLB[d]

Table 4-9 (Cont.)

Taxon	Reason for Rejecting for Formal Risk Assessment		Taxon	Reason for Rejecting for Formal Risk Assessment
Amazon Sailfin Catfish (*Pterygoplichthys pardalis*)	Not established in MRB[a]		Guyanese Arrowhead (*Sagittaria guayanensis*)	Tropical/subtropical[b]; USGS listed as likely not of concern
Zander (*Sander lucioperca*)	Not established in MRB[a]		Giant Salvinia (*Salvinia molesta*)	Tropical/subtropical; only in lower MRB[b]
Spotted Bass (*Micropterus punctulatus*)	Native to MRB; does not appear to be spreading[a]		Marsh Dewflower (*Murdannia keisak*)	No new information; mainly spread by wildlife
Green Swordtail (*Xiphophorus hellerii*)	Establishment in MRB uncertain[a]		Cuban Bulrush (*Oxycaryum cubense*)	No new information
Southern Platyfish (*Xiphophorus maculatus*)	Not established in MRB[a]		Dotted Duckweed (*Landoltia punctata*)	No change in location[c]; primarily non-aquatic transport
Crucian Carp (*Carassius carassius*)	Not established in MRB[a]			
Black Carp (*Mylopharyngodon piceus*)	Rare in the MRB			
Northern Snakehead (*Channa argus*)	No change[a]			
Skipjack Herring (*Alosa chrysochloris*)	No change[a]			
Inland Silverside (*Menidia beryllina*)	No change[a]			

[a] USGS Nonindigenous Aquatic Species (NAS) database, http://fl.biology.usgs.gov/Nonindigenous_Species/non indigenous_species.html.
[b] Jacono et al. (2015).
[c] Midwest Invasive Species Information Network, http://www.misin.msu.edu/.
[d] Herbert (2014).
[e] Source: Hlohowskyj et al. (2014).

species required a formal risk assessment. Some species from the 2011 ANS white paper (Veraldi et al. 2011) (e.g., Zander [*Sander lucioperca*] and Sailfin Catfish [*Pterygoplichthys* spp.]) were considered not yet established in the MRB (Table 4-9). Other ANS were not likely to establish in the GLB because of habitat suitability or did not appear to be spreading toward the GLB (e.g., Brazilian waterhyssop [*Bacopa egensis*], horsefly's eye [*Dopatrium junceum*], and Peruvian watergrass [*Luziola peruviana*]). Several species reviewed are of significant concern currently, including torpedo grass (*Panicum repens*) and Brazilian elodia (*Egeria densa*), but they were determined to spread primarily by non-aquatic pathways like wildfire or the aquarium trade and therefore they were not considered for further risk assessment. Hydrilla, probably the invasive plant of greatest concern, was not brought forward for a formal risk assessment because it is primarily spread by boats and waterfowl and is permitted in the aquarium trade in several Great Lakes states (Jacono et al. 2015). In addition, hydrilla is established in Cayuga Lake, New York, which has an aquatic connection to the Great Lakes (Jacono et al. 2015).

Similarly, there was no change in the risk rating of species that were evaluated in the earlier GLMRIS risk assessment (Table 4-9). One species of significant concern currently that was not included in the formal risk assessment is Black Carp. In April 2017, a Black Carp was captured by a commercial fisher in the LaGrange Pool, approximately 17 mi (27.4 km) downstream of Peoria Lock and Dam (USGS 2017c). This capture extended the upstream detection of the species by 110 mi (177.0 km). Analysis conducted by the USFWS indicated that the fish was diploid, and therefore capable of reproducing. In 2015, the Missouri Department of Conservation confirmed natural reproduction of Black Carp in the middle MRB. However, Black Carp are still rare in the MRB (Kilgore 2014). In Mississippi, no captures of Black Carp have been reported by biologists or commercial fishermen (Riecke 2014). Three Black Carp were collected in Arkansas; two were tested; and both were triploid (Armstrong 2014) and therefore not capable of reproducing. Only one Black Carp was reported from the Missouri Department of Conservation (McCain 2014). While the presence of reproducing Black Carp in the MRB is cause for concern, control measures currently in place to prevent the spread of similar species such as Bighead Carp and Silver Carp are also likely to be effective for Black Carp.

After the above review, three species from the MRB that were identified in the GLMRIS study as high or medium concern remained as high or medium concern for the GLMRIS-BR study. Those species were the Bighead Carp, Silver Carp, and *Apocorophium lacustre* and are discussed in further detail below.

Bighead Carp

The Bighead Carp (Figure 4-15) is native to eastern China, eastern Siberia, and extreme North Korea (Kolar et al. 2005). The species was first introduced to the United States through private fish farms in Arkansas and likely escaped into open waters during flood events (Nico et al. 2015). Subsequently, Bighead Carp have been recorded throughout much of the United States (Nico et al. 2015), with reproducing populations established all along the Mississippi, Missouri, and Ohio Rivers (NBII and ISSG 2005). In Illinois, the species is considered established (Nico et al. 2015) and is abundant in the IWW from Starved Rock LD (RM 231) to its the confluence with the Mississippi River (RM 0). The adult population front is currently located in Dresden Island Pool, a distance of 55 mi (88.5 km) from Lake Michigan. Large numbers of Bighead Carp have been captured in Rock Run Rookery Preserve Lake, approximately 4 mi (6.4 km) downstream of BRLD (ACRCC 2013b). It is also important to note that two (2) Bighead Carp have been captured upstream of BRLD. In 2009, a Bighead Carp was collected during a rotenone application within Lockport Pool, downstream of the CSSC-EB (Illinois DNR 2009). The second Bighead Carp was collected in 2010 during routine monitoring in Lake Calumet, upstream of the CSSC-EB. Examination of the otolith (e.g., small bones in the inner ear of fish) chemical composition of the Bighead Carp from Lake Calumet indicated that the fish may have originated in the Illinois River and then moved or was transported to Lake Calumet.

Bighead Carp can grow to a length of 51 in. (129.5 cm), can weigh up to 88 lb (39.9 kg), and prefer eutrophic rivers, lakes, and backwater habitats (Kolar et al. 2005). The species rarely occupies water depths greater than13.1 ft (4 m) (DeGrandchamp et al. 2008) and prefer water temperatures ranging between 69.8 and 78.8°F (21 and 26°C) for spawning and 77–80.4°F (25–26.9°C) when not spawning (Kolar et al. 2005). Fry occur in water temperatures as low as 50–53.6°F (10–12°C) (Rasmussen et al. 2011). Bighead Carp are typically found in waters with high plankton concentrations but can survive in waters with low concentrations at low growth rates (Kolar et al. 2005). While the species is native to large rivers, during spawning it requires high-flow (Stone et al. 2000), turbid (Kolar et al. 2005) waters.

Figure 4-15 Photograph of a Bighead Carp (Photo Credit: ACRCC)

Bighead Carp are generalist consumers that primarily filter feeds on phyto- and zooplankton (Kolar et al. 2005). In the Illinois and Missouri Rivers, the majority of their diet is comprised of rotifers (Sampson et al. 2009). Spawning in the species is triggered by changes in water levels, flow velocity, and water temperatures (Stainbrook et al. 2007). Previously, it was believed that rivers at least 62.1 mi (100 km) in length were required for spawning, in order to carry eggs to floodplains and prevent eggs from sinking and being covered with silt (Kolar et al. 2005). However, a recent study suggested that with the right temperature and flow conditions, river reaches as short as 15.5 mi (25 km) may allow eggs sufficient time to develop to hatching (Murphy and Jackson 2013). Eggs mature in floodplains or tributary mouths; larvae migrate from nursery areas to river channels (Kolar et al. 2005). Maturity is reached in 2–8 years (Kolar et al. 2005). Fecundity is correlated with increases in body mass and age. In 2004 in the Illinois River, mean fecundity was 180,000 eggs/female (ACRCC 2013a); a single Bighead Carp from the Yangtze River reportedly contained 1.1 million eggs (Kolar et al. 2005).

Since 2007, Bighead Carp were captured in Dresden Island Pool; however, based on this monitoring it appears that few Bighead Carp have moved from Dresden Island Pool to reaches above the BRLD (Illinois DNR 2009, ACRCC 2012).

The factors driving this apparent stalled range expansion are not understood but may include food and habitat availability, water quality, channel morphology and hydrology, and lock-specific differences.

Silver Carp

Silver Carp (Figure 4-16) are native to several major Pacific drainages in eastern Asia from the Amur River of far eastern Russia south through the eastern half of China to the Pearl River (Xie and Chen 2001). The species was first introduced to the United States in 1973 by a private fish farmer in Arkansas (Freeze and Henderson 1982). It was first found in open waters in 1980, likely as a result of escapes from aquaculture facilities (Froese and Pauly 2004). The species has spread throughout the MRB (Nico et al. 2017). In Illinois, the species has established in the Mississippi, Spoon, Illinois, and Ohio Rivers and their tributaries, and has been reported in the Muddy River; Muscooten Bay; Horseshoe Lake, near the Cache River drainage; and in the Embarras River (Nico et al. 2017). In 2009, a confirmed sighting occurred during Asian carp routine monitoring of a Silver Carp at the confluence of the CSSC and Des Plaines River (ACRCC 2013a), and Silver Carp have been captured as far upstream as Dresden Island Pool, four (4) mi (6.4 km) downstream of the BRLD (ACRCC 2013b). The leading front of the population is located in Dresden Island Pool, a distance of 29 mi (46.7 km) from the CSSC-EB and 47 mi (75.6 km) from Lake Michigan. In 2014, no Silver Carp were observed or captured in Lockport or Brandon Road Pools.

Figure 4-16 Photograph of a Silver Carp (Photo Credit: ACRCC)

Silver Carp can grow to a length of 41 in. (104.1 cm) and weigh up to 110 lb (49.9 kg). Silver Carp prefer turbid (Radke and Kahl 2002), eutrophic waters (Kolar et al. 2005), but can survive at low growth rates in waters with low plankton concentrations. The species prefers backwaters and impoundments with low-flow/no-flow conditions, large rivers, and contiguous ponds and lakes (Radke and Kahl 2002). Spawning may be limited to fast-moving waters with high water levels (Radke and Kahl 2002). Silver Carp use tributaries much less often than Bighead Carp and mostly use them in summer rather than winter (Radke and Kahl 2002). Eggs, larvae, and juveniles inhabit wetland floodplains and backwaters (Radke and Kahl 2002; Williamson and Garvey 2005; Varble et al. 2007). Optimal growth for the species occurs between 75 and 93.2°F (24 and 34°C) for adults and at 77–96.8°F (25–36°C) for larvae (Radke and Kahl 2002). The species can tolerate long winters under ice cover, as well as temperatures higher than 104°F (40°C) (Opuszynski et al. 1989).

Larval and young of the year Silver Carp consume zooplankton (Varble et al. 2007), and adults are planktivorous. In the Illinois and Mississippi Rivers, the species mostly consumes rotifers (Sampson et al. 2009). They are pump filter feeders that produce a mucous that allows them to consume various sizes of food items (Radke and Kahl 2002). Silver Carp spawn between April and June (Varble et al. 2007) and require rivers for spawning (Radke and Kahl 2002). Spawning is triggered by rising water levels, flow velocity, and temperatures greater than 62.6°F (17°C) (Stainbrook et al. 2007). Previously, it was believed that successful reproduction required rivers at least 62.1 mi (100 km) in length with fast flow (2.3–4.6 ft/s [0.7–1.4 m/s]) to carry eggs to floodplains and to prevent the eggs from sinking and being covered with silt (Radke and Kahl 2002). However, a recent study suggested that with the right temperature and flow conditions, river reaches as short as 15.5 mi (25 km) in length may allow eggs sufficient time to develop to hatching (Murphy and Jackson 2013). Fecundity is correlated with increases in body mass and age (Radke and Kahl 2002; DeGrandchamp et al. 2007). Populations of Silver Carp appear to be growing exponentially (Radke and Kahl 2002), with abundance peaking quickly following establishment.

In June 2017, a Silver Carp was captured downstream of T.J. O'Brien Lock and Dam, approximately 9 mi (14.5 km) from Lake Michigan. In addition, in 2009, there was a confirmed sighting of a Silver Carp at the confluence of the CSSC and Des Plaines River during Bighead and Silver Carp routine monitoring efforts (MRWG 2015). The remainder of Silver Carp have been captured and observed below BRLD. Since 2007, Silver Carp were captured in Dresden Island Pool; however, based on the monitoring, it appears that few Silver Carp have moved from Dresden Island Pool to reaches above the BRLD (Illinois DNR 2009; ACRCC 2012). The factors driving this apparent stalled range expansion are not understood but may include food and habitat availability, water quality, channel morphology and hydrology, and lock specific differences.

A. lacustre

A. lacustre (Figure 4-17) is native to the Atlantic coast of North America (USGS 2016). Within the MRB, *A. lacustre* has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008). *A. lacustre* was first reported from the lower Mississippi River in 1987 and spread north to the Ohio River by 1996 (Grigorovich et al. 2008). By 2003, *A. lacustre* had invaded the Illinois River (USGS 2016). Surveys for this species in multiple river basins conducted in 2005 found that *A. lacustre* was present just above the Dresden Island LD, less than 20 mi (32.2 km) from the BRLD (Grigorovich et al. 2008). In surveys conducted in 2015, *A. lacustre* was again found as far north as Dresden Island Pool (Keller 2015). In the Illinois River, *A. lacustre* can be locally abundant, but overall, its numbers are highly variable over space and time (Keller 2015).

A. lacustre is a tube-dwelling, benthic filter-feeding amphipod. During reproduction, females brood embryos on their underside, which hatch out as crawling juveniles; therefore, there is no planktonic stage. This species tolerates a wide range of temperatures and is pollution tolerant but is not found in fast-flowing or turbid water (USGS 2016). Habitat for this species includes the benthos of rivers and lakes, as well as rocky or sandy shoals and snags (Angradi et al. 2009; USGS 2016). It has also been found in nearshore nonvegetated areas, including man-made structures such as harbors (USGS 2016).

Apocorophium lacustre is readily transported on boat hulls and is thought to have moved rapidly up the MRB by attaching to the hulls of ships (Grigorovich et al. 2008). There is heavy upward-bound vessel traffic through the IWW and CAWS.

Although it is an estuarine species, *A. lacustre* is a habitat generalist that tolerates a wide range of temperatures, salinities, and habitat types (USGS 2016). However, the presence of *A. lacustre* appears to be positively associated with salinity (Szocs et al. 2014), suggesting it is an important influence on the abundance and distribution of this species. High salinity areas are found in the Great Lakes in locations with anthropogenic inputs, particularly in the CAWS and similar urban drainage features.

Figure 4-17 *Apocorophium lacustre* (Photo Credit: Trent Henry and Gabrielle Habeeb, Loyola University Chicago)

Suitable physical habitat for *A. lacustre* is present in the Great Lakes. The benthos of rivers and tributaries, especially rocky and sandy shoals, are suitable habitat for *A. lacustre* (Grigorovich et al. 2008; USGS 2016). Man-made structures like harbors are also potentially suitable habitat.

4.4.5 Threatened and Endangered Species

Great Lakes

Within the GLB there are 36 federally listed species, which are defined in Table 4-10.

Table 4-10 Federally Listed Species Occurring within the Great Lakes Basin

Species	Status	Preferred Habitat
Plants		
Dwarf Lake Iris (*Iris lacustris*)	Threatened	Occurs close to Great Lakes shorelines along old beach ridges or behind open dunes on sand or in thin soil over limestone-rich gravel or bedrock.
Dwarf Trout Lily (*Erythronium propullans*)	Endangered	Occurs in woodland habitat, rich slopes dominated by maple and basswood, and adjoining floodplains dominated by elm and cottonwood.
Eastern Prairie Fringed Orchid (*Platanthaera leucophaea*)	Threatened	Moderate- to high-quality wetlands, sedge meadow, marsh, and mesic to wet prairie.
Fassett's Locoweed (*Oxytropis campestris var. chartacea*)	Threatened	Grows on gentle, sand-gravel shoreline slopes around shallow lakes fed by groundwater seepage.
Hart's-tongue Fern (*Asplenium scolopendrium var. americanum*)	Threatened	Found in northern deciduous forests. Grows within small fissures in large rocks.
Houghton's Goldenrod (*Solidago houghtonii*)	Threatened	Grows on moist sandy beaches and shallow depressions between low sand ridges along the shoreline.
Lakeside Daisy (*Hymenopsis herbacea*)	Threatened	Found in dry rocky prairies.
Leedy's Roseroot (*Rhodiola integrifolia ssp. leedyi*)	Threatened	Grows on cool cliffs. In Minnesota, populations occur on "moderate" cliffs, which are characterized by the presence of cracks in the rocks, extending from the cliff face to cold underground caves.
Mead's Milkweed (*Asclepias meadii*)	Threatened	Late successional tallgrass prairie, tallgrass prairie converted to hay meadow, and glades or barrens with thin soil.
Michigan Monkey Flower (*Mimulus michiganensis*)	Endangered	Found in mucky soil and sand that is saturated or covered by cold, flowing spring water.
Pitcher's Thistle (*Cirsium pitcheri*)	Threatened	Grows on the open sand dunes and low open beach ridges of the Great Lakes' shores.

Table 4-10 (Cont.)

Species	Status	Preferred Habitat
Prairie Bush Clover (*Lespedeza leptostachya*)	Threatened	Found only in tallgrass prairie.
Western Prairie Fringed Orchid (*Platanthera praeclara*)	Threatened	Occurs most often in mesic to wet unplowed tallgrass prairies and meadows but have been found in old fields and roadside ditches.
Reptiles and Amphibians		
Bog Turtle (*Clemmys muhlenbergii*)	Threatened	Typically found in open, early successional types of habitats such as wet meadows or open calcareous boggy areas generally dominated by sedges or sphagnum moss.
Copperbelly Water Snake (*Nerodia erythrogaster neglecta*)	Threatened	Occurs in wooded and permanently wet areas such as oxbows, sloughs, brushy ditches, and floodplain woods.
Eastern Massassagua (*Sistrurus catenatus*)	Threatened	Graminoid-dominated plant communities (fens, sedge meadows, peat lands, wet prairies, open woodlands, and shrublands).
Mammals		
Indiana Bat (*Myotis sodalis*)	Endangered	Summer habitat includes small to medium-size river and stream corridors with well-developed riparian woods; woodlots within 1–3 mi (1.6–4.8 km) of small to medium rivers and streams; and upland forests. Caves and mines are used as hibernacula.
Gray Wolf (*Canis lupus*)	Endangered	Thrives in a diversity of habitats from tundra to woodlands, forests, grasslands, and deserts. Requires large areas of contiguous habitat.
Canada Lynx (*Lynx canadensis*)	Threatened	Generally found in moist, boreal forests that have cold, snowy winters and a high density of their favorite prey: the snowshoe hare (*Lepus americanus*).
Northern long-eared bat (*Myotis septentrionalis*)	Threatened	Hibernates in caves and mines; swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests and woods.
Birds		
Cerulean Warbler (*Setophaga cerulean)*	Endangered	Nests and raises young in large tracts of deciduous hardwood forests that have tall, large-diameter trees and diverse vertical structure in the forest canopy.
Kirtland's Warbler (*Setophaga kirtlandii*)	Endangered	Nests only on the ground near the lower branches and in large stands of young Jack pines.
Piping Plover (*Charadrius melodus*)	Endangered	Utilizes coastal beaches, such as the Great Lakes, for nesting.

Table 4-10 (Cont.)

Invertebrates		
Clubshell (*Pleurobema clava*)	Endangered	Prefers clean, loose sand and gravel in medium to small rivers and streams.
Hine's Emerald Dragonfly (*Somatochlora hineana*)	Endangered	Spring-fed wetlands, wet meadows, and marshes. Within Cook County, critical habitat has been designated along the Des Plaines River.
Higgins Eye Pearlymussel (*Lampsilis higginsii*)	Endangered	Found in larger rivers in deep water with moderate currents.
Hungerford's Crawling Water Beetle (*Brychius hungerfordi*)	Endangered	Found in cool riffles of clean, slightly alkaline streams.
Karner Blue Butterfly (*Lycaeides melissa samuelis*)	Endangered	Found in dry sandy areas with open woods and clearing-like pine barrens, lakeshore dunes, and sandy pine prairies that contain wild blue lupine (*Lupinus perennis*).
Mitchell's Satyr (*Neonympha mitchellii mitchellii*)	Endangered	Restricted to rare wetlands called fens, which are low-nutrient systems that receive carbonate-rich groundwater from seeps and springs.
Northern Riffleshell (*Epioblasma torulosa rangiana*)	Endangered	Found in a wide variety of streams from large to small. Buries itself in stream bottoms with firmly packed sand or gravel.
Rayed Bean (*Villosa fabalis*)	Endangered	Generally lives in smaller, headwater creeks, but is sometimes found in large rivers and wave-washed areas of glacial lakes.
Sheepnose Mussel (*Plethobasus cyphyus*)	Endangered	Found in large rivers and streams, usually in shallow areas with moderate to swift currents over coarse sand and gravel mixture. Host-specific species with glochidia found only on Sauger (*Stizostedion canadense*) in the wild. In the lab, glochidia have successfully transformed on Fathead Minnow (*Pimephales promelas*), Creek Chub (*Semotilus atromaculatus*), Central Stoneroller (*Campostoma anomalum*), and Brook Stickleback (*Culaea inconstans*).
Snuffbox (*Epioblasma triquetra*)	Endangered	Usually found in small to medium-size creeks, in areas with a swift current, although it is also found in Lake Erie and some large rivers.
Spectaclecase (*Cumberlandia monodonta*)	Endangered	Found in large rivers where they live in areas sheltered from the main force of the river current. Often clusters in firm mud and in sheltered areas, such as beneath rock slabs, between boulders, and even under tree roots.

Table 4-10 (Cont.)

White Catspaw (*Epioblasma obliquata perobliqua*)	Endangered	Prefers coarse sand or gravel bottoms of small to mid-size freshwater streams and rivers. It prefers shallow water and requires a swift current to avoid being buried in silt.
Winged Mapleleaf (*Quadrula fragosa*)	Endangered	Found in riffles with clean gravel, sand, or rubble bottoms and in clear, high-quality water. May have also historically been found in large rivers and streams on mud-covered gravel, and gravel bottoms.

Within the Great Lakes region, there are numerous listed state threatened and endangered species. In general, there are 907 plants, 26 reptiles and amphibians, 15 mammals, 62 birds, 204 invertebrates, and 58 fish that are listed within the Great Lakes area (Appendix B, Planning).

CAWS/Des Plaines River/Illinois River/Kankakee River

There are 10 federally listed and proposed to be listed species within the GLMRIS-BR Illinois Waterway Study Area according to the USFWS Federally Endangered, Threatened, and Candidate Species Illinois County Distribution List (USFWS 2015b). The high-quality, but vulnerable, ecosystem at Lockport Prairie Nature Preserve supports three (3) federally listed species: the federally endangered Leafy Prairie Clover (*Dalea foliosa*) and Hine's Emerald Dragonfly, and the federally threatened Lakeside Daisy. Lockport Prairie is located near 159th Street adjacent to the Des Plaines River within a few miles of the CSSC-EB Project.

Federally listed threatened, endangered, proposed, and candidate species were reviewed. Federally listed species, status, and their critical habitat are identified by the USFWS as potentially occurring within the GLMRIS-BR Illinois Waterway Study Area (Table 4-11).

In addition, there are numerous state-listed threatened and endangered species potentially occurring within the larger project area (Appendix B, Planning). One such state-endangered species, the Black-crowned Nigh Heron (*Nycticorax nycticorax*), has been observed near the GLMRIS-BR Site-Specific Study Area. Currently, no Black-crowned Night Heron colonies have been identified within the GLMRIS-BR Site-Specific Study Area. There are 76 state-listed species within Will County, Illinois (which includes portions of the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR Site-Specific Study Area) according to the Illinois Natural Heritage Database's Illinois Threatened and Endangered Species by County Distribution List (INHD 2016). In general, there are approximately 40 plants, 5 reptiles and 2 amphibians, 1 mammal, 9 birds, 8 invertebrates, and 13 fish listed as potentially occurring within the GLMRIS-BR Site-Specific Study Area (Table 4-12).

Table 4-11 Federally Listed Species Potentially Occurring within the GLMRIS-BR Illinois Waterway Study Area (USFWS 2015b)

Species	Status	Preferred Habitat
Plants		
Eastern Prairie Fringed Orchid (*Platanthaera leucophaea*)	Threatened	Moderate-to high-quality wetlands, sedge meadow, marsh, and mesic to wet prairie.
Lakeside Daisy (*Hymenopsis herbacea*)	Threatened	Found in dry rocky prairies.
Leafy-prairie Clover (*Dalea foliosa*)	Endangered	Prairie remnants on soil over limestone.
Mead's Milkweed (*Asclepias meadii*)	Threatened	Late successional tallgrass prairie, tallgrass prairie converted to hay meadow, and glades or barrens with thin soil.
Reptiles and Amphibians		
Eastern Massassagua (*Sistrurus catenatus*)	Threatened	Graminoid-dominated plant communities (fens, sedge meadows, peat lands, wet prairies, open woodlands, and shrublands).
Mammals		
Northern long-eared bat (*Myotis septentrionalis*)	Threatened	Hibernates in caves and mines, swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests and woods.
Invertebrates		
Hine's Emerald Dragonfly (*Somatochlora hineana*)	Endangered	Spring-fed wetlands, wet meadows, and marshes. Within Cook County, critical habitat has been designated along the Des Plaines River.
Rattlesnake-master Borer Moth (*Papaipema eryngii*)	Candidate	Undisturbed prairie and woodland openings that contain their single food source, rattlesnake master (*Eryngium yuccifolium*).
Rusty Patched Bumble Bee (*Bombus affinis*)	Endangered	Grasslands and tallgrass prairies, nesting sites (e.g., underground and abandoned rodent cavities or clumps of grasses), and overwintering sites (undisturbed soil).
Sheepnose Mussel (*Plethobasus cyphyus*)	Endangered	Found in large rivers and streams, usually in shallow areas with moderate to swift currents over coarse sand and gravel mixture. Host-specific species with glochidia found only on Sauger (*Stizostedion canadense*) in the wild. In the lab, glochidia have successfully transformed on Fathead Minnow (*Pimephales promelas*), Creek Chub (*Semotilus atromaculatus*), Central Stoneroller (*Campostoma anomalum*), and Brook Stickleback (*Culaea inconstans*).

Table 4-12 State-Listed Species Potentially Occurring within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR Site-Specific Study Area

Species	Illinois Status		Species	Illinois Status
Plants				
American Burnet (*Sanguisorba canadensis*)	Endangered		Little Green Sedge (*Carex viridula*)	Threatened
American Slough Grass (*Beckmannia syzigachne*)	Endangered		Marsh Speedwell (*Veronica scutellata*)	Threatened
Beaked Spike Rush (*Eleocharis rostellata*)	Threatened		Mead's Milkweed (*Asclepia meadii*)	Endangered
Blazing Star (*Liatris scariosa* var. *nieuwlandii*)	Threatened		Narrow-leaved Sundew (*Drosera intermedia*)	Threatened
Blue Sage (*Salvia azurea ssp. pitcheri*)	Threatened		Northern Corn Salad (*Valerianella chenopodifolia*)	Endangered
Bristly Blackberry (*Rubus schneideri*)	Threatened		Northern Panic Grass (*Dichanthelium boreale*)	Endangered
Buffalo Clover (*Trifolium reflexum*)	Threatened		Oklahoma Grass Pink Orchid (*Calopogon oklahomensis*)	Endangered
Canada Violet (*Viola canadensis*)	Endangered		Pretty Sedge (*Carex woodii*)	Threatened
Dog Violet (*Viola conspersa*)	Threatened		Primrose Violet (*Viola primulifolia*)	Endangered
Ear-leafed Foxglover (*Tomanthera auriculata*)	Threatened		Quillwort (*Isoetes butleri*)	Endangered
Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)	Endangered		Redveined Prairie Leafhopper (*Aflexia rubranura*)	Threatened
False Mallow (*Malvastrum hispidum*)	Endangered		Running Pine (*Lycopodium clavatum*)	Endangered
Forked Aster (*Aster furcatus)*	Threatened		Shore St. John's Wort (*Hypericum adpressum*)	Endangered
Golden Corydalis (*Corydalis aurea*)	Endangered		Slender Bog Arrow Grass (*Triglochin palustris*)	Threatened
Grass Pink Orchid (*Calcopogon tuberosus*)	Endangered		Slender Sandwort (*Minuartia patula*)	Threatened
Great Lakes Corn Salad (*Valerianella umbilicata*)	Endangered		Small Sundrops (*Oenothera perennis*)	Threatened
Hedge Hyssop (*Gratiola quartermaniae*)	Endangered		Spotted Coral-root Orchid (*Corallorhiza maculate*)	Threatened
Lakeside Daisy (*Tetraneuris herbacea*)	Endangered		Tubercled Orchid (*Platanthera flava* var. *herbiola*)	Threatened
Large Cranberry (*Vaccinium macrocarpon*)	Endangered		White Lady's Slipper (*Cypripedium candidum*)	Threatened
Leafy Prairie Clover (*Dalea foliosa*)	Endangered		Yellow-lipped Ladies' Tresses (*Spiranthes lucida*)	Endangered

Table 4-12 (Cont.)

Species	Illinois Status		Species	Illinois Status
Reptiles and Amphibians				
Blanding's Turtle (*Enydoidea blandingii*)	Endangered		Mudpuppy (*Necturus maculosus*)	Threatened
Eastern Massasauga (*Sistrurus catenatus catenatus*)	Endangered		Orante Box Turtle (*Terrapene ornate*)	Threatened
Four-toed Salamander (*Hemidactylium scutatum*)	Threatened		Spotted Turtle (*Clemmys guttata*)	Endangered
Kirtland's Snake (*Clonophis kirtlandii*)	Threatened			
Mammals				
Franklin's Ground Squirrel (*Spermophilus franklinii*)	Threatened			
Birds				
Barn Owl (*Tyto alba*)	Endangered		Loggerhead Shrike (*Lanius ludovicianus*)	Endangered
Black-crowned Night-heron (*Nycticorax nycticorax*)	Endangered		Northern Harrier (*Circus cyaneus*)	Endangered
Common Moorhen (*Gallinula chloropus*)	Endangered		Upland Sandpiper (*Bartramia longicauda*)	Endangered
King Rail (*Rallus elegans*)	Endangered		Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	Endangered
Least Bittern (*Ixobrychus exilis*)	Threatened			
Invertebrates				
Black Sandshell (*Ligumia recta*)	Threatened		Salamander Mussel (*Simpsonaias ambigua*)	Endangered
Eryngium Stem Borer (*Papaipema eryngii*)	Endangered		Sheepnose (*Plethobasus cyphyus*)	Endangered
Hine's Emerald Dragonfly (*Somatochlora hineana*)	Endangered		Slippershell (*Alasmidonta viridis*)	Endangered
Purple Wartyback (*Cyclonaias tuberculata*)	Threatened		Spike (*Elliptio dilatata*)	Threatened
Fish				
Banded Killifish (*Fundulus diaphanus*)	Threatened		Longnose Sucker (*Catostomus catostomus*)	Threatened
Bigeye Shiner (*Notropis boops*)	Endangered		Pallid Shiner (*Hybopsis amnis*)	Endangered
Blacknose Shiner (*Notropis heterolepis*)	Endangered		River Redhorse (*Moxostoma carinatum*)	Threatened
Gravel Chub (*Erimystax x-punctatus*)	Threatened		Starhead Topminnow (*Fundulus dispar*)	Threatened
Iowa Darter (*Etheostoma exile*)	Threatened		Weed Shiner (*Notropis texanus*)	Endangered
Ironcolor Shiner (*Notropis chalybaeus*)	Threatened		Western Sand Darter (*Ammocrypta clarum*)	Endangered
Greater Redhorse (*Moxostoma valenciennesi*)	Endangered			

Source: INHD (2016).

4.5 Cultural and Archeological Resources

4.5.1 Cultural and Historic Resources

Great Lakes

Prior to European settlement, Native Americans inhabited the Great Lakes region with Algonquin, Iroquois, and Sioux constituting the majority of the population. Around Lake Ontario and in present-day Illinois, Michigan, and Wisconsin, people depended on domesticated plants—mainly corn, beans, and squash—for their survival. In forests where wild game abounded, groups such as the northern Ojibway, Cree, and Assiniboine hunted moose, caribou, bear, and smaller game as well. In the small lakes to the south and west of Lake Superior, the Menominee, Ojibway, Winnebago, and Dakota harvested wild rice. Finally, the southeastern Ojibway, Ottawa, and Huron developed cultures centered around fishing, particularly Lake Trout and whitefish.

European colonization of the Great Lakes region began in the early seventeenth century with the first settlements being built. France, the Netherlands, and Britain all fought for control over the territory, which eventually fell to Britain. During the American Revolution, the region was contested between Britain and the American colonies. In the Peace of Paris (1784), Britain ceded what became known as The Northwest Territory—the area bounded by the Great Lakes, Mississippi, and Ohio Rivers, and the eastern colonies of New York and Pennsylvania – to the United States.

In the mid-1800s, a maritime industry across the Great Lakes began. Fleets of ships served industries around the lakes and helped create port cities, such as Cleveland, Milwaukee, and Chicago. Beginning in the 1840s, the Great Lakes became busy highways for moving wheat, corn, lumber, coal, and iron ore. Midwestern farms sent crops across the lakes to be sold in eastern markets. In the 1870s, lumber from the region's pine forests made Chicago the world's busiest lumber port. The construction of canals to aid navigation helped the Great Lakes prosper.

CAWS/Des Plaines River/Illinois River/Kankakee River

Most prehistoric sites in the Des Plaines, Chicago, and Calumet Rivers watersheds occupy high or well-drained ground, in areas unlikely to be affected by any proposed measures; however, the historic occupation of the Des Plaines valley was focused more on water accessibility, putting the majority of historic sites within the floodplain. The region's history has been driven by its location and the developing waterway system. A trading post was established near the mouth of the Chicago River in the 1770s, followed by Fort Dearborn in 1803. Large-scale settlement in this area of northern Illinois began only after the area was ceded by the Potawatomi Indians to the United States Government in 1816 removing the threat of tribal conflict. Settlement was rapid with large numbers of German immigrants establishing farms in the area in the 1820s and 1830s. Chicago was incorporated in 1833 and granted a city charter in 1837. The city grew based on its favorable location between the GLB and the MRB.

Farming was an early economic driver for the area, with grain and livestock shipped to the markets in Chicago. The first community along this stretch of the Des Plaines River was Lemont. The town was established in 1836 by land speculators gambling on future development stemming from the planned I&M Canal. The community soon served as the agricultural and commercial hub of the region. This area of Illinois experienced rapid population growth based on construction of the I&M Canal from 1837 to 1848. After 1848, Lemont served as a departure point and transit stop for canal traffic. The first railroad was constructed through Lemont in 1854, and the town later developed into a railroad community as canal traffic dwindled. The commercial importance of Lemont faded after 1900 as additional railroads and other transportation links bypassed the town. Lemont's historic buildings and proximity to the I&M Canal National Heritage Corridor have made tourism a major element of the local economy. Recently the town has also developed into a bedroom community for the growing Chicago metropolitan area. Surrounding towns include Lockport, Bolingbrook, Darien, and Romeoville.

The I&M Canal ran 96 mi (155 km) from the Chicago River at the Bridgeport neighborhood in Chicago and joining the Illinois River at LaSalle-Peru, Illinois. It was finished in 1848 and allowed boat transportation between the Great Lakes to the Mississippi River and the Gulf of Mexico. The canal enabled navigation across the Chicago Portage and helped establish Chicago as the transportation hub of the United States, opening before railroads were laid in the area. It ceased transportation operations in 1933. Portions of the canal have been filled. One segment, including a number of engineering structures, between Lockport and LaSalle-Peru, was designated a National Historic Landmark in 1964. Today much of the canal is a long, thin park with canoeing and a 62.5-mi (100-km) hiking and biking trail (constructed on the alignment of the mule tow paths). It also includes museums and historical canal buildings. It was designated the first National Heritage Corridor by the U.S. Congress in 1984.

The CSSC was constructed to divert wastewater away from Chicago by reversing the flow of the Chicago River and directing its flow into the Illinois River drainage. Completed in 1900, the canal was also planned as a replacement for the outdated I&M, thus providing a shipping link between the Great Lakes and the Mississippi Valley. The CSSC is 28 mi (45 km) long and 24 ft (7.3 m) deep, with the width varying from 160 to 200 ft (49 to 61 m). The canal was extended to Joliet by 1907. The Cal-Sag Channel connected the CSSC to the Calumet River in 1922. Construction of the CSSC was the largest earth-moving operation that had been undertaken in North America up to that time and provided important training to a number of engineers who later worked on the Panama Canal. Although not on the National Register of Historic Properties, the system has been named a Civil Engineering Monument of the Millennium by the American Society of Civil Engineers.

The presence of the I&M Canal, and later the CSSC, focused the economy of the project area toward the Des Plaines River valley and the water-based transportation of materials. Industries such as gravel quarries and refineries were developed in the region to take advantage of this transit corridor. Away from the river, agriculture dominated the area's economy until recently. This portion of Illinois remained characterized by farms and widely separated small towns until the explosive development of the 1990s and early 2000s reshaped the area into suburban bedroom communities for Chicago.

A summary of historic properties within the vicinity of the GLMRIS-BR Illinois Waterway Study Area is given in the following paragraphs.

GLMRIS-BR Illinois Waterway Study Area

Twenty-eight individual properties and eight historic districts within the GLMRIS-BR Illinois Waterway Study Area are on the *National Register of Historic Places* (NRHP) (NRHP undated). Only a few of these properties are adjacent to the GLMRIS-BR Site-Specific Study Area. The BRLD and the I&M Canal were listed on the NRHP by the Illinois Historic Preservation Agency (IHPA), while the BRLD was also listed as a Historic American Engineering Record (HAER).

The BRLD was listed as a Historic District on the NRHP in 2004. The district (NRHP 04000163) consists of four contributing structures (i.e., lock, dam, junction lock, and Brandon Road Bridge) (Figure 4-18), one contributing building (i.e., control station), and one noncontributing building (i.e., maintenance shop/pumphouse). The noncontributing building was constructed in 1973, while the other building and structures were part of the original 1927–1933 construction (Henning 2004). This district is part of the

Figure 4-18 View (from top left to bottom right) of Control Station and Lock Looking Southwest; View of Upstream Lock Gate in Closed Position and Auxiliary Gate in Open Position; View of Exterior Detail of Downstream Lock Gates Looking Northwest; and View of Brandon Road Bridge from Downstream Lock Gate Looking South Southwest (Source: Christianson 2008)

greater NRHP Multiple Property Submission for the IWW Navigation System (NRHP 64500877) (Henning 2004).

The I&M Canal, which is located immediately north of the BRLD, was added to the NRHP as a Historic Landmark (NRHP 66000332) (Schroer et al. 1976) in 1979, and is also a National Heritage Corridor. The canal was built between 1839 and 1848. However, the portion of the canal adjacent to the project area is not original construction. Rather, it is a junction lock built circa 1930 in order to keep the canal functioning while the BRLD was being constructed (Figure 4-19). This now abandoned junction lock is on the NRHP as part of the BRLD Historic District.

Figure 4-19 View of Remains of I&M Canal Lock Looking Downstream and Upstream, Respectively (Source: Christianson 2008)

The BRLD has also been recorded as HAER No. IL-164-G (Christianson 2008). This engineering record details all the extant buildings and structures at the BRLD property and describes nonextant features as well. Photographs taken in 1931 and 1932 that accompany the HAER documentation show the extensive disturbance resulting from the construction of the lock and to the left bank, north of the dam (Christianson 2008).

Two properties listed on the NRHP could be affected by a project at BRLD: the structures within the boundaries of the I&M Canal and the BRLD.

Background research was conducted using the following reports to determine the potential for archeological sites within the GLMRIS-BR Site-Specific Study Area: Hajic 2000, Custer and Custer 1997, Henning 2002, Martin et al. 1998, Roberts et al. 1999, and Weedman and Lippel 1975. Martin et al. (1998) describe the presence of an alluvial fan and disturbed soils from landscaping during lock construction in the 1930s. Martin et al. (1998) also describe the BRLD esplanade-associated facilities and grounds as having no to moderate potential to contain undocumented archeological properties. Custer and Custer (1997) documented no known submerged historic properties present within the (bank to bank) channel of the Des Plaines River.

Adjacent to the IWW, the I&M Canal was designated as a National Historic Landmark in January 1964 and listed on the NRHP in October 1966. The I&M Canal was designated the Illinois and Michigan Heritage Canal Corridor in 1984. The T.J. O'Brien Lock, the CSSC, Lockport Lock, BRLD, Dresden Island LD, the Marseilles Lock, Dam, and Canal, and Starved Rock LD may be within the canal corridor boundaries. A portion of the I&M Canal National Heritage corridor is adjacent to the GLMRIS-BR Site-Specific Study Area, consisting of a canal segment, junction lock, and possible loading facility and abandoned barges with ancillary equipment.

In July 1993, IHPA and USACE determined that portions of the IWW Navigation Channel, from IWW RM 80.2 to 327.0, were eligible for listing on the NRHP. In October 1996, the USACE surveyed 331 buildings and structures and identified eight historic districts as eligible to be listed on the NRHP as the Multiple Property Chicago to Grafton, Illinois, Navigable Water Link, 1839–1945. The USACE *Architectural and Engineering Resources of the Illinois Waterway Between 130th Street in Chicago and*

La Grange, Volumes I and II, documents the 72 buildings and structures within the eight historic districts, consisting of the seven lock and dam facilities and the IWW Project Office.

An NRHP nomination form was completed for the BRLD Historic District (i.e., 5 contributing); the Dresden Island Lock and Dam Historic District (i.e., 4 contributing); the Marseilles Lock and Dam Historic District (i.e., 5 contributing); the Starved Rock Lock and Dam Historic District (i.e., 3 contributing); the IWW Project Office (i.e., 10 contributing); the Peoria Lock and Dam Historic District (i.e., 4 contributing); and the LaGrange Lock and Dam Historic District (i.e., 3 contributing), totaling 34 structures and buildings within the IWW Navigation Facilities.

The final NRHP Nomination Registration Form for the IWW Navigation Facilities (http://www.nationalregisterofhistoricplaces.com/il/will/state.html) was accepted by IHPA in January 2002. With the endorsement of USACE Headquarters, the IWW Navigation Facilities nomination forms were formally submitted to the National Park Service (NPS). Following negotiations in early May 2004, the IWW Navigation Facilities were retroactively listed on the NRHP on March 11, 2004. The NPS completed the HAER in 2009 on the historic resources of the IWW Navigation Facilities consisting of seven multiple property historic districts from the La Grange Lock and Dam to the T.J. O'Brien Lock and Controlling Works.

Pursuant to Section 800.3 of the CEQ's regulations promulgated under Section 106 of the National Historic Preservation Act (NHPA) and to meet the responsibilities under the National Environmental Policy Act of 1969 (NEPA), USACE is required to consult with the state historic preservation office and other interested and consulting parties (i.e., Distribution List). A Distribution List of more than 200 mailing addresses of interested and consulting parties was developed for the GLMRIS-BR project to share information concerning historic properties. Agencies, tribes, individuals, organizations, and other interested parties were provided an opportunity to review and comment on the effects of this undertaking during the consultation process. A copy of the Distribution List is included in Appendix K, Coordination.

USACE recognizes that changes to the landscape could affect sacred sites and properties of traditional religious and cultural importance that have significance to tribes and others on the Distribution List. In order to preserve, conserve, and encourage the continuation of the diverse traditional prehistoric, historic, ethnic, and folk cultural traditions within the GLMRIS-BR Site-Specific Study Area, the GLMRIS-BR project will be implemented in compliance with E.O. 13007, NHPA, and other USACE guidance. USACE will continue the identification and notification of traditional religious and sacred sites by tribes and others throughout the planning process. USACE has investigated its trust responsibilities emanating from federally recognized tribes and associated treaty rights and trust responsibilities. No direct trust responsibilities were found to preclude project implementation.

Interested and consulting parties have been, and will continue to be, provided with public meeting announcements, special releases, and notifications of the availability of report(s), including all draft and final agreement documentation, as stipulated by 36 CFR Part 800.14(b)(ii) of the NHPA. Those on the Distribution List may not receive all the enclosures, since specific locations of historic and archaeological properties are subject to protection through nondisclosure under Section 304 of the NHPA. Site location information is not to be released to the public in order to protect the resources at the sites including comments received from federally recognized tribes and others; notification of archeological sites, artifacts, and human remains; site report requests; and changes to the Distribution List.

By letter dated January 22, 2016 (Appendix K, Coordination, letter dated January 22, 2016 IHPA # 002021015), USACE contacted the state historic preservation office, IHPA, Springfield, Illinois, and those on the Distribution List, identifying the GLMRIS-BR Site-Specific Study Area, potential for archeological sites and surveys, and effects on the BRLD Historic District. A portion of the Illinois and

Michigan Canal National Heritage corridor is adjacent to the GLMRIS-BR Site-Specific Study Area, consisting of the aforementioned junction lock, which is also contributing to the BRLD Historic District.

Based on the background research, USACE recommended in the January 22, 2016, correspondence that no aquatic survey be conducted in the main channel (bank to bank) of the Des Plaines River (since no known historic properties are documented as being submerged between IWW RM 285.0 and 286.5. USACE recommended an intensive Phase I archeological survey to search for undocumented terrestrial archeological properties within the GLMRIS-BR Site-Specific Study Area. The Illinois SHPO concurred with the USACE's recommendation (Appendix K, Coordination, letter dated July 15, 2015 IHPA # 002021015). All referenced reports, NRHP forms, and correspondence, comments and reviews are on permanent file with the IHPA, Springfield, Illinois, and USACE, Rock Island District, Rock Island, Illinois.

4.5.2 Infrastructure

Great Lakes

There are currently 63 commercial U.S. federal harbors on the Great Lakes that receive federal assistance. The depths at these harbors range from 16 to 28 ft (4.9–8.5 m). In addition, there are 17 U.S. private deep-draft harbors in the Great Lakes system. Harbors in the GLMRIS-BR System-wide Study Area are listed in Table 4-13.

CAWS/Des Plaines River/Illinois River/Kankakee River

The City of Joliet is the fourth-largest city in Illinois (U.S. Census Bureau 2015) and a suburb of the City of Chicago, the third-largest city in the United States with a population of approximately 2.7 million residents. The physical structures that support and maintain the area's economy, considered herein, are the transportation networks (i.e., water, rail, and roads), sanitary sewers, conveyance of stormwater, and water supply.

A majority of the road network in the Chicago area is utilized for the movement of daily commuters and commodities to destinations within the region. Each day, the Regional Transportation Authority (i.e., Chicago Transportation Authority [CTA], Metropolitan Rail Corporation [Metra], and Pace) provides more than two million rides a day in a six-county region of almost eight million people. A share of this rail and road capacity in the Chicago area gives the nation one of its major hubs for intermodal transfer for rail and truck movements between the East and West Coast markets.

The CAWS is both a natural and an artificial system for the conveyance of sanitary and stormwater. The direction of flow for the CAWS is predominantly toward the MRB, but it has the capacity to convey extreme stormwater overflow events to Lake Michigan. The upper portions of the watersheds that drain the CAWS are nonnavigable waterways and primarily function to drain storm runoff and some sanitary overflow. The primary navigable waters in use are the CSSC, Cal-Sag Channel, and the Calumet River.

In addition to the natural riverine and canal system, the area has invested heavily in the conveyance of stormwater through a complex network of combined sewer and separated stormwater networks. The MWRDGC, in cooperation with USACE, is currently implementing TARP, which will assist with the water quality issues associated with combined sewer overflows in Chicago and 51 suburban communities.

The area's water resources and water infrastructure have supported the economic growth of the region since the settlement of the area in the late eighteenth century. Overland modes of transportation (rail and

Table 4-13 Infrastructure within the Great Lakes (Major U.S. harbors are in bold.)

Federal		Private
Lake Superior	***Lake Michigan (cont.)***	***Lake Superior***
Grand Marais, Minnesota	Frankfort, Michigan	**+ Taconite, Minnesota**
+ **Two Harbors,** Minnesota	Charlevoix, Michigan	**+ Silver Bay, Minnesota**
+ Duluth-Superior, Minnesota/ Wisconsin		
Ashland, Wisconsin	***Lake Huron***	***Lake Michigan***
Ontonagon, Michigan	**+ Alpena, Michigan**	Oak Creek, Wisconsin
+ Presque Isle/Marquette, Michigan	Cheboygan, Michigan	Buffington, IN
Keweenaw Waterway, Michigan	**+ Saginaw, Michigan**	+ Gary, IN
	Harbor Beach, Michigan	Port Dolomite, Michigan
Lake Michigan	+ St. Clair/Detroit Rivers	**Port Inland, Michigan**
+ Saugatuck, Michigan	Marysville, Michigan	**+ Escanaba, Michigan**
+ Menominee/Marinette, MI/Wisconsin	Port of Detroit, Michigan	Petoskey Penn Dixie Harbor, Michigan
+ Green Bay, Wisconsin	+ Detroit River	
Sturgeon Bay, Wisconsin	St. Clair	***Lake Huron***
Kewaunee, Wisconsin	+ Rouge River	**+ Calcite, Michigan**
Two Rivers, Wisconsin	+ Monroe, Michigan	**+ Stoneport, Michigan**
Manitowoc, Wisconsin		Port Gypsum, Michigan
+ Sheboygan, Wisconsin	***Lake Erie***	**Alabaster, Michigan**
Port Washington, Wisconsin	**+ Toledo, Ohio**	+ Drummond Island, Michigan
+ Milwaukee, Wisconsin	**+ Sandusky, Ohio**	
Racine, Wisconsin	**Huron, Ohio**	***Lake Eire***
Kenosha, Wisconsin	**+ Lorain, Ohio**	Marblehead, Ohio
Waukegan, Illinois	**+ Cleveland, Ohio**	
+ Chicago, Illinois	**+ Fairport, Ohio**	
+ Calumet Harbor, Indiana/Illinois, and Lake Calumet	**+ Ashtabula, Ohio**	
+ Indiana Harbor, Indiana	**+ Conneaut, Ohio**	
+ Burns Waterway, Indiana	**Erie, Pennsylvania**	
Michigan City, Indiana	**+ Port of Buffalo, New York**	
St. Joseph, Michigan		
South Haven, Michigan	***Lake Ontario***	
Holland, Michigan	**Rochester, New York**	
Manistique, Michigan	Great Sounds Bay, New York	
Gladstone, Michigan	**Oswego, New York**	
Grand Haven, Michigan	Ogdensburg, New York	
Muskegon, Michigan		
White Lake, Michigan		
Ludington, Michigan		
Manistee Harbor, Michigan		

+ 33 harbors under review.

road) have provided additional economic growth and prosperity during the nineteenth through the twenty-first centuries.

Brandon Road Lock and Dam

The BRLD is located at the southwest edge of Joliet, Illinois, 27 mi (43.4 km) southwest of Chicago. The structure contains one lock chamber and a dam. The lock is 600 ft (182.9 m) long and 110 ft (33.5 m) wide, with a nominal lift of 34 ft (10.4 m). The dam is 2,391 ft (728.8 m) long and contains 8 operational headgates and 21 tainter gates. The lock opened in 1933 as part of the IWW 9 Foot Navigation System project that extended down the upper Mississippi River from Minneapolis–St. Paul to its confluence with the Ohio River and up the IWW to the T.J. O'Brien Lock in Chicago. The IWW 9 Foot Navigation System was initiated when Congress passed the River and Harbor Act of 1927, which authorized funds for its improvement from Utica, Illinois, to St. Louis, Missouri. This legislation was modified in 1930 to include the State of Illinois-initiated project from Utica to Lockport, Illinois, and further modified in 1935 to increase the lower portion to its present 300 ft (91.4 m) width. Extending for approximately 333 mi (535.9 km), the IWW links Lake Michigan with the Mississippi River and connects with the Atlantic Ocean via the Great Lakes Region, the St. Lawrence Seaway, and the Inland Coastal Waterway.

Both commercial and recreational vessels navigate through the BRLD. During warm weather months, the area waterways are used extensively by recreational vessels; those recreational vessels also take part in the Great Loop (refer to Section 4.7.2, Non-Cargo Navigation for more details on the Great Loop). In 2014, there was a total of 3,384 lockages with 284 recreational vessel lockages (Table 4-14).

Built in the 1930s, the lock and dam system on the IWW (including BRLD) was originally designed to handle tow sizes (towboat, plus barges) of up to 600 ft (182.9 m) long. Present-day tows within the IWW routinely push 15 barges with a length up to 1,200 ft (365.8 m); however, a 15-barge tow is not typical for BRLD. Table 4-15 shows the percentage of tows going through the BRLD between 2009 and 2015 that either required only a single lockage or a double lockage. Based on Lock Performance Monitoring System (LPMS) data collected from 2009–2015, only 8% of the tows transiting Brandon Road Lock required two cuts or more to transit.

Table 4-14 Vessel and Lockage Data for BRLD 2014

Category	Quantity
Barges empty	4,239
Barges loaded	7,552
Commercial vessels	2,984
Commercial flotillas	2,812
Commercial lockages/cuts	3,080
Nonvessel lockages	–
Noncommercial vessels	20
Noncommercial flotillas	20
Noncommercial lockages/cuts	20
Percentage of vessels delayed	46%
Recreational vessels	442
Recreational lockages	284
Total vessels	3,446
Total lockages/cuts	3,384

Source: USACE (2016).

Table 4-15 Percentage (%) of Tows Going through BRLD that Either Required or Did Not Require a Double Lockage[a]

Year	% of Tows
2009	
Single lockage	87
Double lockage	13
2010	
Single lockage	93
Double lockage	7
2011	
Single lockage	92
Double lockage	8
2012	
Single lockage	98
Double lockage	2
2013	
Single lockage	92
Double lockage	8
2014	
Single lockage	88
Double lockage	12
2015	
Single lockage	94
Double lockage	6

[a] Source: LPMS

The period between when a vessel arrives at a lock and the time it sufficiently clears the lock area so that another lockage can occur is referred to as the vessel's *transit time*. Specifically, transit time is the sum of processing time and delay time. Processing time is the time related to the actual lockage process, which includes the following five components: approach, entry, chambering, exit, and turnback times. The times to complete each of these components are tracked by direction and can be further broken down according to the type of approach or exit, which is determined by a vessel's interaction with other vessels in the system. Delay time is the time period between when a vessel arrives at the lock and when the lock is ready to begin processing that vessel. Delay can occur because another vessel is utilizing the chamber or the chamber is out of operation.

In Figure 4-20 the yellow polygons indicate the arrival area for vessels wishing to utilize the lock chamber. In general, when a vessel enters this area (i.e., yellow polygon downstream of BRLD), the lock operator begins the data recording process in the LPMS and tags the vessels as arrived. A vessel's transit time begins at this point. If the lock is not being utilized by another vessel, the transiting vessel immediately begins its approach, generally indicated by the yellow polygon downstream of BRLD in Figure 4-20. This begins the vessel's processing time and, more specifically, its approach time. Approach time is generally calculated as the time it takes to transit the yellow polygon area downstream of BRLD and begin its entry into the lock chamber. This is referred to as a long approach. This period may be shortened if the vessel is the next vessel on queue following a vessel in the same direction. In this scenario, a vessel is already utilizing the chamber, and the next vessel traveling in the same direction can tie off on the lock wall behind the first tow. This time is referred to as a short approach.

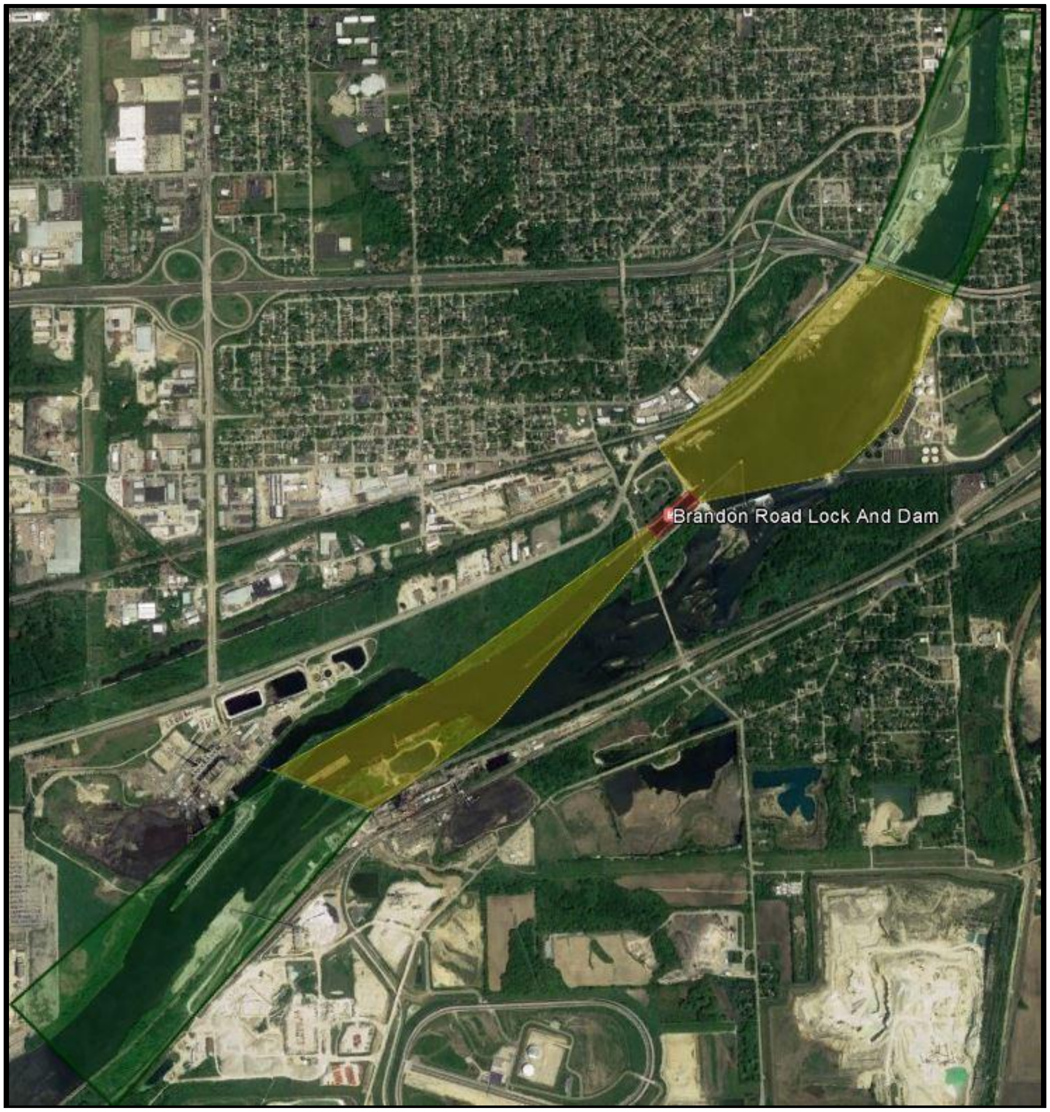


Figure 4-20 Aerial View of BRLD (Yellow polygons indicate the arrival area for vessels wishing to utilize the lock chamber and represent where processing time begins. The red polygon identifies BRLD; movement through the lock and dam is also included in processing time.)

Entry time is the time period between a vessel exiting the yellow polygon area downstream of BRLD (Figure 4-20) and entering the lock chamber, indicated by the red polygon. Once a vessel has tied off in the lock chamber and all gates are closed for the lockage process to begin, entry time is considered complete and the time it takes to raise or lower the water elevation is referred to as chambering time.

Once chambering has been completed and the vessel is ready to continue its transit, the exit time begins. Similar to approach time, this field is divided into a long and a short subclassification. If a vessel is exiting the chamber and there is no vessel coming in the immediate area transiting in the opposite direction, exit time is considered complete as soon as the vessel has cleared the lock gates and the chamber can begin to service another vessel. This is referred to as a short exit. If the exiting vessel is in the way of another vessel wishing to transit the project in the opposite direction, it must clear the area (i.e., upstream yellow polygon in Figure 4-20), and its time is tracked until the vessel has sufficiently cleared the area such that another vessel can begin its approach uninhibited. This interaction is referred to as a long exit. Turnback is the time period between when a vessel exits the chamber and the chamber's elevation can be changed to serve another vessel traveling in the same direction. Approach, entry, chambering, exit, and turnback are all summed to calculate a vessel's processing time. This processing time is then added to the delay time, or the time from when the vessel arrived to when it was able to begin its approach, to calculate the vessel's overall transit time.

The current average transit time for BRLD is approximately 2.10 hr. This includes an average processing time of 1.09 hr and an average delay time of 1.01 hr. In general, lockage delays on the IWW occur due to increased tonnage. Delays can also be attributed to lock component failure or tow-related accidents. At BRLD, lockage delays are most likely a result of aging infrastructure.

Brandon Road Bridge

The Brandon Road Drawbridge located downstream of the BRLD was built in 1932 and rehabilitated in 1949. The bridge spans approximately 198 ft (60.4 m) of the Des Plaines River, just south of Joliet, Illinois. Approximately 6,250 vehicles traverse the bridge daily.

CSSC Electric Dispersal Barrier System

The CSSC electric dispersal barrier system is located in Romeoville, Illinois, in the CSSC, which is a man-made waterway creating the only continuous connection between Lake Michigan and the MRB. The system is operated to deter the movement of invasive fish species between the MRB and the GLB. Each barrier (Table 4-16) is formed of steel electrodes secured to the bottom of the CSSC (Figure 4-21). A low-voltage, pulsing direct current (DC) is generated on land in a control building and sent through the cables, creating an electric field in the water. The electric field is uncomfortable for fish and deters them from swimming across it.

Table 4-16 History of Barrier Completion

CSSC Electric Dispersal Barrier	Fully Operational (Year)
Demonstration Barrier	2002
Barrier IIA	2009
Barrier IIB	2011

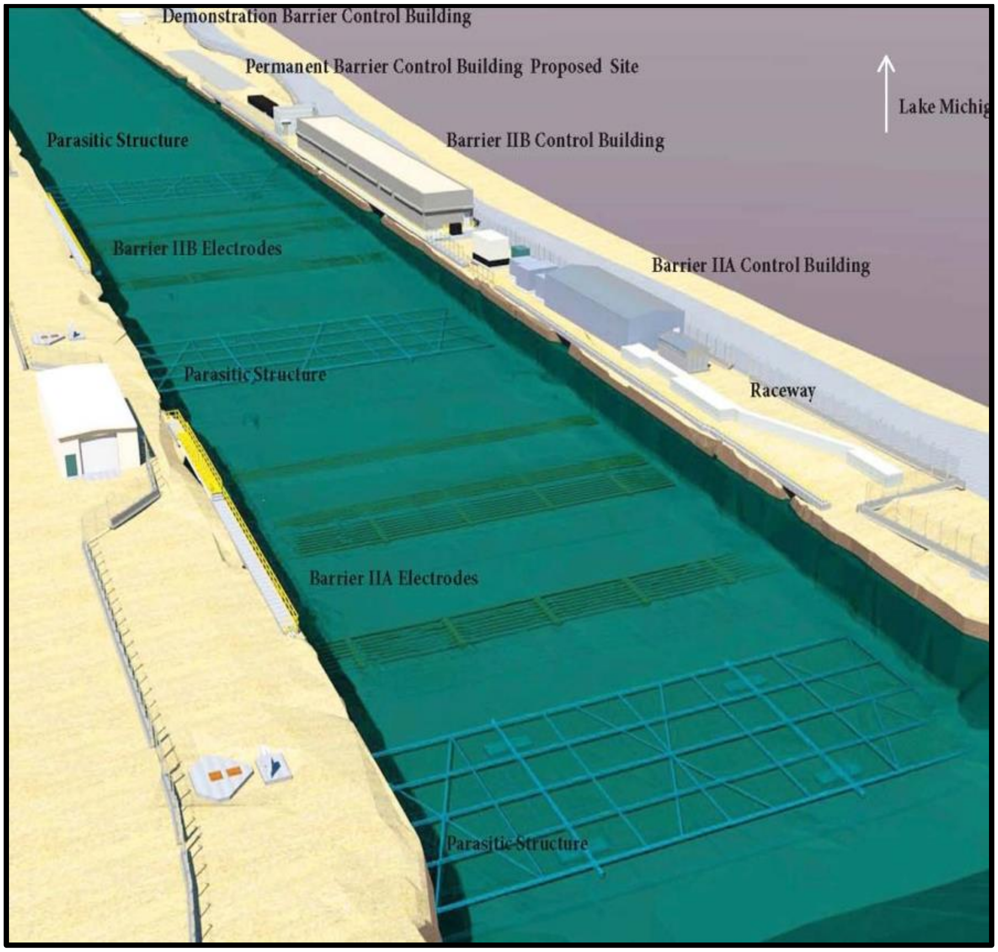


Figure 4-21 Schematic of CSSC Electric Dispersal Barriers

All three CSSC barriers are kept in continuous operation except when maintenance or construction needs require a barrier to be off for safety reasons. Maintenance and construction are scheduled so that at least one (1) barrier is always operational. Construction of the upgraded CSSC Permanent Barrier I began in 2013. Once construction is complete, the barrier will undergo operational and safety testing before full-time activation. An Interim IV Efficacy Study report will be completed and released in fiscal year 2017. The Interim IV report will document the results of ongoing testing and analysis related to the barriers and include a systematic risk assessment of identified barrier failure modes.

The effectiveness of the electric dispersal barrier system is dependent on the electric field parameters (e.g., field strength, pulse frequency, pulse duration), biological factors (e.g., fish species and size), and environmental factors (e.g., water temperature, conductivity, and depth and presence of conductive objects in the water such as boats or debris). Only the electric field parameters can be directly controlled during operation. USACE has sponsored an ongoing research program investigating optimal operating parameters for the barrier system for deterring Asian carp. Several reports have been published (Holliman 2011, 2014a, 2014b; Holliman et al. 2015), and others are under development. Barriers IIA and IIB currently operate at a maximum in-water field strength at the water surface of 2.3 Volts (V)/in. with a pulse frequency of 34 pulses/second and a pulse duration of 2.3 milliseconds. In the laboratory these parameters were found to be effective at immobilizing Asian carp as small as approximately 3–5 in. (76.2–127 mm) in total length. Tests on smaller fish are ongoing, and initial results indicate some combination of larger field strength and/or higher pulse frequencies is necessary to immobilize Asian carp 1–2 in. (25.4–50.8 mm) in total length.

The primary tool used to monitor the barrier system effectiveness is a telemetry-tracking program that uses surrogate species of fish, primarily Common Carp. The program involves surgically implanting individually coded ultrasonic transmitter tags in the fish and then monitoring movements with a series of stationary and mobile hydrophones. A total of 148 tagged fish have been released in the Lockport Pool (Figure 4-14 and Table 4-17) below the barriers. There have been 4.4 million detections of these fish, and no fish have been recorded swimming upstream through any active barrier. There are, however, two instances of transmitters originally implanted into fish downstream being detected upstream of the CSSC barrier system. These tags were not detected on receivers at the barriers and were both identified as deceased at their upstream locations (MRWG 2015).

USACE continues to evaluate and improve the efficacy of the barriers. Current vulnerabilities include preventing small fish transfer, barge entrainment, and field warping of electric field when vessels move through, reverse flows, and loss of power in a waterway that has no control structure, and flood bypass. Actions to reduce the risk of movement by people are beyond the authority of USACE. Movement by animals is possible, but a relatively low risk.

Table 4-17 Pool and Lock and Dam Information for the Upper Illinois Waterway and CAWS

Pools of the Upper Illinois River and CAWS				Lock and Dams of the Upper Illinois River and CAWS		
Pool	River Miles (RM)	Approximate Length mi	Approximate Length km	Lock and Dam	Approximate Distance from CSSC Electric Dispersal Barrier System mi	Approximate Distance from CSSC Electric Dispersal Barrier System km
Lockport Pool				Chicago Lock	31	49.9
CSSC Electric Dispersal Barrier System	296	--		T.J. O'Brien LD	30.5	49.1
				Lockport LD	5	8
To Chicago Lock	291–327	36	57.9	Brandon Road LD	10	16.1
To T.J. O'Brien LD	291–326.5	35.5	57.1			
Brandon Road Pool	286–291	5	8	Dresden Island LD	24.5	39.4
Dresden Island Pool	271.5–286	14.5	23.3	Marseilles LD	49	78.9
Marseilles Pool	247–271.5	24.5	39.4	Starved Rock LD	65	104.6
Starved Rock Pool	231–247	16	25.7	Peoria LD	138.4	222.7
Peoria Pool	157.6–231	73.4	118.1	LaGrange LD	215.8	347.3
LaGrange Pool	80.2–157.6	77.4	124.6			

The Interim I Efficacy Study investigated the potential bypass of the barriers through the Des Plaines River and other neighboring waterways during flood flows. The report recommended blockage of the I&M Canal at a natural flow divide and construction of approximately 13 mi (20.9 km) of a combination of concrete barriers and fine-mesh fencing between the Des Plaines River and CSSC to minimize the risk of fish bypass during high-water events. Construction of these barriers was completed in October 2010.

The CSSC barrier system can fail to perform effectively because of loss of power; equipment failure, operation at less-than-optimal operating parameters, fish moving near irregular surface of sidewalls; and variations in the electric field due to metal vessel hulls. Risks due to loss of power or equipment failure are reduced by preventive maintenance and installation of redundant backup systems. The effect of fish size is very significant when barrier operating parameters are being evaluated. The operating parameters must be selected for the smallest fish size of concern. Environmental factors can also change the effectiveness of a barrier for a given size of fish. For example, initial results of tests of temperature variations indicate the barriers are less effective in warmer water. Small fish may be able to utilize any reduced electric field strength near irregularities in the canal walls to pass through the electric fields. This concern is based on observed behavior during laboratory testing in which fish appeared to prefer to stay in a recess in a flume wall. Field measurements indicate that the electrical field strength temporarily drops when large metal hulls are over the barrier electrodes, providing a potential opening for fish to move across the barrier.

Three ways that vessels could inadvertently transport fish across the barrier are movement in ballast or bilge water, fish jumping on vessels, and entrainment within water movements created by vessel movement or impingement on the vessel itself. The first two are relatively low risks (USCG 2013a, 2013b). Field and laboratory studies on the potential entrainment of fish by moving vessels have been completed (USFWS 2014), and in every model or on-site field test completed to date at least some fish were moved across the barriers.

Results of a 2011 indoor scaled physical model (1:16:7) study indicated that fish could become entrained within the recesses between barges or trapped in the residual currents and carried past simulated control structures (e.g., electric fish barriers) for a variety of tow configurations, speeds, and directions. In some cases, fish were carried over the scaled-up distance of 2,000 ft (609.6 m).

Several studies have been conducted near the CSSC barrier system by the USFWS to determine the efficacy of the barriers. These studies primarily focus on whether and how small fish interact with the barriers and in what manner vessel traffic affects these barriers. In 2013, USFWS deployed fixed DIDSON cameras at the CSSC barrier system to ensonify the barrier IIB narrow array along the canal wall where the electrical fields are the strongest. Video footage was collected in 10-minute increments, and video was reviewed in the laboratory to determine if fish were able to penetrate the barrier. All video footage was taken while barrier IIA was under maintenance and not operational. Results indicated that 44 out of 72 (61%) 10-minute videos captured at least one occurrence of a school of fish, estimated to be between 2 and 4 in. (50.8 and 101.6 mm) in length, passed through the barrier in an upstream direction. The study was repeated in 2014; however, this time barriers IIA and IIB were operational, and fish densities near the barriers were low due to the time of year. No fish were observed passing through the barrier IIB narrow array in the upstream direction. A similar follow-up study was conducted in 2016. DIDSON multibeam sonar was used to observe wild fish near the narrow array of barrier IIB during passage of barge vessels, while the USACE measured surface voltage at the narrow array and the USGS collected flow measurements.

Preliminary data suggested that a drop and warping in surface voltage from barge interference and reverse flows induced by water displacement during downstream passage may assist in the upstream movement of fish through the CSSC barrier system. During the study, the DIDSON observed fish moving upstream through the barrier system during downstream passage on 17 out of 19 trials. Fish observed on the DIDSON had an average length of 2.4 in. (61 mm), and physical captures confirmed the species of fish to be a mixture of Gizzard Shad and Threadfin Shad. The study was conducted at a known time when small shad are very abundant just downstream of the barrier to provide a worst-case scenario. These data are still being analyzed, and final results are expected to be available in 2017.

Additional studies by USFWS investigated how barge junctions may facilitate the movement of fish through the barrier system. Research conducted in 2012 demonstrated that large bodied fish can move through the demonstration barrier when placed into a cage within a barge junction. These data resulted in a follow-up study in 2013 using fish tethered to small bobbers by fishing line. USFWS released tethered fish either directly into the various junction wedges of barges to evaluate the likelihood of entrainment when the fish had the ability to leave under its own volition or they were released in advance of an upstream bound barge to assess the likelihood of entrainment into the junction wedges after a barge strike. During the trials, several barge configurations were tested. In total, 340 Gizzard Shad were tethered resulting in 21 breaches of the dispersal barrier after direct placement into a junction, and an additional 20 breached after they were deployed in front of the moving barge. These fish ranged from 3.9 to 9.7 in. (99–247 mm) in total length.

As a follow-up to the 2013 study, USFWS conducted additional tests in 2015. These tests resulted in releasing fin-clipped Golden Shiners into barge junctions while traversing both the BRLD and the CSSC barrier system. The data demonstrated that Golden Shiners with fin clips were found within the junctions after traversing both BRLD and the CSSC barrier system. These fish were captured post transit via a cast net. As a pilot study, USFWS then stocked around 2,000 fin-clipped Golden Shiners into the barge junction and had the tow transit in the upstream direction from the Interstate 80 Bridge through the Lockport LD and finally through the CSSC barrier system, resulting in a distance of approximately 10 mi (16.1 km). Once the barge stopped, USFWS personnel were still able to capture some of the fin-clipped Golden Shiners, demonstrating that small fish may be entrained for long distances. It is important to note that USFWS reported that a strong reverse by the tow results in the barge junctions being flushed and may be used as a mitigation tool. In a similar study, adult Asian carp were placed into the junctions while the barges were in transit. All adult Asian carp quickly exited the barge junctions on their own volition; therefore, entrainment of adult Asian carp may not be viable since they are stronger swimmers than small fish. Mitigation measures to minimize the risk of barge-assisted fish passage upstream of the barrier are currently being investigated; however, their effectiveness is unknown at this time.

Flow reversals in the CSSC caused by wind, lock operations, and other hydraulic conditions are another way fish can pass through the CSSC barrier system. If a fish is immobilized by a barrier and remains afloat, a relatively low reverse flow at the surface could move it across the barrier.

Hydropower

Since 1978, there has been interest in developing the BRLD site for hydropower. The Village of Rockdale, Illinois, received a preliminary permit from the Federal Energy Regulatory Commission (FERC) on September 29, 1981, for a period of 24 months, giving the village priority of application for a license to develop hydropower at BRLD. Prior to this, USACE had initiated a study to determine the engineering, environmental, and economic feasibility of developing the hydroelectric potential of this site. A final feasibility report for hydropower at the BRLD was completed in January 1982. In the final feasibility report, a total of 11 different installations were evaluated. The recommended plan was a 9.9-MW installed capacity powerhouse with an average annual energy production of 61,050,000 kWh.

The plant would have three 3,000-mm tubular turbines in a powerhouse that would be approximately 61 ft (18.6 m) long by 90 ft (27.4 m) wide.

Under the Federal Power Act and FERC regulations, a holder of a preliminary permit has three years to apply for a license application. After three years, the potential applicant loses priority for developing the site. Therefore, Northern Illinois Hydropower, LLC (NIH) applied to the FERC and received a preliminary permit in November 2006 to undertake site review and development for a hydroelectric project at BRLD. In May 2009, a final license application was submitted to the FERC by NIH for the BRLD hydroelectric project (FERC Project No. 12717). According to the final license application, the proposed hydroelectric project would include a turbine generating system, with an approximate maximum head of 34.5 ft (10.5 m). The expected gross annual generation of the project was approximately 59,000 MWh (FERC 2016). In 2014, NIH applied for a Section 401 water quality certification of the CWA for impacts associated with the construction of a new powerhouse at the BRLD (IEPA 2014a). The IEPA made a tentative determination to issue the Section 401 water quality certification.

4.6 Socioeconomic and Human Resources

Great Lakes

The GLB accounts for approximately 28.9% of the total U.S. population (Tables 4-18 and 4-19). The five largest metropolitan areas of Chicago, Detroit, Cleveland, Milwaukee, and Buffalo account for a large portion of the regional population, which is approximately 18 million (2010 Census).

Table 4-18 Socioeconomic Information for the Great Lakes Basin (Based on 2010 U.S. Census Data)[a]

State	Estimated Population within the GLB	Median Home Value	Median Household Income
Minnesota	72,085	$178,667	$48,634
Wisconsin	137,977	$150,960	$50,066
Illinois	2,971,063	$234,750	$66,351
Indiana	255,479	$141,633	$53,184
Michigan	113,246	$112,641	$43,333
Ohio	342,227	$127,238	$48,518
Pennsylvania	278,045	$117,200	$45,703
New York	238,761	$107,055	$48,632
Great Lakes States Average	551,110	$146,268	$50,552

[a] Information obtained from the United States Census Bureau, 2015.

Table 4-19 Racial Composition and Education Attainment Statistics for the Great Lakes Basin (Based on 2010 U.S. Census Data)[a]

State	Racial Composition				Education Attainment	
	White	Black	American Indian or Alaska Native	Asian	Graduated High school	Bachelor's Degree or Higher
Minnesota	92.2%	0.9%	4.0%	0.7%	94.2%	30.1%
Wisconsin	90.4%	3.8%	6.9%	1.6%	91.1%	23.9%
Illinois	74.1%	16.0%	0.9%	7.2%	87.0%	39.0%
Indiana	83.1%	13.5%	0.4%	1.2%	88.5%	21.2%
Michigan	90.7%	3.7%	2.7%	0.8%	89.2%	20.0%
Ohio	85.9%	10.1%	0.4%	1.5%	89.1%	22.7%
Pennsylvania	88.5%	7.6%	0.3%	1.4%	90.4%	25.6%
New York	88.9%	6.4%	1.3%	1.3%	88.0%	22.4%
Great Lakes States Average	86.7%	7.7%	2.1%	2.0%	89.7%	25.6%

[a] Information obtained from the United States Census Bureau, 2015.

CAWS/Des Plaines River/Illinois River/Kankakee River

The GLMRIS-BR Site-Specific Study Area is located near the town of Joliet in Will County, Illinois. Joliet, Will County, and Illinois have all experienced population increases since 1980. For 2014, the estimated population for Joliet (based on 2010 Census) was 147,928, with a median home value of $171,700 and a median household income of $61,744. For Will County, the estimated 2014 population was 685,419, with a median home value of $219,400 and a median household income of $76,147. In comparison, the estimated 2014 population for the entire state of Illinois was 12,880,580, with a median home value of $182,300 and a median household income of $56,797 (U.S. Census Bureau 2015).

In 2010, Joliet's racial composition consisted of the following (Table 4-20): white, 67.5%; black, 16.0%; American Indian and Alaska Native, 0.3%; and Asian, 1.9%. Persons reporting two or more races accounted for 2.9%. In comparison, Will County reported the following racial composition: white, 80.6%; black, 11.8%; American Indian and Alaska Native, 0.3%; Asian, 5.4%; and persons reporting two or more races, 2.3% (U.S. Census Bureau 2015).

Education attainment in Joliet showed 83.7% of the population age 25 years or older having graduated high school and 23.4% having obtained a bachelor's degree or higher from 2010 to 2014. Educational attainment in Will County showed 90.5% of the population age 25 years or older having graduated high school and 32.6% having obtained a bachelor's degree or higher from 2010 to 2014. In comparison, the state of Illinois showed 87.6% of the population age 25 years or older having graduated high school and 31.9% having obtained a bachelor's degree or higher for the same period.

Table 4-20 Social Composition of Illinois, Will County, and Joliet (Based on 2010 U.S. Census Data)[a]

Area	White	Black	American Indian and Alaska Native	Asian	White (Hispanic)	White (Non-Hispanic)
Illinois	77.5%	14.7%	0.3%	5.3%	16.7%	62.3%
Will County	80.6%	11.8%	0.3%	5.4%	16.6%	65.3%
Joliet	67.5%	16.0%	0.3%	1.9%	27.8%	53.0%

[a] Information obtained from the United States Census Bureau, 2015.

4.6.1 Recreation

Great Lakes

The Great Lakes provide a popular tourist attraction. The region is home to many park systems, conservation and wilderness areas, and beaches. The major recreational activities in the Great Lakes are recreational fishing, hunting, boating, beach and lakefront use, and wildlife viewing (USFWS 2016). As presented in the GLMRIS Report (USACE 2014a), it is estimated that the annual economic contribution of recreational fishing in and around the GLB is approximately $13.3 billion (2012 price level). Refer to Section 4.6.2, Fishing, and Section 4.7.2, Non-Cargo Navigation, for a discussion of recreational fishing and non-cargo navigation, respectively.

CAWS/Des Plaines River/Illinois River/Kankakee River

In general, within the region of the CAWS there are numerous community and county parks that provide a wide range of public recreational facilities, including tennis courts, fieldhouses, and soccer and baseball facilities. Recreational opportunities include outdoor sports, picnicking, bird watching, hunting, fishing, and boating. The Cal-Sag portion of the CAWS also includes a number of recreational opportunities including boat launches, forest preserves and other natural areas. Area waterways are utilized extensively during warm weather months by recreational vessels. Refer to Section 4.6.2, Fishing, and Section 4.7.2, Non-Cargo Navigation, for a discussion of recreational fishing and non-cargo navigation, respectively.

The Des Plaines River presents a wide variety of recreational opportunities for residents and visitors alike. With almost 40,000 ac (16,187.4 ha) of conservation and natural areas (e.g., state, county, local, and private), the Des Plaines River watershed provides hiking, biking, horseback riding, cross-country ski trails, golf courses, and boating opportunities for the public. On the lower Des Plaines River and, more specifically, downstream of BRLD in the tailwaters, duck hunting is prevalent. Refer to Section 4.6.2, Fishing, and Section 4.7.2, Non-Cargo Navigation, for a discussion of recreational fishing and recreational navigation.

The Illinois River ranks among Illinois' top recreational resources. According to the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, outdoor recreation activities contribute significantly to Illinois' economy – more than $4 billion in economic output, 42,000 jobs, and $315 million in state and local taxes.

The Kankakee River provides recreational opportunities similar to those of the Des Plaines River. It remains a popular destination for recreational canoeing and fishing for warm-water fish species. Several parks along the river as well as a fish and wildlife area provide additional recreational opportunities.

4.6.2 Fishing

Great Lakes

Commercial Fishing

Primary commercial catches include whitefish, smelt, Walleye, and Yellow Perch. The average annual harvest level from the most recent five years of NOAA data at the time of the analysis (2005–2009) for U.S. waters within the GLB is estimated to be 18 million pounds, with an associated dockside value of about $20 million at a 2013 price level (Figure 4-23). Table 4-21 displays the average harvest level and dockside value for each of the Great Lakes during this time period. Lake Michigan and Lake Erie support the greatest amount of commercial fish harvest and dockside value.

Table 4-21 Average Annual Harvest Levels and Values by Great Lake (2005–2019)

Lake	Harvest Level[a] (lb)	Percentage of Total Harvest Level (%)	Dockside Value[a] ($)	Percentage of Total Dockside Value (%)
Lake Michigan	6,363,000	32.9	8,920,000	39.6
Lake Erie	4,880,000	25.2	5,013,000	22.3
Lake Huron	3,539,000	18.3	4,553,000	20.2
Lake Superior	4,541,000	23.5	3,990,000	17.7
Lake Ontario	21,000	0.1	32,000	0.1
Total All Lakes	19,345,000	100.0	22,506,000	100.0

[a] Harvest levels and values reflect a five-year average from 2005 through 2009. All values are rounded to the nearest thousand. Dockside values are at a 2013 price level. The data do not reflect Canadian harvests. Dockside value is the sales price of the harvest amount at the dock prior to any further sales or processing.

Recreational Fishing

Recreational fishing is a tourist attraction in the Great Lakes region and has been responsible for the introduction of nonnative fish species such as salmon, which were purposely introduced to support sport fishing activity. Based on fishing license sales data provided by the states, it was estimated that 6.6 million anglers lived and fished in the 12-state GLMRIS-BR System-wide Study Area in 2011. These anglers spent an estimated 62.9 million days fishing in those portions of the GLB below barriers (e.g., dams) impassable to fish. The average net value per angler day, estimated from Cornell University's recreational fishing model, was $19.52 (fiscal year 2013 price levels). The aggregate net value of recreational fishing in those portions of the GLB below barriers impassable to fish is estimated to be $1.228 billion for calendar year 2011 (Figure 4-23).

Charter Fishing

In 2011, there were an estimated 1,904 active licensed charter captains in the Great Lakes. Of these, approximately 1,700 captains operated as independent small businesses, while another estimated 200 were non-boat-owning captains. Together they generated between $34.4 million and $37.8 million in annual sales and salary (fiscal year 2011 price levels) (Figure 4-23).

Subsistence Fishing

The GLMRIS Report (USACE 2014a) identified that 16 tribes engage in subsistence fishing within the MRB and GLB under one of four treaties, mostly in the western GLB (Figure 4-22). Subsistence harvesting is an important part of tribal cultural heritage that has value that extends beyond economics and is an important element in maintaining the sovereign status of the tribes. The annual value of subsistence fishing activities to an individual subsistence household would be between $15,000 and $16,500 (fiscal year 2011 price levels). While a small proportion of tribal members engage in subsistence fishing, the subsistence harvest is shared according to traditional priorities throughout the communities. Nontreaty tribes engage in less subsistence fishing, especially those with reservations close to urban areas where water bodies are more likely to be polluted, and tribal members are more likely to be employed off of the reservation. The main target species for subsistence fishers are Walleye, whitefish, Yellow Perch, and Trout; Lake Sturgeon (*Acipenser fulvescens*) is culturally important.

Currently, 37 federally recognized tribes reside within the U.S. portion of the GLB and upper MRB. Table 4-22 lists the tribes within the GLMRIS-BR System-wide Study Area and shows the locations of tribal reservations within the GLMRIS-BR System-wide Study Area. These tribes, most of which are located near the Great Lakes, are descendants of a larger indigenous population that was reduced and displaced by the arrival of European immigrants. In the face of continued immigration, many tribes in the GLMRIS-BR System-wide Study Area were forced to move west. Others sought to remain in their native lands and, through a series of treaties, ceded most of their traditional lands, retaining only small reserves (Figure 4-22).

Fishing, hunting, and gathering were important elements of these tribes' traditional ways of life, providing most or all of their subsistence. In some but not all treaties, tribes reserved the right to hunt, fish, and gather on the lands they ceded, since they perceived that this right was essential to their survival and their way of life. Sixteen federally recognized tribes retain hunting, fishing, and gathering rights under the treaties, and all these tribes continue subsistence harvesting in the GLB and upper MRB to some extent today. Among the other federally recognized tribes in the GLMRIS-BR System-wide Study Area, those with reservations that provide access to major waterways still practice subsistence fishing. Many of the tribes that do not have access to rivers and streams on their reservation fish under the applicable state regulations on public land or purchase lakes for subsistence fishing purposes. In addition, tribes that live close to contaminated waters have programs in place to help restore these waters in order to provide their members fishing opportunities.

Four separate treaties reserve subsistence hunting, gathering, and fishing rights for tribes in ceded territories in Michigan, Wisconsin, and Minnesota. Both the Ojibwe (Chippewa) and Ottawa bands retain these rights under the treaties, and both are also engaged in subsistence activities. Although harvests associated with these activities are small, the activities do play a large role in the tribes' cultural identities. Usually, only a small number of tribal members are fully engaged in subsistence harvesting, but their harvest is shared with many throughout the community. Typically, some of the people in the tribes are unable to purchase fish and would go without fish if they were unable to share in the subsistence harvest. Thus, subsistence harvesting is a core value for these bands, and the right to fish and hunt for subsistence

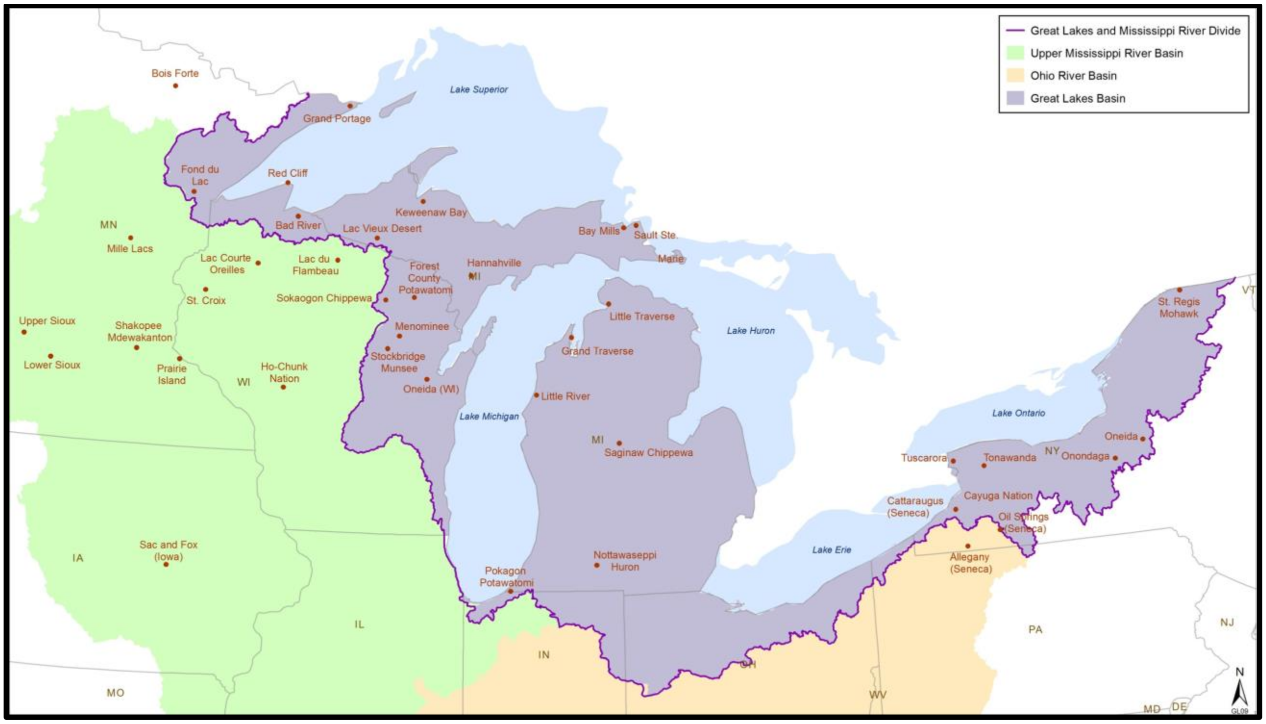


Figure 4-22 Indian Reservations in the GLMRIS-BR System-Wide Study Area

Table 4-22 Federally Recognized Tribes within the GLMRIS-BR System-Wide Study Area

Treaty Tribe	State
Grand Portage Band of Lake Superior Chippewa Indians	Wisconsin
Fond du Lac Band of Lake Superior Chippewa Indians	Minnesota
Mille Lacs Band of Ojibwe	Minnesota
St. Croix Chippewa Indians of Wisconsin	Wisconsin
Lac Courte Oreilles Band of Ojibwe	Wisconsin
Lac du Flambeau Band of Lake Superior Chippewa Indians	Wisconsin
Lac Vieux Desert Band of Lake Superior Chippewa Indians	Michigan
Bad River Band of Lake Superior Chippewa Tribe	Wisconsin
Red Cliff Band of Lake Superior Chippewa Indians	Wisconsin
Keweenaw Bay Indian Community	Michigan
Sokaogon Chippewa Community	Wisconsin
Sault Ste. Marie Tribe of Chippewa Indians	Michigan
Bay Mills Indian Community	Michigan
Little Traverse Bay Bands of Odawa Indians	Michigan
Little River Band of Ottawa Indians	Michigan
Grand Traverse Band of Ottawa and Chippewa Indians	Michigan

Table 4-22 (Cont.)

Nontreaty Tribe	State
Prairie Island Indian Community	Minnesota
Shakopee Mdewakanton Sioux Community	Minnesota
Lower Sioux Indian Community	Minnesota
Upper Sioux Community of Minnesota	Minnesota
Sac and Fox Tribe of the Mississippi in Iowa	Minnesota
Menominee Indian Tribe of Wisconsin	Wisconsin
Oneida Tribe of Indians of Wisconsin	Wisconsin
Ho-Chunk Nation	Wisconsin
Hannahville Indian Community	Michigan
Pokagon Band of Potawatomi Indians	Michigan
Nottawaseppi Huron Band of the Potawatomi	Michigan
Forest County Potawatomi	Wisconsin
Stockbridge-Munsee Community	Wisconsin
Saginaw Chippewa Indian Tribe of Michigan	Michigan
St. Regis Mohawk Tribe	New York
Seneca Nation of Indians	New York
Oneida Nation of New York	New York
Onondaga Nation	New York
Tuscarora Nation	New York
Tonawanda Band of Seneca Indians	New York
Cayuga Nation	New York

is valued by all, even those who are not currently engaged in the practice. It is part of the tribes' cultural identity and an indication of their status as sovereign entities.

Data on subsistence fish harvests in the Great Lakes and tributaries were not available from a single source, and only one source, the Chippewa Ottawa Resource Authority (CORA), provided comprehensive data over a recent time period. CORA data were limited to subsistence fishing in Michigan state waters that were ceded under the Treaty of March 28, 1836, including portions of Lake Huron, Lake Michigan, Lake Superior, and St. Mary's River, which connects Lake Superior with Lake Huron. The CORA Michigan data included 25 species of fish and 2 fishing methods—gill net and spear. The data received from CORA were from 2006–2010. These numbers are based on reported data and have not been extrapolated to estimate total harvests, and as a result, many underrepresent subsistence harvests.

The subsistence catch in Michigan waters in Lake Michigan was larger than that in the other two lakes. On average 11,357 lb of fish were caught over the period from 2006–2010, with 11,240 lb (98.9%) being caught by gill net and 117 lb (1.1%) being caught by spear fishing. In Lake Superior, 4,752 lb (99.5%) were caught by gill net and 23 lb (0.5%) by spear fishing. The subsistence catches in St. Mary's River (i.e., 1,479 lb) and in Lake Huron (i.e., 1,383 lb) were relatively small.

The subsistence fish caught in the largest quantity in Michigan waters in Lake Michigan was Walleye, with 4,432 lb caught by gill net and 93 lb caught by spear fishing over the period from 2006 through 2010 (Table 4-23). Other fish caught in larger numbers were whitefish (1,531 lb) and suckers (1,120 lb); all

Table 4-23 Reported Harvest for CORA-Licensed Subsistence Fishing in Michigan by Method: Annual Average Weight, 2006–2010

Fish Species	Reported Harvest (lb)							
	Lake Michigan		Lake Huron		Lake Superior		St. Mary's River	
	Gill Net	Spear	Gill Net	Spear	Gill Net	Spear	Gill Net	Spear
Atlantic Salmon	0	0	0	0	0	0	0	1
Bass	85	0	21	0	2	0	10	0
Brown Trout	14	0	13	0	12	0	2	1
Bullhead	13	0	1	0	0	0	13	0
Burbot	210	0	10	0	22	0	23	0
Common Carp	471	0	10	0	0	0	6	0
Catfish	0	0	34	0	0	0	0	0
Freshwater Drum	29	0	0	0	0	0	4	0
Gizzard Shad	20	0	0	0	0	0	0	0
Lake Herring	0	0	52	0	655	1	134	3
Lake Trout	739	0	245	0	246	0	4	0
Menominee (Round Whitefish)	70	0	52	0	145	0	53	0
Musky	0	0	0	0	6	0	5	0
Northern Pike	515	0	9	0	56	0	93	28
Pink Salmon	0	0	0	0	5	0	4	0
Rainbow Trout	314	0	0	0	124	0	11	2
Rockbass	17	0	0	0	0	0	1	0
Salmon	180	25	4	5	1,313	25	223	29
Smelt	1	0	0	0	347	0	36	0
Splake	6	0	0	0	10	0	0	0
Steelhead	870	0	6	0	108	0	14	0
Suckers	1,120	0	33	0	392	0	169	0
Walleye	4,432	93	321	0	151	17	254	11
Whitefish	1,531	0	513	0	1,142	3	332	8
Yellow Perch	602	0	60	0	16	0	89	0
Total	11,240	117	1,383	5	4,752	23	1,479	84

Source: CORA (2010).

were caught with gill nets. A fairly large share of salmon caught in Lake Michigan was caught with spears (i.e., 25 lb of a total of 180 lb, or 13.8%). None of the other species caught for subsistence use in Lake Michigan amounted to more than 1,000 lb on average over the period from 2006 through 2010, and all were caught with gill nets.

In Lake Superior, salmon (i.e., 1,313 lb) and whitefish (i.e., 1,142 lb) were the only species for which more than 1,000 lb was landed. Salmon was the only fish caught regularly with spears (i.e., 25 lb of a total of 1,313 lb caught, or 1.9%). In St. Mary's River and Lake Huron, whitefish was the most numerous fish caught for subsistence, but no fish caught in either area amounted to more than 500 lb on average over the period from 2006 through 2010. Although almost all fish taken in both areas were caught with gill nets, a larger-than-average amount of salmon (i.e., 29 lb from a total catch of 223 lb, or 13.0%) and Northern Pike (i.e., 28 lb from a total catch of 93 lb, or 30.1%) was caught in St. Mary's River by using spear-fishing methods.

Professional Fishing Tournaments

Each tournament is regulated by its own set of rules, which generally vary in specificity or strictness depending on the seriousness and size of the tournament. General elements covered by tournament rules include entry fees, tournament dates and times, fishing boundaries, team structures, boat size and equipment descriptions, catch limits, fish-weighing or -measuring procedures, and point calculation and winner determination. Tournaments are held for the purpose of competing and winning prizes, or as fundraisers for charitable organizations. Formats for tournaments include one-day or weekend catch-and-release events, derby-style events that span an entire season, or tournament trails where anglers compete in a series of weekend tournaments and obtain cumulative points to determine an overall winner. The availability of information on tournament fishing varies by state. On the Great Lakes, it is estimated that states such as Wisconsin or Minnesota host 450 to 700 fishing tournaments per year (Figure 4-23). It is estimated that there are fewer tournaments in states such as Illinois or Indiana. Based on a cursory analysis of fishing tournaments, bass fishing events seem to be particularly popular in all water bodies researched.

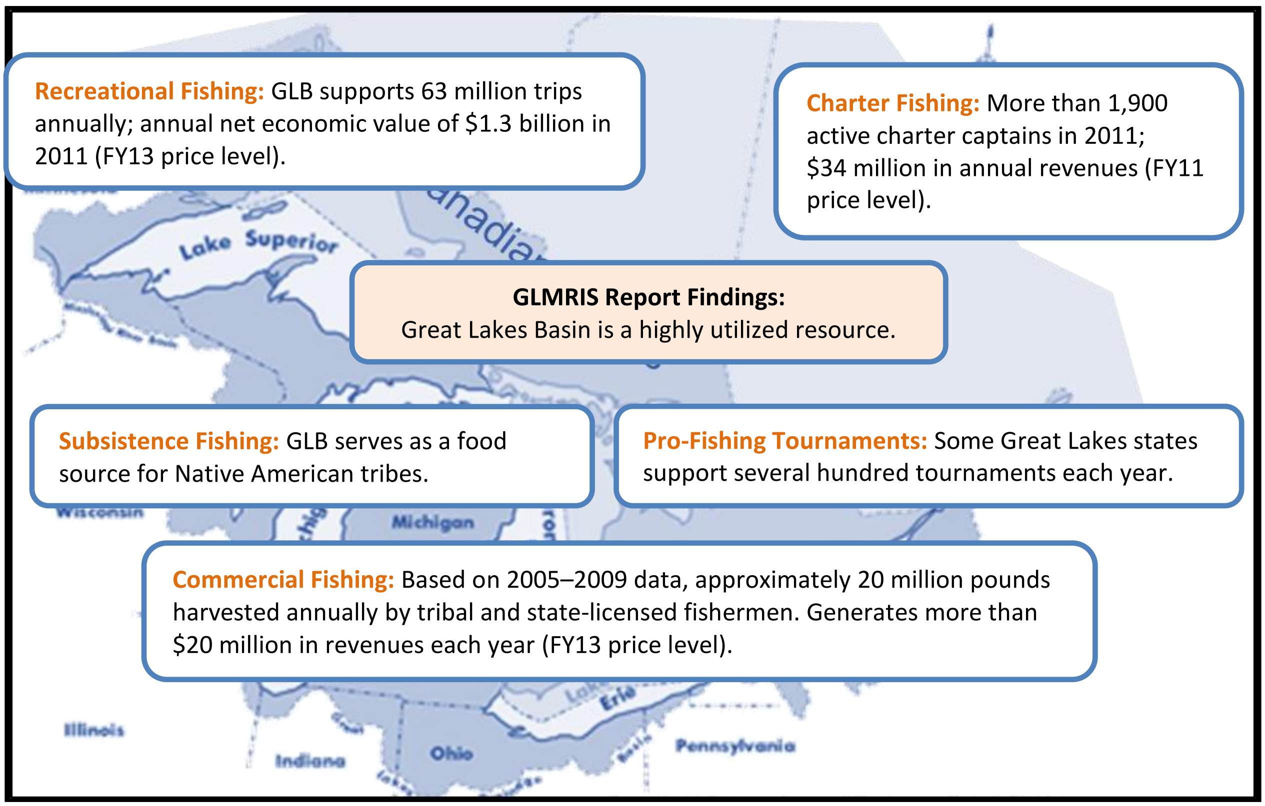


Figure 4-23 Key Findings from GLMRIS Report Fisheries Baseline Economic Assessment (Source: USACE 2014a)

CAWS/Des Plaines River/Illinois River/Kankakee River

The Des Plaines River supports a thriving urban fishery with numerous opportunities for anglers. The Des Plaines River has the highest catch rate for Northern Pike over any other river in Illinois. In the fall, Walleye are a common catch throughout the river. Anglers can also expect to catch Channel Catfish, Smallmouth Bass, Sauger, Rock Bass, crappie, Largemouth Bass, and Bluegill. On the lower Des Plaines River and, more specifically, downstream of BRLD in the tailwaters, recreational fishing is prevalent. Commercial fishing is not permitted upstream of the Route 89 Highway Bridge, which is near Spring Valley, Illinois. There are portions of the upper Illinois River/lower Des Plaines River that are open to commercial removal of Asian Carp, but require a restricted period contract with the Illinois DNR (Illinois DNR 2012). Commercial fishing does not occur within the CAWS.

Commercial fishing in the Illinois River has been an integral part of the local economy for many years. Common Carp were introduced in 1885 and became an important part of the Illinois River commercial fishery by 1890. Beginning in 1900 with the operation of the CSSC, this fishery produced a higher percentage of the U.S. harvest of freshwater fish, excluding anadromous species (i.e., species that migrate up rivers from the lake to spawn), than any other North American river. Since the canal caused a rise in the water level in the Illinois River from the diversion of water from Lake Michigan, commercial catch rates increased from about 8 million lb in 1900 to more than 20 million lb in 1908 (Starrett 1972). However, this water contained raw sewage from the residents of Chicago and soon began degrading water quality. Additional damage to the river resulted between 1910 and 1920, when levees were built to create more tillable land. By the 1920s, many believed that above Starved Rock Dam, the river was devoid of fish.

A decline continued until the 1970s, when industries and wastewater treatment plants were required to improve the quality of discharges. Since the 1970s, the river has experienced fewer fish kills, and there has been an increase in fish biodiversity. Today's commercial fisherman can expect to catch 40–50 lb/day (Illinois State Museum 2016). In regard to the Kankakee River, sport fishing is common throughout; however, commercial fishing is prohibited (Kwak 1993).

4.7 Navigation

4.7.1 Commercial Navigation

Great Lakes

The Great Lakes Navigation System (GLNS) is a complex deepwater navigation system stretching 2,400 mi (2,862 km) through all five Great Lakes and connecting channels from Duluth, Minnesota, to Ogdensburg, New York (USACE 2013g). It is a nonlinear system of interdependent locks, ports, harbors, navigational channels, dredged material disposal facilities, and navigation structures. The U.S. portion of the system includes 140 harbors (i.e., 60 commercial and 80 recreational), 3 navigation lock facilities, 104 mi (167.4 km) of breakwaters and jetties, and more than 600 mi (965.6 km) of maintained navigation channels. The GLNS is a vital component of America's transportation system. Federal commercial ports on the Great Lakes are linked in trade with each other, with Canadian ports, and with ports throughout the rest of the world. Unlike ports along the eastern and western U.S. coasts that compete against each other for trade business, Great Lakes ports are part of an overall system that competes against other modes of transportation that are less economically viable and far less environmentally sustainable. On average, 145 million tons of commodities is transported between and within U.S. ports located on the waterways of the Great Lakes system annually (2006–2010). In addition, the GLNS accounts for approximately 10% of all U.S. waterborne domestic traffic (USACE 2013g).

CAWS/Des Plaines River/Illinois River/Kankakee River

The Chicago River, CSSC, and the Cal-Sag Channel are the primary navigation channels that make up the Chicago portion of the IWW, also known as the CAWS. Commercial waterway navigation provides the most cost-effective mode of transit for commodities required by several industries. Major industry groups that operate and rely on the waterway include coal, petroleum, aggregates, grain, chemicals, ores and minerals, iron and steel, and other commodities. The movement of these goods via the waterway contributes to both the regional and national economies. For example, waterborne transportation and its supporting activities (e.g., cargo handling, loading and unloading, terminal operations, transport of goods to and from the waterway via truck and rail) on the Cal-Sag Channel alone support more than 700 jobs, allowing for the movement of approximately 13 million tons of goods annually.

Normally, commercial waterway navigation is the most efficient form of transit because it takes fewer resources to move bulk commodities via waterways than by land modes such as truck and rail. While the difference between land route and waterway costs varies based on the distance between the shipment origin and destination, the economic benefit of utilizing the waterway is dependent on its relative savings to land routes. Maintaining navigable channels by dredging and lock maintenance contributes to the efficiency of using waterborne transportation versus truck or rail to transport goods. The transit of goods by rail and truck would consume more energy, with truck traffic requiring the most energy. Truck traffic is also a greater source of primary air pollutants, which would affect regional air quality. Moving goods by barge reduces traffic and wear and tear on area roadways.

The average annual commercial tonnage transported through BRLD between 1994 and 2014 was 13.2 million tons, with the major commodities being crude materials, primary manufactured goods, and petroleum/petroleum products (Tables 4-24 and 4-25).

Table 4-24 Annual Commercial Tonnage Transported through BRLD (20-yr Historical)

Year	Thousand Tons	Year	Thousand Tons
1994	19,218	2004	15,744
1995	14,281	2005	14,184
1996	14,161	2006	11,643
1997	14,670	2007	11,313
1998	15,202	2008	9,278
1999	14,617	2009	9,109
2000	15,521	2010	9,598
2001	13,932	2011	9,830
2002	14,489	2012	8,849
2003	14,329	2013	11,339

Source: USACE Waterborne Commerce Statistics Center.
Data compiled from Domestic Vessel Operator Reports, 2016.

Table 4-25 Commodities and Tonnages[a,b] Transported through BRLD in Select Years

Commodity	Tonnage (thousands)							
	1994	2000	2005	2010	2011	2012	2013	2014
Coal and coke	3,631	2,592	2,667	1,615	1,554	1,582	1,224	1,832
Petroleum fuels	2,569	2,053	1,318	1,476	1,577	1,670	1,546	1,671
Crude petroleum	W[c]	0	0	W[c]	0	233	237	W[c]
Aggregates	2,399	1,973	2,345	521	651	461	554	1,006
Grains	1,594	753	674	427	109	365	259	310
Chemicals	1,757	1,835	1,216	1,318	1,241	1,164	1,085	1,245
Ores and minerals	1,390	751	960	751	764	565	542	1,012
Iron and steel	4,221	3,635	4,148	1,578	2,153	2,379	2,041	2,700
All other	1,657	1,929	2,416	1,423	1,549	1,411	1,361	1,563

[a] For reference, an average barge can carry 1,750 tons dry bulk or 27,500 bbl liquid bulk. In comparison, an average railcar can carry 110 tons, while an average truck trailer can carry 25 tons (Kruse et al. 2012).
[b] For reference, a barge can move 1 ton of cargo 576 mi (927.0 km) for every gallon of fuel consumed. In comparison, for the same amount of fuel, a railcar can move 1 ton of cargo 413 mi (664.7 km), and a tractor trailer can move 1 ton of cargo 155 mi (249.4 km) (Kruse et al. 2012).
[c] Data withheld due to an insufficient number of operators.

Commercial commodities have been divided into the following nine categories:

- *Group 1*. The coal and coke category consists of coal, metallurgical coke, petroleum coke, and other related commodities.
- *Group 2*. The petroleum fuels category consists of gasoline, gas oils, fuel oils, kerosene, and other related commodities.
- *Group 3*. The crude petroleum category consists of unrefined crude petroleum in any form.
- *Group 4*. The aggregates category consists of sands, pebbles and crushed stone, limestone, and other related commodities.
- *Group 5*. The grains category consists of farm products such as wheat, corn, soybeans, and other related commodities.
- *Group 6*. The chemicals category consists of antifreeze and deicer, propylene glycol, ethanol glycol, fertilizers and other related commodities.
- *Group 7*. The ores and minerals category consists of salt, clays, and other related commodities.
- *Group 8*. The iron and steel category consists of iron ore, pig iron, iron and steel bars, and other related commodities.
- *Group 9*. The all others category consists of crude petroleum, asphalt, wood, cement, iron or steel scraps, paper, autos, machinery, and other related commodities.

4.7.2 Non-Cargo Navigation

Great Lakes

In regard to recreational navigation, the eight Great Lakes states have about 3.7 million registered recreational boats, or about one-third of the nation's total (USFWS 2016). Approximately 1 million recreational boats ply the U.S. waters of the Great Lakes each year, and the recreational industry generates about $4 billion annually. Throughout the GLB, recreational boating accounted for more than 246,000 jobs and contributed $19 billion annually to the U.S. economy based on a 2000 report (Great Lakes Waterways Management Forum 2000) and is likely to be greater today (USFWS 2016). Great Lakes boaters spend more than $1.5 billion on annual direct and secondary watercraft-related sales and support more than 50,000 jobs related to watercraft sales and trips (USACE 2008).

CAWS/Des Plaines River/Illinois River/Kankakee River

Within the CAWS, Des Plaines River, and Illinois River, recreational vessels utilize portions of the waterways as part of the route for the Great Loop (also known as the American Loop or the Great Circle Route), a continuous waterway that encompasses the eastern portion of North America. Some of the waterways composing the Great Loop are: the Atlantic Intracoastal Waterway, Delaware Bay, the Great Lakes, Hudson River, Tennessee River, Ohio River, Mississippi River, Gulf of Mexico, Lake Okeechobee, and various locks and canals (America's Great Loop Cruiser's Association 2017). The Great Loop is popular; travelers attempting the journey are called *loopers*; and this interest spawned the America's Great Loop Cruiser's Association, which assists cruisers with safety, navigational, and cruising information. The majority of loopers navigate the loop counterclockwise with distances traveled varying between 5,000 mi (8,046.7 km) and 7,500 mi (12,070.1 km) depending on the route selected.

Multiple groups utilize the CAWS, some of which include passenger boats and ferries and recreational vessels. Passenger boats and ferries primarily serve the tourist industry near downtown Chicago; however, newly constructed passenger vessels added to existing fleets are frequently transported through the lock system within the GLMRIS-BR Illinois Waterway Study Area to reach their home port. Recreational vessels such as kayaks and canoes can found utilizing the CAWS, especially the downtown Chicago area where multiple boathouses and kayak liveries are present. In addition to kayaks and canoes, powered recreational vessels utilize the CAWS and locks within the GLMRIS-BR Illinois Waterway Study Area. The Chicago Park District has nine lakefront harbors that stretch from Lincoln Park in the northern part of Chicago to Jackson Park in the south. The lakefront harbors can accommodate upward of 5,000 vessels, constituting the nation's largest municipal harbor system. The harbors are very popular with area boaters and have had occupancy in excess of 98% for the past several years (http://www.chicagoharbors.info/). Many of the recreational vessels that utilize these harbors travel through the locks within the GLMRIS-BR Illinois Waterway Study Area to access recreational areas further inland, to avoid severe weather of the Great Lakes, or to reach dry storage for off-season storing of their vessels.

The Des Plaines River provides ample kayaking and canoeing opportunities, especially with the removal of low-head dams along the mainstem. The Des Plaines River Canoe and Kayak Marathon, which is held annually, attracts hundreds of canoers and kayakers every year (USFWS 2016). Recreational boating, including kayaking and canoeing, is also prevalent within the Kankakee River.

4.8 Hazardous, Toxic, and Radioactive Wastes

In accordance with Engineering Regulation (E.R.) 1165-2-132 (USACE 1992), a Phase I site assessment was completed for the proposed project area. Two potential issues were identified. Fine-grained sediment within portions of the waterways included in this study is generally of poor quality and not suitable for open water placement. It is recommended that if construction activities require sediment disturbances, the sediment be characterized for upland disposal, probably at a commercial landfill. Sediment is also discussed in Section 4.3.6, Sediment Quality.

The land adjacent to the existing downstream approach channel to the BRLD appears to have been used as a borrow area and then for fill, potentially for anthropogenic waste materials. It is recommended that a Phase II site investigation, including soil borings and chemical characterization of the materials found, be conducted once the footprint of land usage is better defined. The objectives of the investigation are to identify materials that have been placed on the land as fill and to characterize these materials for future disposal. The Phase II investigation will identify the need for the development of a response plan to address recognized environmental conditions if a plan cannot be formulated to avoid the recognized environmental conditions. Per E.R. 1165-2-132, the Phase II analysis is part of the feasibility study costs. The development and implementation of any response plans or site remediation would be 100% non-federal. Additional details on the Phase I investigation can be found in Appendix G, Phase I Environmental Site Assessment (HTRW).

Note that if the land adjacent to the downstream approach, which is planned for project support, is found to have environmental conditions, there may be several project impacts. First, the extent of the contamination and the nature of any risks and exposure pathways will need to be fully characterized. Second, it is likely that addressing any issues may elevate costs associated with the project because of remediation activities or additional work required to mitigate any conditions or risks identified on the site. Third, it is likely that additional time will be needed for coordination with the existing property owner and regulatory agencies. Based on the currently available information, it is anticipated that the site will be a *brownfield* site that requires some amount of regulatory coordination as well as mitigation prior to use.

4.9 Future Without-Project Condition

Identification of the most likely condition expected to exist in the future is a fundamental first step in the evaluation of potential alternatives. The Future Without-Project (FWOP) condition serves as a baseline against which alternative plans are evaluated. The reduction in risk between an alternative plan and the FWOP condition provides the basis for evaluating the beneficial or adverse environmental, economic, and social effects of the considered plan. Overall, the FWOP condition reflects the conditions expected during the period of analysis.

A significant amount of documentation was developed to fully define the FWOP condition and the significance of environmental resources for the GLMRIS-BR Study. FWOP conditions were broadly evaluated not only to include the specific problems to be addressed by this study, but also to describe the natural environment, the human environment, and the uses of the waterway that will be considered as part of the formulated plans. In addition to the discussions in the previous sections on the affected environment, the technical appendices document the evaluations that have been completed to fully define FWOP conditions.

Quantification of target resources expected to change is not the only consideration for determining the FWOP conditions. For the GLMRIS-BR Study, USACE utilized a 50-yr period of analysis. In order to understand area activities, plans, operations and significant changes that could occur in the future, USACE sent letter requests (Appendix K, Coordination) to agencies whose missions (1) could affect relevant future conditions in and around the CAWS and (2) address ANS prevention, control, and abatement in the Mississippi River and GLB. USACE requested information for a 50-yr time period ending in 2070. USACE had previously contacted these same agencies to solicit similar information to define the FWOP conditions for the GLMRIS Study. Responses received during the GLMRIS Study are still relevant, unless updated information was received during the GLMRIS-BR Study solicitation. For a summary of responses received during the GLMRIS Study refer to the GLMRIS Report (USACE 2014a).

Responder-provided ANS control efforts are currently underway by many federal, state, and local agencies. Respondents to GLMRIS-BR information requests reported actions underway to address the interbasin transfer of Asian carp but did not include the construction and operation of ANS controls in the waterway. No efforts are underway currently to address the interbasin transfer of *A. lacustre*.

4.9.1 Current Efforts

Current efforts for controlling Asian carp by ACRCC member agencies are as follows:

- The ACRCC Monitoring and Response Working Group (MRWG) currently coordinates planning of Asian carp monitoring and control activities within the IWW and CAWS. Actions are conducted by state and federal resource management and research agencies, universities, and commercial entities. The ACRCC members include a total of 27 U.S. and Canadian federal, state, provincial and local agencies. The MRWG prepares an annual Asian Carp Monitoring and Response Plan (MRP), which provides new information on member project plans, as well as coordinates the incorporation of new information, technologies, and methods as they are discovered and implemented. The 2016 MRP also includes the Upper Illinois Waterway Contingency Response Plan, which describes specific actions by members in the event a change is detected in the status of Bighead and Silver Carp within the Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock Pools indicating an increase in risk level.

- The USFWS serves as cochair of the ACRCC and leads coordination of interagency eDNA monitoring efforts within the upper IWW, CAWS, and Great Lakes. In addition, USFWS participates in traditional gear and remote sensing monitoring within the upper IWW and CAWS; maintains the asiancarp.us website; conducts research projects such as the Barge Entrainment and Interaction Study; and enforces the Lacey Act in partnership with other resource management agencies. Currently, the bulk of funding for the aforementioned activities conducted within the CAWS and upper IWW comes from the Great Lakes Restoration Initiative (GLRI). In addition, USFWS has authority under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to fund management actions in approved State ANS Management Plans and works cooperatively with the EPA and Great Lakes State resource agencies to administer ANS grants supported through GLRI. Refer to Section 2.4.2, Aquatic Invasive Species Management for additional details on the MRWG and MRP.

- The USGS primarily conducts research projects related to detection, risk assessment and control of Asian carp, and provides critical hydraulic data and analyses to inform management decisions. Currently, funding for the aforementioned research projects comes from both the agency's appropriated and GLRI funds.

- EPA efforts are tied to program support for GLRI. The EPA also serves as the cochair of the ACRCC.

- The USCG focuses on ensuring the safety of mariners, vessels, ACRCC personnel, and the public when Asian carp activities are conducted on or near federally navigable waterways or in the vicinity of the CSSC electric dispersal barrier system.

The USCG carries out short-term waterway management closures/restrictions when operations associated with the CSSC electric dispersal barrier system, rapid response, research, or any other Asian carp activity will impede the flow of traffic on a navigable waterway. In addition, the USCG, through the Research and Development Center (RDC), helps shape the USACE formal evaluation of ANS control technologies to include analyzing USACE results and identifying associated risks and mitigation strategies to vessels and mariners.

- NOAA Great Lakes Environmental Research Laboratory scientists, together with University of Michigan scientists, conduct research for risk assessments of Asian carp in the Great Lakes, specifically to predict Asian carp impacts on Great Lakes food webs. This year, their efforts are jointly funded from internal base funds and ACRCC funds to predict Asian carp effects on Lake Ontario's food web. NOAA GLERL scientists also will continue to support the USACE GLMRIS-BR PDT by providing estimates of how Asian carp establishment would affect the food webs (i.e., changes in biomass of resident species) of Lake Michigan, Lake Huron, and Lake Erie. These estimates provide the PDT with additional information to address the environmental consequences of AC establishment in the GLB, and is also necessary for the quantification of changes to the economic values of recreational, charter, and commercial fishing in the respective Lakes.

- USACE operates the CSSC electric dispersal barrier system. Barriers IIA and IIB currently operate at a maximum in-water field strength that was found in the laboratory to be effective at immobilizing Asian carp as small as approximately 3–5 in. (76.2–127 mm) in total length. The Demonstration Barrier is being upgraded to a more powerful barrier (Permanent Barrier I). Permanent Barrier I is designed to operate at higher voltages than Barriers IIA and IIB and therefore may have an increased ability to deter small fish. The CSSC electric dispersal barrier system has a known flood bypass via the Des Plaines River, and USACE continues to evaluate and improve the efficacy of the barriers. Current vulnerabilities include preventing small fish transfer, barge entrainment and field warping of electric field when vessels move through, reverse flows, and loss of power in a waterway that has no control structure, and flood bypass. For a detailed discussion of the CSSC electric dispersal barrier system, refer to Section 4.5.2, Infrastructure.

- Section 1039(c) of WRRDA 2014, P.L. 13-121, authorizes the Secretary of the Army to implement measures recommended in the efficacy study directed by Section 3061(b)(1)(D) of the WRDA 2007, or in interim reports, with any modifications or any emergency measures the Secretary determines to be appropriate to prevent ANS from dispersing into the Great Lakes by any hydrologic connections between the GLB and the MRB. In the Explanatory Statement, Consolidated Appropriations Act 2016, P.L. 114-113, (*Congressional Record*, December 17, 2015, at H10056), USACE was directed to establish formal emergency procedures, including rapid response protocols, monitoring, and other countermeasures, that are appropriate to prevent Asian carp from passing beyond the BRLD. These procedures were established in coordination with the USFWS and in consultation with the ACRCC.

- The Illinois DNR is an active participant in the ACRCC and the MRWG, both of which coordinate policy, authorities, and monitoring activities for Asian carp within the upper IWW and CAWS within Illinois. The Illinois DNR is the lead agency for contract fishing and removal activities. The Illinois DNR reports that contract fishing and removal activities have resulted in a greatly reduced population toward the leading edge of the Asian carp in Dresden Island Pool compared to when focused measures first began.

- The Illinois DNR leads and supports ACRCC activities, including public outreach activities, education, and enforcement of regulations about ANS both in Illinois and the Great Lakes region, as well as R&D activities that maximize understanding and reduce risk. The Illinois DNR co-chairs both the Communication Work Group and MRWG to effectively develop appropriate plans and then communicate those plans and results to administrative agencies, partners, and the public. Illinois DNR efforts are coordinated through the ACRCC and funded through cooperative agreements with the USFWS by GLRI funds.

- The Illinois DNR has updated its Fisheries Division Strategic Fish Management Plan. It is also planning an update of the Illinois State Comprehensive Management Plan for Aquatic Nuisance Species, which was first published in 1999.

- Other Great Lake states take various actions, many of which are generally described in the ACRCC Asian Carp Action Plan.

- In general, further information about these agencies' activities concerning Asian carp can be found at http://asiancarp.us.

Current efforts for controlling Asian carp by binational and international agencies are as follows:

- The Great Lakes Commission will continue to advocate for programs and funding to prevent and control invasive species in the Great Lakes, especially through the CAWS.

- The Great Lakes Fishery Commission (GLFC) was established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries. The commission coordinated fisheries research, controls the invasive Sea Lamprey, and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies.

- The Ontario Ministry of Natural Resources and Forestry (MNRF) currently partners with the Ontario Federation of Anglers and Hunters (OFAH) to deliver the Invading Species Awareness Program, the purpose of which is to prevent the introduction and spread of invasive species in Ontario by increasing public knowledge and awareness. MNRF is also a significant funding agency for the Invasive Species Centre (Sault Ste. Marie, Ontario), which brings together stakeholders in conducting research, innovation, outreach, and education to prevent the introduction of invasive species.

- The Canada Ontario Agreement on Great Lakes Water Quality and Ecosystem Health of 2014 covers the current five-year period from December 2014 to December 2019. Projects funded under Annex 6 Aquatic Invasive Species can involve the prevention, control, monitoring, or management of ANS or related research. When this agreement expires in 2019, it is hoped that a new agreement can be negotiated between the Ontario Provincial and Canadian Federal Governments.

4.9.2 Future Efforts

Future efforts for controlling Asian carp in the GLMRIS-BR Illinois Waterway Study Area will be as follows:

- Asian carp control and management activities within the upper IWW and the CAWS are currently carried out by federal and state agencies. The USFWS, USGS, EPA, USACE, and Illinois DNR are funded by GLRI and agency base funds. As a conservative measure, the analysis assumes future Asian carp management activities are reduced from current levels because future actions are subject to the continuation of GLRI, the availability of future appropriations, and the budgetary allocations of other agencies.

- USACE anticipates continued O&M funding to operate the CSSC electric dispersal barrier system in Romeoville, Illinois. Monitoring of fish in the vicinity of the barrier system will continue to ensure that target species do not pose a threat to bypass the system. USACE will continue to evaluate ways to improve the functionality and efficacy of the barrier system and document these evaluations in efficacy studies.

Future efforts for controlling Asian carp by binational and international agencies will be as follows:

- The Great Lakes Commission will continue to advocate for programs and funding to prevent and control invasive species in the Great Lakes, especially through the CAWS.

- The Ontario MNRF will continue to partner with the OFAH to deliver the Invading Species Awareness Program and will likely continue to provide funding for the Invasive Species Centre (Sault Ste. Marie, Ontario) and its associated activities. In addition, the MNRF will help foster negotiations between the Ontario Provincial and Canadian Federal Governments to reach a new agreement for the Canada Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, which expires in 2019.

Future efforts aimed at controlling aquatic habitat will be as follows:

- Illinois DNR has worked closely with USACE and local agencies to identify habitat improvements in the Des Plaines River such as the removal of low-head dams. Illinois DNR has also been involved with the installation of habitat structures within the CAWS for channel catfish use. For the future, Illinois DNR will continue to identify habitat work that will benefit natural resources as part of its broad mission. This is an ongoing project that has already shown some evidence of movement and establishment of native species in this river.

- The flow regime in the Dresden Pool, immediately below the BRLD, may change during the period of analysis based upon changed operational conditions at the NRG Energy Joliet facility. NRG Energy converted its coal-fired plant to a natural-gas-fired power plant (under application number 15030051, permit 197809AAO). Switching to a natural-gas-fired plant offers a number of advantages for the operation, including making it easier to operate the plant intermittently, as a "peaking plant" (which operates only when demand is high). However, the refurbished plant utilizes the cooling system that was in place prior to the conversion. Even though the plant will operate as a peaking plant, it needs to be ready to operate when demand arises. As a result, the need for intake water is expected to continue, and any actions that affect the amount of water available for withdrawal to support cooling could be problematic to NRG operations. The future schedule of operation for a peaking plant is unknown, since it would depend on a variety of economic factors, energy demand, weather conditions, and other factors around the country that influence overall power consumption. The future operations could vary from full-time (current condition) to no operation (for a short or longer duration, depending on the energy environment). Based upon the potential for operations to occur on an as-needed basis, it is appropriate to assume that the water intake operations downstream of the BRLD would continue during the period of analysis. Further, considerations for potential ANS control measures will need to contemplate requirements associated with downstream uses and users.

- The current flow regime just below BRLD (Figure 4-24) is dominated by a stagnant flow area identified by USGS during dye tracer studies of the lock (Engle 2016). The stagnant flow area is created by the diversion of the river for cooling water for the Midwest Generation power plant. If the power plant were not operating, flow in that stretch of the river would be on the order of 1,600 cfs (45.3 cms) (a minor diversion on the south bank is assumed to continue) as opposed to the current −68 cfs (−1.9 cms) (with the "−" indicating that the flow is backwards or is cycling but not moving downstream). A continuous flow in the main channel would prevent the current stagnant conditions and the low dissolved oxygen that accompanies such stagnant flows during warm weather. The improved flow regime, even if intermittent, would represent more attractive habitat for both native and nonnative aquatic species. The improved habitat conditions may encourage the upstream spread of ANS, as well as support the native fish populations.

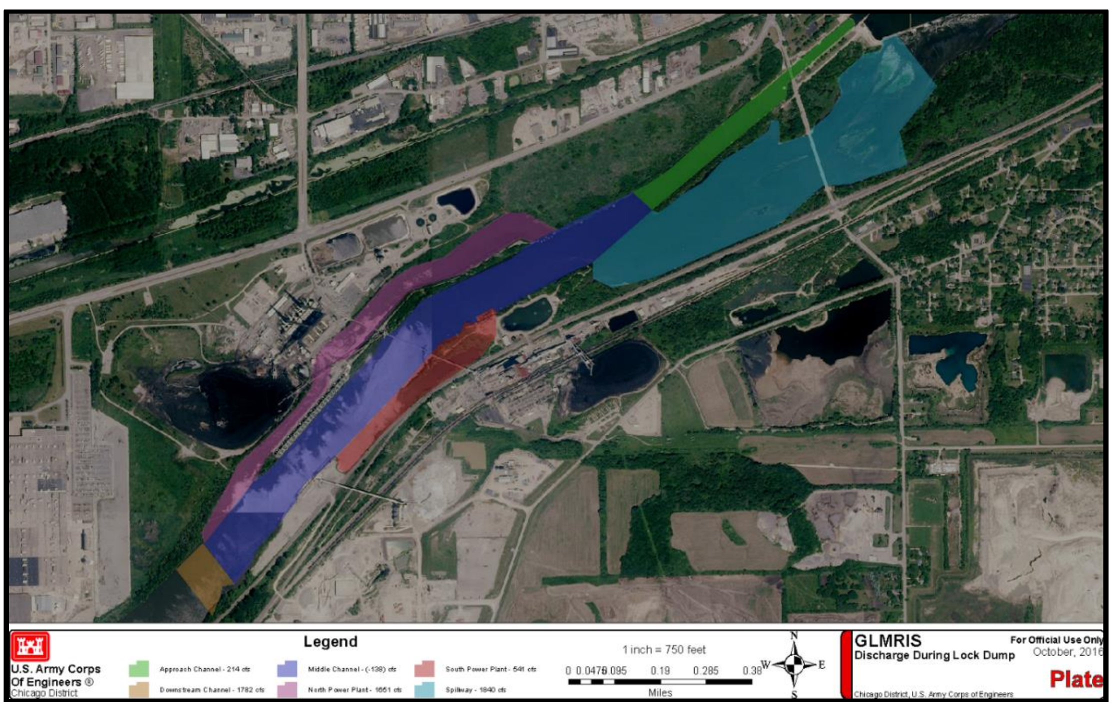


Figure 4-24 Current Flow Regime Downstream of BRLD

Future efforts for controlling water quality will be as follows:

- The CAWS waterways and the lower Des Plaines River (Upper Dresden Island Pool and Brandon Pool) recently went through a rulemaking (R2008-009) at the Illinois Pollution Control Board. The results of the rulemaking are that the "Use Designations" and water quality standards have been upgraded for these waterways. The rulemaking has to be approved by the EPA before it is enforceable. The IEPA is currently assembling the record for submittal to EPA for approval.

- The Upper North Branch Chicago River Watershed TMDL Draft Project is currently in the early stages of the Draft Stage 3 TMDL development process and is expected to be completed in the spring of 2017. The TMDL Report will address the following water body segments: North Branch Chicago River (HCC-07), West Fork North Branch Chicago River (HCCB-05), Middle Fork North Branch Chicago River (HCCC-02, HCCC-04), Skokie River (HCCD-01, HCCD-09), Middle Fork of the North Branch Chicago River, Skokie Lagoons (RHJ), Chicago Botanical Garden (RHJA), and Eagle Lake (UHH).

- IEPA has developed the Illinois Lake Michigan Beaches Bacteria (*E. coli*) TMDL, and the EPA approved the TMDL report on July 31, 2013. The TMDL report comprises three sections and addresses 51 Lake Michigan shoreline segments (10-digit HUC 0404000205) located in the Chicago Metropolitan Area within Cook County (29 segments), suburban Cook County (13 segments), and Lake County (9 segments), which were identified to be in nonattainment of their designated use, Primary Contact Recreation.

- IEPA is working with the EPA to develop toxics (mercury and PCBs) TMDL Draft Report. There are a total of 56 segments impaired due to PCBs and mercury. The impaired nearshore open-water segment is 180 mi^2 (466.2 km^2) in size, extending 5 km (3 mi) into Lake Michigan from the Illinois Lake Michigan shoreline, with Lake Michigan serving as its eastern boundary. In addition, there are 51 shoreline (beach) segments, approximately 63.5 mi (102.2 km) total, identified as impaired due to mercury and PCBs. Finally, there are four harbors (Waukegan Harbor North, North Point Marina, Diversey Harbor, and Calumet Harbor) that are impaired due to mercury and PCBs.

- The Illinois DNR Office of Water Resources is in the process of pursuing changes to Part 3700 Construction in Floodways of Rivers, Lakes and Streams Rules.

- The current discretionary diversion allocation of Lake Michigan water to the CAWS is 270 cfs (7.6 cms), but it will decrease to 220 cfs (6.2 cms) for water year 2018 and then 101 cfs (2.9 cms) in water year 2031. The Interveners' filed a petition for reconsideration and rehearing of the modified allocation, which is still pending. There is also 35 cfs (1.0 cms) allocated to the MWRDGC for navigation makeup water.

- MWRDGC will deliver 10,000 rain barrels by January 2017 and a minimum of an additional 5,000 rain barrels by January 2019 to be used throughout the MWRDGC area of responsibility. MWRDGC is also partnering with others on green infrastructure projects to reduce flooding.

- The EPA anticipates that the GLWQA of 1972, amended September 2012, will continue to provide the framework for binational coordination on Great Lakes water quality for the foreseeable future.

- The EPA states that future water quality management activities in the CAWS and lower Des Plaines River, as guided by implementation of new and/or revised WQS, may include implementation of a TMDL, more stringent point-source permit limits, better stormwater control, and/or new, holistic strategies to improve aquatic life. To the extent that stricter permit limits, installation of stormwater controls, or improved instream habitat are shown to be necessary to remedy aquatic life use impairments in order to meet the applicable designated use for a water body, improvements in treatment technologies and/or habitat may be required. In addition, management activities in the CAWS could also include flow augmentation, aeration, and/or sediment removal in certain segments.

- The EPA is assessing the consistency of Illinois' and Indiana's WQS with new and revised EPA criteria recommendations. Since 2012, EPA has finalized the following new criteria recommendations: ammonia aquatic life criteria, bacterial indicator recreational water quality criteria, and human health criteria for 94 chemicals. Currently, EPA is working on revising aquatic life criteria for selenium, cadmium, copper, aluminum, and chloride criteria; evaluating human health criteria issues related to perchlorate, perfluorooctanoic acid, and perfluorooctane sulfonate; and developing recreational water quality criteria for viruses (bacteriophage).

- The EPA works with its state counterparts to administer Section 319 of the CWA (support development of nonpoint-source management program plans to be implemented by state). Projects are selected by the state through a competitive process and should be aligned with the state Nonpoint Source Management Program Plan. Projects can be implemented by various partners including state and local agencies, nonprofit entities, and third parties.

- Once approved, the Coastal Nonpoint Pollution Control Program, which addresses nonpoint pollution problems in coastal waters, will implement projects consistent with the state's management measures and will be partially funded through the state's Section 319 program.

- The EPA states that for the reasonably foreseeable future, the Section 319 nonpoint-source program will continue to provide funding to states to implement the schedules contained in the Management Program Plan document.

- The EPA will continue to review and take final actions on the state Section 303(d) lists and TMDL submittals, and to fund IEPA's program consistent with national Section 319 funding allocation methodology. Where EPA-approved TMDLs are developed within the CAWS, this may result in changes to existing effluent limits for point sources, nonpoint-source project implementation, and overall reductions in pollutant loading to impaired water bodies.

- The EPA issued permits in 2013 for MWRDGC's O'Brien and Calumet WRPs that reflect the finalized upgrade of WQS for the CAWS, because they now contain fecal coliform limits and construction schedules for disinfecting the discharge from the two plants. The Calumet WRP began chlorination/dechlorination in July 2015 and is moving forward according to its compliance schedule for phosphorus removal in the 2013 issued permit. The O'Brien WRP construction for disinfection and phosphorus removal is moving forward according to the compliance schedule in its 2013 issued permit. The Stickney WRP construction for phosphorus removal is moving forward according to the compliance schedule in its 2013 issued permit. The O'Brien, Calumet, and Stickney permits all contain a 1 mg/L phosphorus limit.

Future efforts aimed at controlling air quality will be as follows:

- IEPA has proposed amendments to its SO_2 regulations in the Lemont, Illinois, area, and those proposals are near the end of the Illinois Pollution Control Board rulemaking process. The emission standards affect specific named facilities in that area. There are no other proposed regulatory amendments related to air quality, nor any that are expected to affect the Chicagoland region, in the near future.

Future efforts aimed at flood risk management and with secondary water quality improvements will be as follows:

- Construction of the McCook Stage I and Stage II Reservoirs, which are expected to come on line December 31, 2017, and December 31, 2029, respectively.

4.9.3 Summary of Future Without-Project Condition

Water Quality

In general, the water quality in the CAWS and lower Des Plaines River is improving over time and is expected to improve in the future. A number of individual regulatory and related actions are in progress or planned, as discussed below, and cumulatively these actions are expected to address a number of the historical water quality issues that have long plagued the waterways. The ultimate goal for the waterways is to meet the CWA goals of "fishable, swimmable" and for the rivers to be a source of good-quality water providing a stable habitat for a diversity of native wildlife and supporting human consumption and agricultural and manufacturing activities.

Various agencies within the state and nation have planned regulatory and related activities for targeting water quality issues in the CAWS and lower Des Plaines River. A few of the more significant actions are highlighted below; these are not all the activities that combined will lead to long-term water quality improvement. These actions represent the status as of August 2016.

An updated water quality agreement for the Great Lakes between the United States and Canada was signed in 2012 (i.e., GLWQA). This agreement provides a framework for both countries to enact legislation, take protective and restorative actions, and document changes to the lakes via research in a cooperative manner. Coupled with this agreement, the GLRI has provided funding to support many actions related to water quality and addressing needs identified under the water quality agreement. Currently the GLRI is authorized through 2021 but could be extended by congressional action. Under GLRI, funded actions include but are not limited to comprehensive, long-term monitoring and database development to document water quality conditions and changes throughout the lakes; clean-up actions at areas of concern where legacy contamination or other historical problems continue to threaten water quality; ecosystem restoration to maintain and restore the nearshore habitat including the control of invasive aquatic species; and beach-monitoring and wildlife (bird) control actions to address fecal coliform issues in recreational areas. These and many other actions related to the GLWQA are expected to support long-term improvements in the Great Lakes and tributaries over the long-term future.

The CAWS and lower Des Plaines River have been the subject of recent rulemaking to upgrade the "use designations" and water quality standards. The EPA is assessing the consistency of new water quality standards with new and revised EPA criteria recommendations related to aquatic life and human health. Based on the revised water quality standards, it is anticipated that future actions such as additional point and nonpoint discharge controls and new waterway management actions will be undertaken to systematically address water quality issues in the waterways. Some actions already undertaken that will continue to provide positive long-term changes include the implementation of disinfection at the wastewater treatment plants in the greater Chicago area, as well as the addition of phosphorus treatment processes at those plants. Additional measures to address waterways on the CWA Section 303(d) list of impaired waterways (which includes the CAWS and lower Des Plaines River) include the development of TMDL reports; this is already underway for the Upper North Branch Chicago River Watershed, with a completed report expected by spring 2017. An additional TMDL report is underway for mercury and PCBs, which affect numerous segments of the various waterways and which also affect the Lake Michigan shoreline. It is anticipated that EPA will continue to provide funding for IEPA to work on TMDL and state Section 303(d) list actions consistent with the national CWA Section 319 funding allocation methodology. The application of TMDLs will result in changes to point-source effluent limits and nonpoint-source management and will result in overall reductions in pollutant loadings to the waterways.

More specifically for nonpoint, stormwater controls, the completion of the TARP system (tunnels and reservoirs) will provide long-term improvements in water quality since combined sewer overflows will be greatly reduced. The tunnel portion of the system is substantially complete as of summer 2016, with the Thornton and O'Hare (i.e., Majewski) reservoirs already online and in use. Stage 1 of the final large reservoir (i.e., McCook reservoir) is scheduled to be online by the end of 2017, with Stage 2 being online by 2029. This system will continue to provide substantial water quality benefits to the CAWS and downstream waterways. Other stormwater plans are also in the works, with the MWRDGC actively promoting rain barrel usage and working with other agencies on green infrastructure. EPA, state, and local partners can work together through programs such as the Nonpoint Source Management Program Plan, which is funded by Section 319, to implement smaller scale nonpoint-source projects aimed at local improvements to water quality. Although stormwater is generally of higher quality than combined sewer effluent, stormwater quality improvement initiatives, such as street sweeping and waste control projects, are also anticipated to provide benefits to water quality in the future. Finally, the Section 319 program is also anticipated to provide future funding for the Coastal Nonpoint Pollution Control Program, which addresses nonpoint pollution problems in coastal waters.

Water quality within the CAWS is partly controlled by the diversion of Lake Michigan water, which enters the system through the Chicago Locks. Part of the diversion is incidental to the lockages that occur regularly during warmer weather and is also used to maintain safe navigational depths in the waterways; however, a separate diversion is termed a *discretionary* diversion with a purpose of maintain flows and preventing stagnant water conditions during low-flow periods such as mid- to late- summer. The current discretionary diversion allocation of Lake Michigan water to the CAWS is 270 cfs (7.6 cms) but will decrease to 220 cfs (6.2 cms) for water year 2018 and then 101 cfs (2.9 cms) in water year 2031. The Interveners' filed a petition for reconsideration and reheading of the modified allocation, which is still pending at the time of this report. There is also 35 cfs (1.0 cms) allocated to the MWRDGC for navigation makeup water. Water quality could decrease in localized areas under low-flow conditions if the discretionary diversion is decreased, although the use of side-stream aeration and other techniques could be used to offset the effects caused by a lower flow. In the long term, it is anticipated that acceptable water quality will be maintained during low-flow conditions either by the use of discretionary diversion flows or by other means. Any low-flow impacts are expected to be localized and temporary.

In summary, various federal, state, and local agencies are actively involved in changes to regulations and in the implementation of projects and programs that will have beneficial long-term impacts on water quality within the CAWS, the lower Des Plaines River, and downstream waterways. It is anticipated that because of the examples listed above and many more actions not included in this discussion, historical water pollution issues and current and future discharges will be addressed, and activities on and around the waters will be managed in a manner that results in improved water quality. Based on these examples, the anticipated FWOP condition of the CAWS and lower Des Plaines River is a generally improved water quality, which is closer than current conditions to the national CWA goal of "fishable, swimmable" and which better supports a range of human and ecological uses.

ANS Populations

Bighead and Silver Carp

The following paragraphs in regard to Asian carp population are taken directly from the USFWS Draft FWCA Report (Appendix A, Draft FWCA Report).

Within the Illinois River and the GLMRIS-BR Site-Specific Study Area, adult Asian carp—specifically Bighead and Silver Carp—are abundant in parts of the Illinois River. Downstream populations are well established in the Alton, LaGrange, and Peoria Pools. While comparatively less than at these downstream locations, Asian carp are still commonly present in the Starved Rock and Marseilles Pools. Adult Asian carp are collected in the Dresden Island Pool (including the Rock Run Rookery backwater approximately 4 mi [6.4 km] south of BRLD) and lower Kankakee River, but these captures are relatively rare. One adult Bighead Carp was captured in Lockport Pool in 2009, and there have been two credible sightings of Asian carp in the Brandon Road Pool. In addition, field tracking information demonstrates that telemetered adult Asian carp have been shown to approach the BRLD. It is also important to note that one Bighead Carp was captured in 2010 via contract fishing in Lake Calumet, which is located between T.J. O'Brien Lock and Dam and Lake Michigan, upstream of BRLD and the CSSC electric dispersal barrier system. In addition, one Silver Carp was captured in June 2017 as part of the ACRCC's MRWG seasonal intensive monitoring event. The Silver Carp was captured by a contracted commercial fisherman downstream of T.J. O'Brien Lock and Dam, approximately 9 mi (14.5 km) downstream of Lake Michigan. Additional analysis of the Silver Carp is being conducted by Southern Illinois University.

Small Asian carp (<6 in. [<15.24 cm]) are more of an invasion concern, compared to large adults, because they are less susceptible to electricity (control and detection) and they have a higher potential to be inadvertently entrained by moving barges. To date, this smaller cohort has not been found as far upstream as adults. Prior to 2015, small Asian carp collections were confined to Peoria Pool and areas downstream. In 2015, small Asian carp have been captured in Starved Rock Pool, just a few hundred feet downstream from the Marseilles LD, including the presence of three larval Silver Carp in Dresden Island Pool in June 2015. Monitoring efforts also take place in Brandon Road and Lockport Pools. There have been no collections of Bighead Carp or Silver Carp in Brandon Road Pool (i.e., upstream of BRLD); however, sightings in 2010–2011 of one Bighead Carp and one Silver Carp have been made by ACRCC's Monitoring and Response Workgroup efforts. This represents an upstream increase in the range of detected small Asian carp of 48 mi (77.2 km) from 2014 to 2015. Spawning has been verified as far upstream as the Marseilles LD. See Figure 4-25 for more details on adult and juvenile Asian carp and spawning. For more information on these sources, see http://asiancarp.us/documents/MRP2014-InterimSummary.pdf.

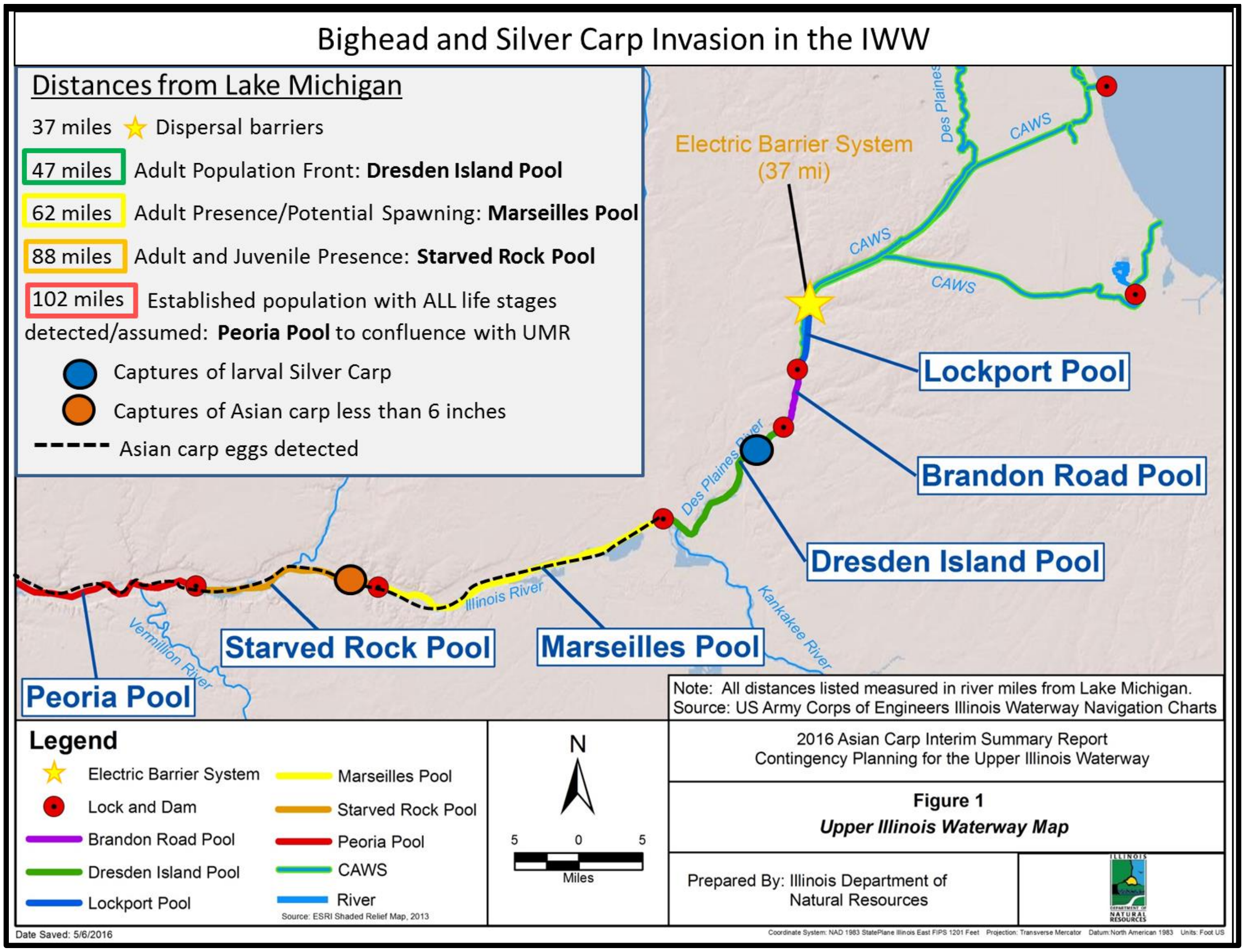


Figure 4-25 Presence of Asian Carp in the Illinois Waterway (Source: USFWS 2016)

While the adult Asian carp population front has remained in the Dresden Island Pool since 2006 and is believed to have not progressed significantly over the past nine years (Irons 2015), small Silver Carp (<6 in. [<15.24 cm]) have been detected 48 mi (77.2 km) farther upstream from 2014 to 2015. The 2015 upstream detections of small Silver Carp may be attributed to recent improvement in sampling gears and methodologies for Asian carp and/or recruitment success from a strong 2015 spawning year below Starved Rock LD. Small fish recruitment is the ability of larval fish to survive and be added to the small fish population. However, time lags between ANS establishment in one location and arrival and establishment in another location can be found. Recognizing that invasion-related lags can occur is often critical when managing ANS, since ignoring ANS may lead to an inaccurate assessment of the risk posed by the ANS as well as missing windows for action (Crooks 2005).

Based on this input, the assumptions for the FWOP condition are:

- Continued movement of Asian carp toward the GLB,
- Continued migration of Asian carp into the Dresden Island Pool, and
- Asian carp removed from the waterway will be replenished by downstream populations.

A. lacustre

A. lacustre was first reported from the Illinois River in 2003. Surveys conducted in 2005 found *A. lacustre* present just above Dresden Island LD in the Dresden Island Pool, less than 20 mi (32.2 km) from BRLD (Grigorovich et al. 2008). Surveys conducted in 2015 found *A. lacustre* still present in the Dresden Island Pool but did not find the species further upstream in the CAWS (Keller 2015). However, the abundance of *A. lacustre* within an area can be highly variable over space and time; therefore, the 2015 survey, which was small in scale, may have not targeted locations where the species was currently in abundance or occurring (Keller 2015). There is uncertainty whether *A. lacustre* are already established in the GLB.

Future ANS

A total of 119 ANS were identified as having the potential to disperse between the MRB and GLB and become invasive. That number was then reduced to 39 species that were identified as having the potential risk for both transferring from one basin to another, and a potential risk in that if they do disperse, the invaded ecosystem would be moderately to severely affected by their colonization. Of the 39 species, 7 species (excluding Bighead Carp, Silver Carp, and *A. lacustre*) were identified as having a potential risk to the GLB if they were to invade and colonize (Table 4-26). Included in the remaining seven species is the Black Carp, which the USFWS considers a high-risk species because of the increasing frequency of Black Carp captures from the MRB since 2011 (USFWS 2016).

Table 4-26 ANS Occurring in the MRB Having a Potential Risk to the GLB

Species Type	Common Name	Scientific Name
Fish	Black Carp	*Mylopharyngodon piceus*
	Inland Silverside	*Menidia beryllina*
	Northern Snakehead	*Channa argus*
	Skipjack Herring	*Alos chrysochloris*
Plants	Cuban bulrush	*Oxycaryum cubense*
	Dotted duckweed	*Landoltia punctate*
	Marsh dewflower	*Murdannia keisak*

Chapter 5 Consequences of ANS Establishment in the Great Lakes Basin

5.1 Aquatic Nuisance Species Considered in the GLMRIS-BR Consequence Evaluation

As part of an initial risk screening for the 2014 GLMRIS Report (USACE 2014a), a risk assessment was conducted on 10 nonnative ANS currently established in the MRB (USACE 2014a). Of the 10 species evaluated, the Bighead Carp, Silver Carp, and *A. lacustre* were considered medium risk (USACE 2014a). For the GLMRIS-BR, alternatives were developed to prevent the entry of these three species into Lake Michigan through the CAWS. Basic information on life history and current population status in the MRB for Asian carp and *A. lacustre* are provided below.

The 10 species evaluated previously, as well as other nonnative species established in the MRB (Veraldi et al. 2011), were reevaluated in 2016 to determine whether their population status had changed to a degree that would warrant their inclusion in the GLMRIS-BR alternative evaluation. After reviewing the available literature, it was determined that no significant change in species status had occurred, and that it was not necessary to add new species to the GLMRIS-BR. See Appendix B, Planning, for a detailed description of the species evaluations.

The GLMRIS-BR consequence evaluation specifically evaluates the consequences of establishment for Asian carp and *A. lacustre*. The impacts of future ANS establishment in the GLB could be more or less significant depending on the characteristics of newly established species. Although the GLMRIS-BR alternative evaluation was conducted specifically for Asian carp and *A. lacustre*, the GLMRIS-BR alternatives were purposely formulated to prevent the movement of any future ANS from the MRB into the GLB. In this way, the GLMRIS-BR alternatives address future ANS that use forms of interbasin movement similar to Asian carp and *A. lacustre* (e.g., swimming and hitchhiking). For example, alternatives for preventing the movement of Asian carp target swimming ANS and therefore would control the movement of Black Carp, another Asian carp species currently spreading in the MRB.

5.2 Consequence Evaluation Approach

The GLMRIS-BR consequence evaluation examined international studies of Asian carp impacts, as well as recent studies in the MRB, and whether these studies demonstrate that actual environmental, economic, or sociopolitical harm has occurred due to Asian carp establishment. Also used were studies specific to the GLB, including qualitative Asian carp risk assessments and quantitative models of Asian carp establishment and ecosystem impacts. While speculation is minimized in favor of empirical data, it should also be noted that (1) different regions have unique economic, social, and environmental conditions, and, therefore, it cannot be assumed that Asian carp impacts on the GLB would be similar to those found in previously invaded systems, and (2) it is inherently difficult to demonstrate cause and effect in studies of ANS impacts, because most studies rely on monitoring data rather than controlled experiments. Therefore, correlation (i.e., a native species declining as an invasive increases) is often all that can be established. In addition, the effects of invasive species or the population growth of invasive species may occur slowly over time, and, therefore, future impacts may not be captured in existing studies. Given these limitations, this assessment presents the best available information on the impacts of Asian carp as documented in previously invaded systems.

As described in the 2014 GLMRIS risk assessment (Hlohowskyj et al. 2014), the establishment of *A. lacustre* in the GLB was evaluated qualitatively and is expected to have negligible economic and sociopolitical impacts. However, a medium ecological risk was assigned to this species because it can form extensive mats over bottom substrate that could adversely impact protected mussel species. Aside from the potential impacts on protected mussels, minimal ecological impacts were identified for this species if it were to establish in the GLB. Therefore, the GLMRIS-BR analysis re-examined only the potential environmental impacts of *A. lacustre* in the GLB, particularly focusing on the potential for interaction with protected mussels. The environmental consequence analysis consisted of (1) a review of new literature related to ecological consequences, (2) an evaluation of the potential for *A. lacustre* to reach habitats in which protected species are present, and (3) an evaluation of the potential to adversely affect protected mussels if it were to occupy the same habitat.

An underlying assumption of the consequence evaluation is that the ANS has successfully entered and become established within the GLB, and, unlike the probability of the establishment assessment, the consequence evaluation did not consider the time frame in which consequences would occur. Consequences were not specified by time because impact magnitude depends on ANS abundance, and there were no data or method to estimate the time frame in which Asian carp or *A. lacustre* would spread throughout the Great Lakes and reach a population size of sufficient magnitude to generate impacts.

5.3 Environmental Consequence Evaluation of Asian Carp Establishment in the Great Lakes Basin

5.3.1 Data Sources for Asian Carp Consequence Evaluation

The environmental consequences evaluation used multiple data sources for assessing the potential impacts of Asian Carp. Peer-reviewed literature and government reports were used first. The literature review was conducted by searching scientific databases (i.e., Google Scholar and Web of Science) and contacting state environmental managers for Asian carp impact studies conducted by their agencies. The literature review covered:

- Impacts in other systems, including the MRB;
- Qualitative risk assessments (including habitat suitability evaluations of the Great Lakes and their tributaries); and
- The results of the quantitative food web modeling conducted by the NOAA-Great Lakes Environmental Research Laboratory (NOAA-GLERL) (Zhang et al. 2016).

The NOAA-GLERL modeling employed a well-established ecosystem modeling program – Ecopath with Ecosim (Langseth et al. 2012) – to estimate the food web changes in the biomass of resident fish, benthic invertebrates, and plankton following the colonization of Asian carp in Lake Erie (Figure 5-1). The model specifically evaluated Asian carp effects on multiple species or species groups, examples of which include zooplankton, phytoplankton, and different life stages of Walleye, Steelhead (i.e., Rainbow Trout), Yellow Perch, and Smallmouth Bass. Table 5-1 shows the species or species groupings considered in the model. The model was run under multiple potential scenarios, each with different assumptions about the diet of Asian carp, their plankton consumption efficiency, and the vulnerability of Asian carp to predation. The model also used model inputs derived from an expert elicitation regarding Asian carp production, consumption, and mortality (Zhang et al. 2016). Using the biomass output from the model, the percentage difference in biomass of the resident organisms between baseline conditions (no Asian carp) and under each scenario with Asian carp established in Lake Erie was calculated. See Zhang et al. (2016) for a full description of the model.

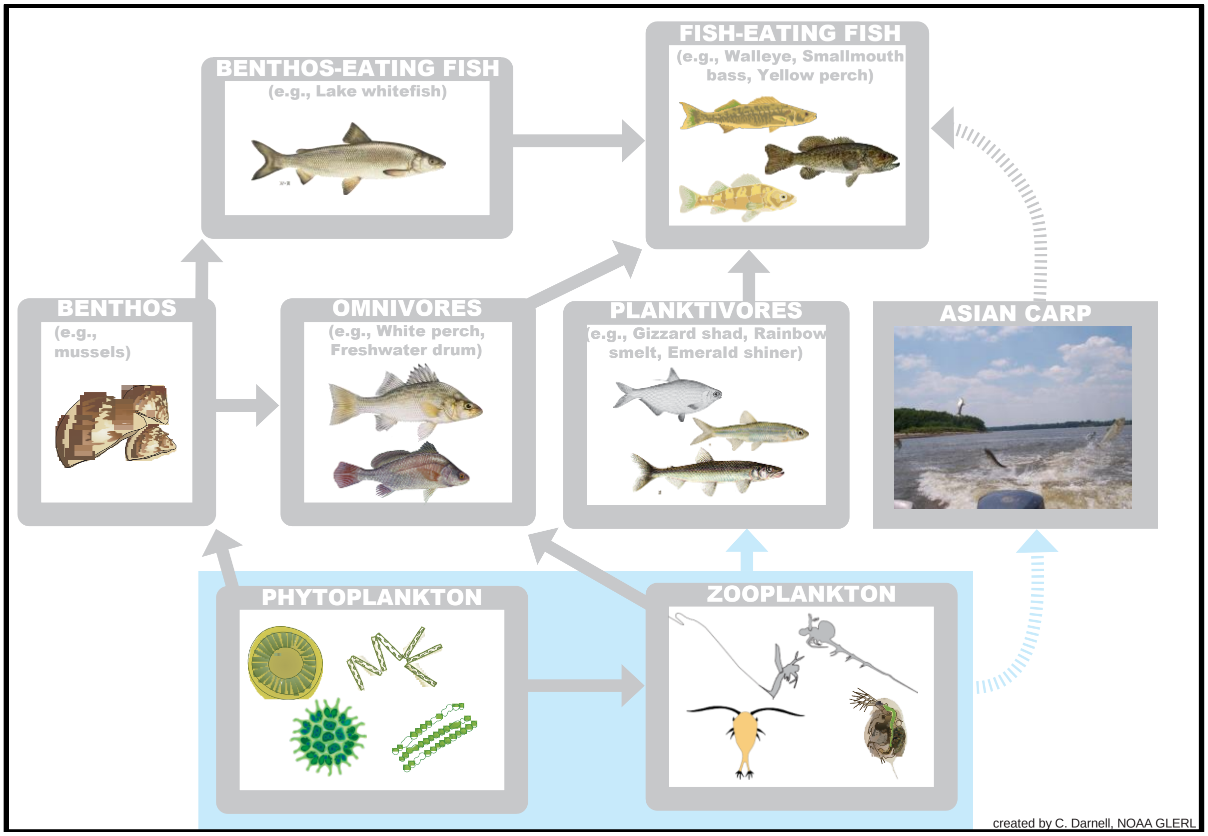


Figure 5-1 Simplified Lake Erie Food Web Model, Modified to Include Asian Carp and Used by NOAA-GLERL

The NOAA-GLERL modeling results for Lake Erie have been peer reviewed and published in *Transactions of the American Fisheries Society* (Zhang et al. 2016). An extensive literature review indicated that there are no other quantitative modeling evaluations of the ecological consequences of Asian carp establishment in the GLB. The NOAA-GLERL analysis, therefore, represents the best available quantitative information for the GLMRIS-BR consequence evaluation.

The NOAA food web model was only developed for one of the five Great Lakes (Figure 5-2). NOAA-GLERL is also working to complete additional models of the Great Lakes – individual-based models (IBMs) and the Atlantis Ecosystem Model – that use different approaches to quantify ecosystem changes resulting from Asian carp. Once complete, the output from these models can be compared to the Ecopath with Ecosim model results to see whether a consistent picture of Asian carp impacts emerges. Although the models run have not been finalized or peer reviewed, some preliminary results will be presented in this review.

5.3.2 Results of Asian Carp Consequence Analysis

The NOAA-GLERL Modeling for Lake Erie

The results of the NOAA-GLERL modeling suggest Asian carp (Bighead and Silver Carp only) have the potential to significantly alter the food web of Lake Erie (Zhang et al. 2016). NOAA-GLERL modeling simulated multiple alternative scenarios regarding Asian carp feeding efficiency, susceptibility to predation, and diet composition. Certain key variables in these scenarios had a significant influence on the

Table 5-1 Species and Species Groupings for Which Biomass Was Modeled Using Ecopath with Ecosim

Plankton		
Phytoplankton	Protozoans	Bacteria
Zooplankton		
Benthos		
Dreissenids	Chironomids	Sphaeriids
Oligochaetes	Gastropods	Amphipods
Ephemoroptera	Trichoptera	Odonates
Fish		
Walleye (*Sander vitreus*) Larval, Age 0, Juvenile (Age 1–2), Adult (Age 3C)	Freshwater Drum (*Aplodinotus grunniens*)	Quillback (*Carpiodes cyprinus*)
Yellow Perch (*Perca flavescens*) Larval, Age 0 Juvenile (Age 1) Adult (Age 2C)	Alewife (*Alosa pseudoharengus*)	Bigmouth Buffalo (*Ictiobus cyprinellus*)
Gizzard Shad (*Dorosoma cepedianum*)	Lake Trout (*Salvelinus namaycush*) Stocked Yearlings and Adults	Emerald Shiner (*Notropis atherinoides*)
Rainbow Trout (*Oncorhynchus mykiss*) Stocked yearlings and adults	Rainbow Smelt (*Osmerus mordax*)	Spottail Shiner (*Notropis hudsonius*)
Lake Whitefish (*Coregonus clupeaformis*)	Common Carp (*Cyprinus carpio*)	Channel Catfish (*Ictalurus furcatus*)
Burbot (*Lota lota*)	Round Goby (*Neogobius melanostomus*)	Brown Bullhead (*Ameiurus nebulosus*)
White Perch (*Morone Americana*)	Silver Chub (*Macrhybopsis storeiana*)	Pan Fish
White Bass (*Morone chrysops*)	Trout Perch (*Percopsis omiscomaycus*)	Common Logperch (*Percina caprodes*)
Smallmouth Bass (*Micropterus dolomieu*)	White Sucker (*Catostomus commersonii*)	

Figure 5-2 A NOAA Food Web Model of the Impacts of Asian Carp Has Been Published for Only Lake Erie (Source: Zhang et al. 2016)

magnitude of impacts of Asian carp on fish and invertebrate biomass in Lake Erie. These variables included:

1. Asian carp *biomass*. As expected, the magnitude of the impact on the Lake Erie food web increased with Asian carp biomass. Although they occurred infrequently (<2% of simulation runs) in simulations where Asian carp biomass grew to exceed 178 lb/ac (200 kilograms/hectare [kg/ha]) (similar to the biomass of Asian carp reported in the Illinois River), the biomass of many resident piscivore, planktivore, omnivore, and zooplankton taxa was 25% to more than 40% lower than biomass under the no Asian carp baseline (Zhang et al. 2016). As discussed below, one key factor determining Asian carp biomass is the vulnerability of plankton to being consumed by Asian carp. Asian carp grew to approximately 10% and 35% of the total fish biomass in Lake Erie under the low and high plankton vulnerability scenarios, respectively (NOAA-GLERL 2016).

2. *Plankton vulnerability to consumption by Asian carp*. Zhang et al. (2016) examined a range of plankton vulnerability scenarios and found that the reduction in the biomass of resident Great Lakes species generally increased with increasing plankton vulnerability to consumption by Asian carp. In the low plankton vulnerability

scenario, young Asian carp were assumed to have lower feeding efficiency than adults, which were assumed to have feeding abilities similar to Gizzard Shad (Text Box 5-1). Under this scenario, the biomass of fish, benthic invertebrates, and plankton in Lake Erie generally differed by less than 10% from the no Asian carp scenario. However, in high vulnerability scenarios, where Asian carp were assumed to feed as efficiently as Gizzard Shad at all life stages, there was a 10 to 20% reduction in Rainbow Trout and predatory zooplankton, and a greater than 20% reduction in young-of-year (YOY) Walleye, Burbot, White Perch, and Emerald Shiner (NOAA-GLERL 2016) compared to the no Asian carp baseline. The decreases in White Perch biomass and Emerald Shiner were due to competition with Asian carp for zooplankton. The decreases in Rainbow Trout, YOY Walleye, and Burbot were due to the decreases in their prey (i.e., White Perch, Emerald Shiner, and Rainbow Smelt). Yellow Perch biomass was 10 to 20% higher under the high feeding efficiency scenario, because adult Yellow Perch are able to eat young Asian carp, and because the reduction in White Perch reduced predation on larval Yellow Perch (Text Box 5-1).

3. *Larval fish consumption by Asian carp*. Asian carp significantly reduced the biomass of the early life stages of certain fish, assuming carp consumed fish larvae while filter feeding on plankton. Of the resident Lake Erie species for which larval life stages were quantified, the biomass of Gizzard Shad and larval and juvenile Yellow Perch in the larval consumption scenario was 25% less than in simulations with no Asian carp. Reductions in the biomass of all life stages of Walleye, generally less than 15%, were also greatest under the larval fish feeding scenario (Zhang et al. 2016).

The NOAA-GLERL model has several limitations, which may result in the full impact of Asian carp on the Lake Erie food web not being revealed (Zhang et al. 2016). First, the model calculates an average species biomass for all of Lake Erie and does not specifically examine impacts on productive nearshore

Text Box 5-1 NOAA Model – Impacts on Lake Erie Fish Biomass Depend on Assumptions

Impacts on Lake Erie fish biomass depend on assumptions:

- Asian carp biomass;
- Feeding efficiency: as Asian carp feeding efficiency increases, their biomass increases; and
- Whether Asian carp will consume larval fish.

These parameters are uncertain.

Walleye Fish Larvae (Photo Credit: NOAA)

Asian Carp Gill Rakers (Photo Credit: ACRCC)

habitat where Asian carp are expected to be most abundant. Nor does the model include tributaries or bays. Therefore, the impacts of Asian carp on these habitats were not modeled.

This represents a significant data gap considering that the Great Lakes have more than 5,000 tributaries, many of which are high-quality ecosystems. Second, the model is not temporally and spatially explicit, and, therefore, cannot quantify changes in biomass by season, depth, or location within Lake Erie. Thus, the model does not account for the spatial and temporal variation in the interactions between Asian carp and resident species. Also, the model only considers biological interactions and does not incorporate physical processes and habitat that could be important determinants of impact magnitude. Finally, there was a large range in modeled biomass outputs, both within individual model scenarios and among the several modeled scenarios. This variability was a product of the large range in certain model inputs. Some model input ranges were obtained from an expert elicitation, and the large range in the elicited inputs reflected the basic uncertainty about the physiological and ecological response of Asian carp to environmental conditions in Lake Erie. In addition, multiple scenarios were run, each with different assumptions about Asian carp feeding efficiency, predation by salmonids, predation rates on young Asian carp, and Asian carp diet. These differences in model assumptions resulted in significant variation in results across model scenarios, and were another source of overall uncertainty in the NOAA model results (Text Box 5-2).

Although the model runs have not been finalized or peer reviewed, the preliminary results of IBM model simulations appear to support the conclusions reached by Zhang et al. (2016) for Lake Erie; that is, Asian carp have the potential to pose a significant threat to Great Lakes food webs. The impact magnitude primarily depended on the assumptions about the juvenile Asian carp survival rate, which in turn determined the population density of Asian carp and the subsequent effects on resident species. The preliminary results of the IBM analysis also indicate that relatively few individuals could establish a viable population if the model assumes a high juvenile survival. These results are similar to those of Cuddington et al. (2014), who found that, with early maturation, Asian carp could establish in the Great Lakes with a founding population of fewer than 20 individuals. Text Box 5-3 presents a summary of the results of the NOAA food web model.

Qualitative Evaluations of Asian Carp Impacts on the Great Lakes

Qualitative risk assessments have also been used to estimate the environmental consequence of Asian carp. The USGS and Fisheries and Oceans, Canada conducted a binational risk assessment of Asian carp (Bighead and Silver Carp only) in the Great Lakes (Cudmore et al. 2012). The risk assessment considered both the probability of Asian carp establishment and the consequences of establishment in the Great Lakes. They concluded that Asian carp were very likely to establish and spread in most of the Great Lakes, with high certainty. In addition, the risk assessment rated the ecological consequences of Asian carp in Lakes Michigan, Huron, Erie, and Ontario as high, with moderate certainty (Cudmore et al. 2012).

Text Box 5-2 Sources of Variation in NOAA Model Results across Scenarios

Large variation in results (i.e., fish biomass estimates) due to:

- Variation in results *across* model scenarios related to scenario assumptions about Asian carp feeding efficiency, predation by salmonids, predation rates on young Asian carp, and Asian carp diet.
- Uncertainty *within* scenarios related to the wide range in expert opinion on parameter inputs—carp production, consumption, and carp mortality rates.

Text Box 5-3 Environmental Consequences of Asian Carp Establishment in the Great Lakes Basin

NOAA-GLERC Modeling of Lake Erie Food Web

- The results of the NOAA-GLERL modeling suggest Asian carp have the potential to significantly alter the food web of Lake Erie.
- Generally, ≤10% change in fish and invertebrate biomass for all species under low plankton vulnerability scenarios (NOAA Great Lakes Environmental Research Laboratory 2016).
- Under high plankton vulnerability scenarios:
  - 10 to 20% lower biomass of rainbow trout and predatory zooplankton (NOAA Great Lakes Environmental Research Laboratory 2016);
  - >20% decrease in the biomass of YOY Walleye, Burbot, White Perch, and Emerald Shiner (NOAA Great Lakes Environmental Research Laboratory 2016); and
  - ~10 to 20% increase in Yellow Perch biomass and Smallmouth Bass (NOAA Great Lakes Environmental Research Laboratory 2016).
- Impacts on resident species increase with Asian carp biomass (Zhang et al. 2016; Kipp et al. 2011).
- >25% decrease in Gizzard Shad and larval and juvenile Yellow Perch biomass if Asian carp consume fish larvae (Zhang et al. 2016; Kipp et al. 2011).
- Asian carp biomass could range from 10 to 34% of fish biomass in Lake Erie (NOAA Great Lakes Environmental Research Laboratory 2016; Zhang et al. 2016; Kipp et al. 2011).
- Limitations of NOAA-GLERC model:
  - Does not include tributaries, bays, or nearshore areas where Asian carp are expected to be most abundant;
  - Does not examine changes by depth or location; calculates species biomass averaged across the lake;
  - Does not account for seasonal interactions of Asian carp on resident fish;
  - Large range in estimated biomass outputs due to large range in model inputs; and
  - Does not incorporate physical processes and habitat features.

In contrast, using an expert elicitation, Wittmann et al. (2015) found that the impact of Asian carp on the biomass of commercial and recreational fishes in Lake Erie was estimated by experts to be small, with little uncertainty. Most experts did expect small declines in the biomass of Gizzard Shad and Walleye. However, it is important to note that the impacts of Asian carp on tributaries and on recreational activities, water quality, or other species were not addressed. The impacts of Asian carp on tributaries are of particular concern for the Great Lakes.

The most recent qualitative risk assessment of Asian carp establishment in the Great Lakes (Lauber et al. 2016) used expert elicitation to evaluate the impacts of Asian carp (Bighead and Silver Carp only) on recreationally important game fish under multiple invasion and establishment scenarios. Each scenario included descriptions of the spatial habitat distribution of Asian carp in the Great Lakes and estimated reductions in fish abundance in each of the Great Lakes. The impacts defined in the scenarios ranged from small (<10% decrease for most species) to large decreases in game fish (up to a 40% decrease for some species). The experts qualitatively rated the likelihood of each scenario. Most scenarios were rated "Possible, but not likely" or "less likely to occur." The mean rating for scenarios that included up to 40% reductions in game fish were generally, but not always, rated as "Unlikely" or "Highly Unlikely." The scenarios rated as most probable were those that projected, for high productivity areas of the Great Lakes, a 10% reduction in Walleye; a 10% increase in Smallmouth Bass, Largemouth Bass, and

Yellow Perch; and a 5% decrease in salmonids (Lauber et al. 2016). Text Box 5-4 presents a summary of the qualitative analyses of the environmental consequences of Asian carp establishment in the Great Lakes.

Studies of Asian Carp Impacts Outside of the United States

Throughout the world, Asian carp have been used to control nuisance algae in ponds and reservoirs. Thus, there is a fairly extensive literature on the effects of Asian carp on plankton in lentic systems, much of which was reviewed in Kolar et al. (2005), Kipp et al. (2011), and Cudmore et al. (2012). Theoretically, Asian carp can affect phytoplankton communities by direct consumption or indirectly by consuming zooplankton that graze on phytoplankton (Zhou et al. 2011; Kipp et al. 2011). The results of experimental manipulations and observational studies suggest Asian carp have variable impacts on phytoplankton density, biomass, and size (Kipp et al. 2011). Both increases (Domaizon and Devaux 1999; Cook et al. 2009; Zhou et al. 2011; Zhao et al. 2013, 2016) and decreases (Starling 1993; Guo et al. 2015) in total phytoplankton biomass in the presence of Asian carp have been reported, sometimes depending on the abundance and species composition of the phytoplankton community (Zhou et al. 2013; Guo et al. 2015). A shift to smaller phytoplankton species due to the consumption of larger phytoplankton by Asian carp has been well documented by several investigators (Radke and Kahl 2002; Zhang et al. 2006; Ma et al. 2010; Zhao et al. 2013).

The literature reveals fairly consistent effects of Asian carp on zooplankton (Text Box 5-5). Asian carp reduce the abundance of large-bodied crustacean zooplankton (Xie and Yang 2000; Kipp et al. 2011; Zhao et al. 2013). A reduction in the cladoceran *daphnia* and a shift to copepods and/or rotifers is frequently reported in mesocosm studies and in natural environments (Domaizon and Devaux 1999; Cooke et al. 2009; Lin et al. 2014; Zhao et al. 2013). A reduction in total zooplankton biomass has also been documented in experimental studies with Asian carp (Domaizon and Devaux 1999; Zhang et al. 2006; Zhou et al. 2011; Zhao et al. 2013).

The reduction in large zooplankton described above could reduce the availability or quality of food for planktivorous fish and early life stages of piscivorous fish. The effects of Asian carp on fish

Text Box 5-4 Qualitative Analyses of the Environmental Consequences of Asian Carp Establishment in the Great Lakes Basin

Environmental Consequences of Asian Carp Establishment in the GLB

- The results of a binational risk assessment for the Great Lakes indicate a high ecological consequence with moderate certainty for Asian carp (Cudmore et al. 2012).
- Wittmann et al. (2015) expert elicitation:
  - The impact of Asian carp on the biomass of commercial and recreational fishes in Lake Erie was estimated by experts to be small, with little uncertainty;
  - Most experts did expect small declines in Gizzard Shad and Walleye biomass; and
  - Impacts of Asian carp on tributaries and on recreational activities, water quality, or other species were not addressed.
- Lauber et al. (2016) expert elicitation:
  - The scenarios rated as most probable were those that projected a 10% reduction in Walleye; a 10% increase in Smallmouth Bass, Largemouth Bass, and Yellow Perch; and a 5% decrease in salmonids.

Text Box 5-5 Field Studies of the Environmental Consequences of Asian Carp Establishment in Other Countries

Observational and Experimental Studies in Other Countries

- Variable impacts on phytoplankton biomass (Starling 1993; Domaizon and Devaux 1999; Zhou et al. 2011; Zhao et al. 2013; Xie and Yang 2000; Guo et al. 2015; Zhao et al. 2016.)
- Well-documented shift to smaller phytoplankton species due to the consumption of larger phytoplankton by Asian carp (Zhao et al. 2013; Xie and Yang 2000; Radke and Kah 2002; Zhang et al. 2006; Ma et al. 2010).
- Reductions in larger crustacean zooplankton consistently associated with Asian carp (Zhoa et al. 2013; Xie and Yang 2000; Kipp et al. 2011).
- A reduction in total zooplankton biomass has also been documented in experimental studies (Domaizon and Devaux 1999; Zhou et al. 2011; Zhao et al. 2013; Xie and Yang 2000; Zhang et al. 2006).
- Well-documented large decline in native fish species as a percentage of population (Kipp et al. 2011; Xie and Chen 2001; Cudmore et al. 2012).
- Limited empirical evidence for absolute decline in predatory fish due to Asian carp (Shetty et al. 1989; Pavlovskaya 1995; Kolar et al. 2005).
- The greatest impacts will likely be on planktivorous fish, which directly compete with Asian carp (Cudmore et al. 2012; Kolar et al. 2005).

communities are less well studied, and the results reported in the literature are typically anecdotal (Text Box 5-5). Species-specific impacts on native fish have been reported when Asian carp were stocked in small ponds (Milstein et al. 2006).

There is also a well-documented decline in native fish species as a percentage of population in systems invaded by Asian carp (Petr 2002; Pavlovskaya 1995; Xie and Chen 2001). Petr (2002) notes that, in India and Pakistan, Silver Carp have come to dominate the fishery catch in lakes and reservoirs where they have established, sparking debate among fisheries biologists about impacts on native species (Shetty et al. 1989; Suganan 1997). Similarly, in China, Xie and Chen (2001) reported that following the introduction of Asian carp in the early 1950s, the proportion of native, Barbless Carp (*Cyprinus pellegrini*) in the total fish yield declined from 50% in the 1950s to less than 1% since the 1980s.

However, these studies often do not report whether there was a decline in native species based on a systematic sampling method. For example, Arthur et al. (2010) found no significant decline in native fish biomass in riverine wetlands over time, despite a large increase in stocked Bighead Carp biomass within the same water bodies. Also, the changes in native fish communities following Asian carp introduction reported in many studies were concurrent with the introduction of other nonnative species, significant hydrologic modification, and eutrophication, making it difficult to conclusively attribute the changes in native fish populations to Asian carp (Petr 2002; Pavlovskaya 1995; Yang 1996).

Overall, despite the lack of strong data sources, declines in the tonnage catch of native species have been documented to coincide with increasing catch of Silver Carp in lentic systems (Shetty et al. 1989; Pavlovskaya 1995). The greatest direct impacts will likely be on plankton-eating fish, which directly compete with Asian carp (Kolar et al. 2005; Cudmore et al. 2012). Indirect impacts on piscivorous species following Asian carp establishment are less clear; however, there is some limited empirical evidence for an absolute decline in predatory fish due to Asian carp (Costa-Pierce 1992, cited in Kolar et al. 2005).

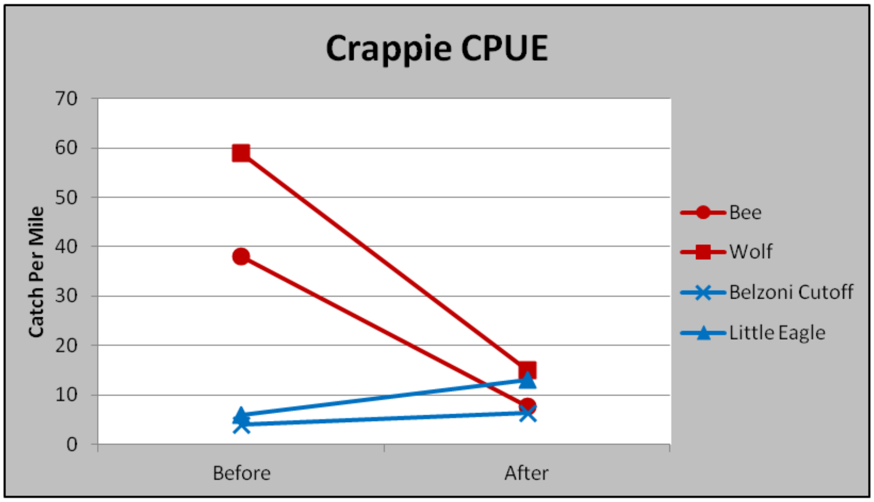
Text Box 5-5 presents a summary of the results of studies of Asian carp impacts on aquatic systems outside of the United States.

Studies of Asian Carp Impacts in the Mississippi River Basin

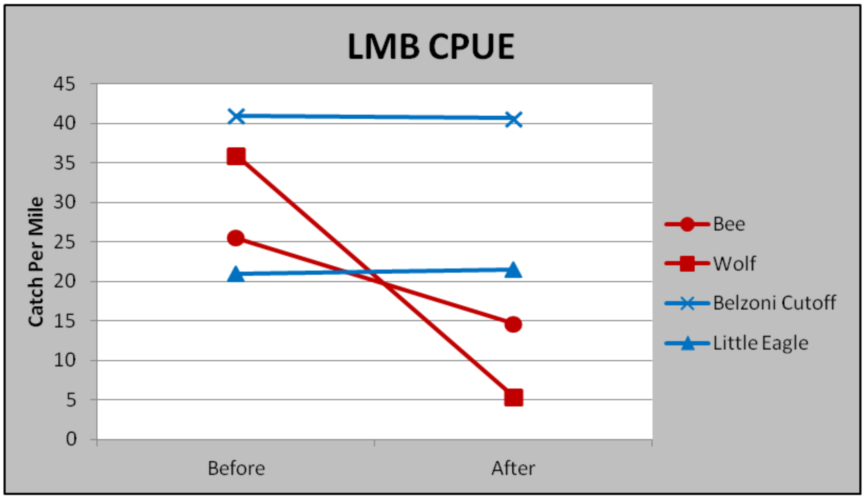
Studies of Asian carp impacts in the MRB are potentially more informative than international studies, because many of the native fish species in the MRB are the same as those found in the GLB. A recent study from the lower MRB provides a natural experiment that suggests a cause and effect relationship between the establishment of Asian carp and declines in native fish communities (Aycock 2016). This study examined four oxbow lakes in the Yazoo River Basin (Mississippi), two of which do not have Silver Carp, and two nearby lakes that were recently colonized by Silver Carp following above average flooding in 2011. In the two lakes colonized by Silver Carp, mean catch rates of Largemouth Bass were approximately 43 to 85% lower in the years after Silver Carp invaded (2012–2015), compared to catch rates in the pre-invasion years (2007–2010). For crappie, mean catch rate declined approximately 75 to 80% following Silver Carp invasion of the two lakes (Figure 5-3). In the two reference lakes not invaded by Silver Carp, the mean catch rates of Largemouth Bass and crappie were similar in the two time periods, suggesting that Silver Carp were the cause of the decline in the two invaded lakes (Aycock 2016). In addition, at one of the invaded lakes, the body weight of Largemouth Bass and crappie was significantly lower in the post-invasion period (Table 5-2). In contrast, Largemouth Bass and crappie body weights generally increased over the same time period in the uninvaded lakes. The authors also found that the growth rates of crappie were lower following Silver Carp invasion. Growth rate is critical in the life of fish because faster growth rates improve survival of young fish by reducing vulnerability to predation.

Studies in riverine habitat of the MRB have also found significant ecological changes following Asian carp establishment. As in studies of lakes, a reduction in copepods and cladoceran taxa and a shift to rotifers was associated with Asian carp invasion of the main channel of the Illinois River (Sass et al. 2014). Studies in the MRB also suggest that Asian carp have adversely affected fish populations. Overall, the relative abundances and species richness of native fish in the Illinois River have shown a significant increase between the 1970s and 2009, which has been attributed to water quality improvements (McClelland et al. 2012). While McClelland et al. (2012) did not note a decline in native fish following the increase in Asian carp beginning in 2000, the invasion of the Illinois River by Asian carp is relatively recent, and the long-term effects of Asian carp on fish populations may not have had time to fully manifest. In addition, more recent long-term monitoring studies targeting specific sections of the Illinois River appear to show profound local shifts in fish communities following the establishment of Asian carp. For example, using multiple gear types deployed in a variety of riverine habitats, Solomon et al. (2016) compared fish communities in the LaGrange reach of the Illinois River before Asian carp establishment (1993–1999) and after Asian carp establishment (2000–2013). They reported post-carp establishment declines in the relative abundance of crappie, Sauger, buffalo (*Ictiobus* spp.), and Common Carp. For several of these species, reductions in relative abundance were consistent across gear types. In addition to relative shifts in abundance, the absolute catch of native species (defined as mass per unit effort) decreased more than 35% between 1996 and 2012, and the decline appeared to track the concurrent increase in Silver Carp (Ickes 2014) (Figure 5-4). LaGrange Pool is only 163 mi (262.3 km) from Lake Michigan and contains similar fish species as found in GLB.

Plankton feeders like Bigmouth Buffalo (*Ictiobus cyprinellus*) and Gizzard Shad also declined, which supports other studies showing that Asian carp have a strong dietary overlap with native planktivores (Sampson et al. 2009) and a reduction in the body condition of resident planktivorous fish following the Asian carp invasion of the Illinois River (Irons et al. 2007) and rivers in South Dakota (Hayer et al. 2014). The most comprehensive study (Phelps et al. 2016) used long-term field monitoring data and lab studies to examine the effects of Asian carp on planktivorous fish. Six Mississippi and Illinois River reaches



a)



b)

Figure 5-3 Mean Electrofishing Catch Per Unit Effort (CPUE) Rates for Crappie (a) and Largemouth Bass (b) before and after Silver Carp Introduction (Red) and in Lakes Where Silver Carp Have Not Been Introduced (Blue) over the Same Time Period (Source: Aycock 2016)

ranging from La Crosse, Wisconsin, south to Cape Girardeau, Missouri, were examined. The three southernmost river reaches have established Asian carp populations; the three northernmost reaches did not, and were, therefore, used as reference sites. Phelps et al. (2016) also examined fish communities in four floodplain lakes with different abundances of Silver Carp. Catch rates for Silver Carp, Gizzard Shad, and Bigmouth Buffalo, all planktivores, were available for all sites in the years before (1982–1992) and after (1993–2012) carp established. They found a significant decrease in the catch rate of Bigmouth Buffalo and Gizzard Shad compared to the 1982 to 1992 period in the reaches invaded by Silver Carp. No change in catch rate over time was observed at the control locations (Phelps et al. 2016). They also examined the body weight and body condition in one of the reaches with Silver Carp and found a negative trend in the condition factor of Bigmouth Buffalo and Gizzard Shad over the 1993 to 2012 invasion period. Monitoring data from floodplain lakes indicated that the greatest reduction in the abundance of native species occurred in the lakes with the highest Silver Carp abundance, and no changes in fish communities were observed in the lakes where Silver Carp were absent (Phelps et al. 2016).

Table 5-2 Paired T-Tests Show Significant Declines (α = 0.10) in Mean Relative Weight Values for Largemouth Bass and Crappie Since 2011 in Lakes Invaded by Silver Carp (Bee Lake and Wolf Lake)[a]

Lake	Species	Avg. Relative Weight Before	Avg. Relative Weight After	P-value	N
Bee	Largemouth bass	98	94	0.02	172
Wolf	Largemouth bass	95	90	0.06	256
Little Eagle	Largemouth bass	96	101	0.008	85
Belzoni Cutoff	Largemouth bass	91	94	0.02	126
Bee	Crappie	106	89	0.002	143
Wolf	Crappie	103	91	>0.001	380
Little Eagle	Crappie	96	97	0.50	29
Belzoni Cutoff	Crappie	87	99	0.04	30

[a] During the same period, there were either significant increases or no change in relative weight in lakes not invaded by Silver Carp (Little Eagle and Belzoni Cutoff).

Source: Aycock (2016).

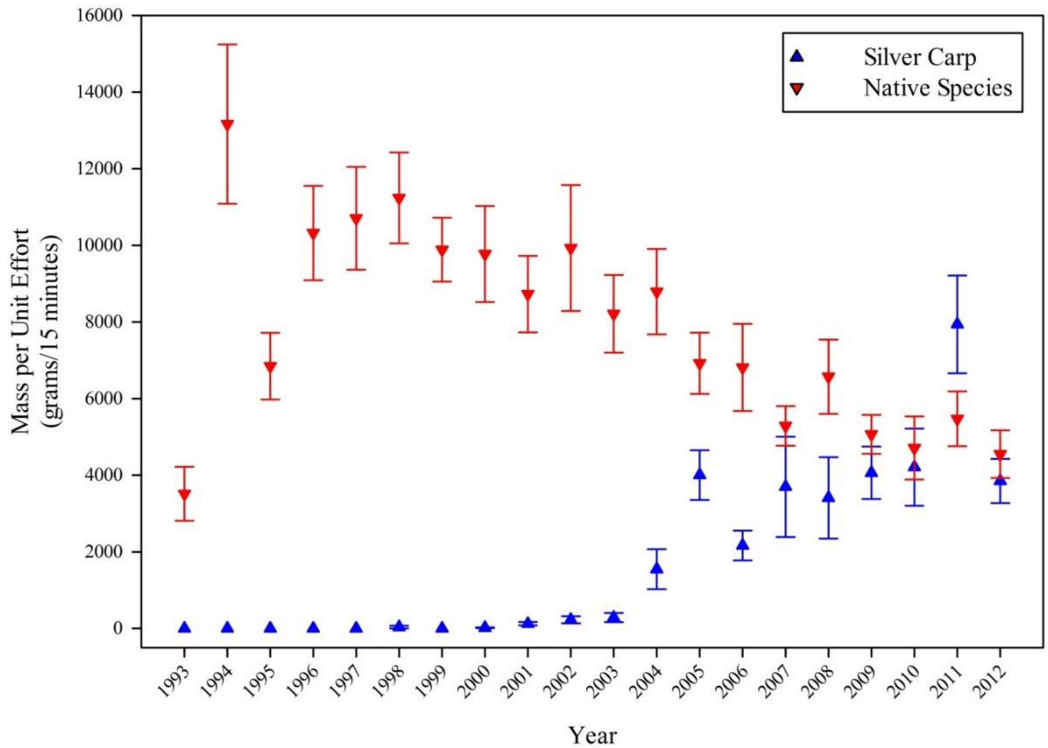


Figure 5-4 Mass Per Unit Effort of Native Species before (1993–1999) and after (2000–2012) Asian Carp Establishment (Source: Ickes 2014)

The mechanism explaining the post-invasion changes in Bigmouth Buffalo and Gizzard Shad in Phelps et al. (2016) was explored in laboratory experiments where Silver Carp were held in aquarium tanks with Bigmouth Buffalo and Gizzard Shad. They found that that the survival of Gizzard Shad, but not Bigmouth Buffalo, was significantly lower in the presence of Silver Carp compared to the control group without carp. They also found that Bigmouth Buffalo had significantly lower growth when held with Silver Carp, compared to the control group of Bigmouth Buffalo (Phelps et al. 2016). Gizzard Shad growth was not evaluated because mortality was high and too few were left for adequate analysis. Gizzard Shad are key forage fish in the Great Lakes, and impacts on this species and other plankton-eating fish could indirectly affect important sport fish species such as Walleye and Yellow Perch (Knight et al. 1984). Text Box 5-6 presents a summary of the studies of Asian carp establishment impacts in the MRB.

5.3.3 Summary of Environmental Consequence Evaluation

In summary, both international studies and studies in the MRB indicate that large Asian carp populations can radically alter resident fish and invertebrate communities in aquatic habitat (Text Box 5-7). In the MRB, YOY Asian carp occupy very shallow wetlands, and adult fish are "present in nearly every habitat available, using primarily low-velocity waters when not spawning" (Kolar et al. 2007). The five Great Lakes cover about 302,000 mi^2 (782,176.4 km^2), and within the GLB there are more than 5,000 tributaries, as well as associated floodplain water bodies (Figure 5-5). Thus, Asian carp are known to occupy a wide range of aquatic habitat, and while all of the areas in Figure 5-5 will not be suitable for these species, studies suggest that if Asian carp were to negatively affect resident species, the effects could be widespread over a large proportion of the GLB.

Text Box 5-6 Observational and Experimental Studies of Asian Carp Impacts in the Mississippi River Basin

- Shift to smaller zooplankton (rotifers) associated with Asian carp invasion of the Illinois River (Sass et al. 2014; Sampson et al. 2009).
- Adverse impacts on some resident planktivorous fish following Asian carp invasion (Irons et al. 2007; Hayer et al. 2014).
- Decreased native fish abundance and changes in fish community composition in several reaches of the Mississippi River that tracked the concurrent increase in Asian carp (Ickes 2014; Solomon et al. 2016; Phelps et al. 2016).
- Decrease in the abundance and condition of sport fish in oxbow lakes in the lower Mississippi River after Silver Carp invasion (Aycock 2016).

Text Box 5-7 Environmental Consequence Evaluation Summary

Based on multiple data sources for assessing the potential impacts of Bighead and Silver Carp:

- Modeling studies for Lake Erie and monitoring data from previously invaded systems suggest that Asian carp have the potential to become a dominant species in the Great Lakes and tributaries.
- Studies of specific river reaches in the MRB indicate significant negative impacts on native fish following Asian carp establishment.
- Most studies indicate that habitat in the GLB is sufficient for Asian carp establishment.
- There is significant uncertainty about the ultimate population size the GLB can support, and, therefore, uncertainty about the magnitude of environmental impacts.

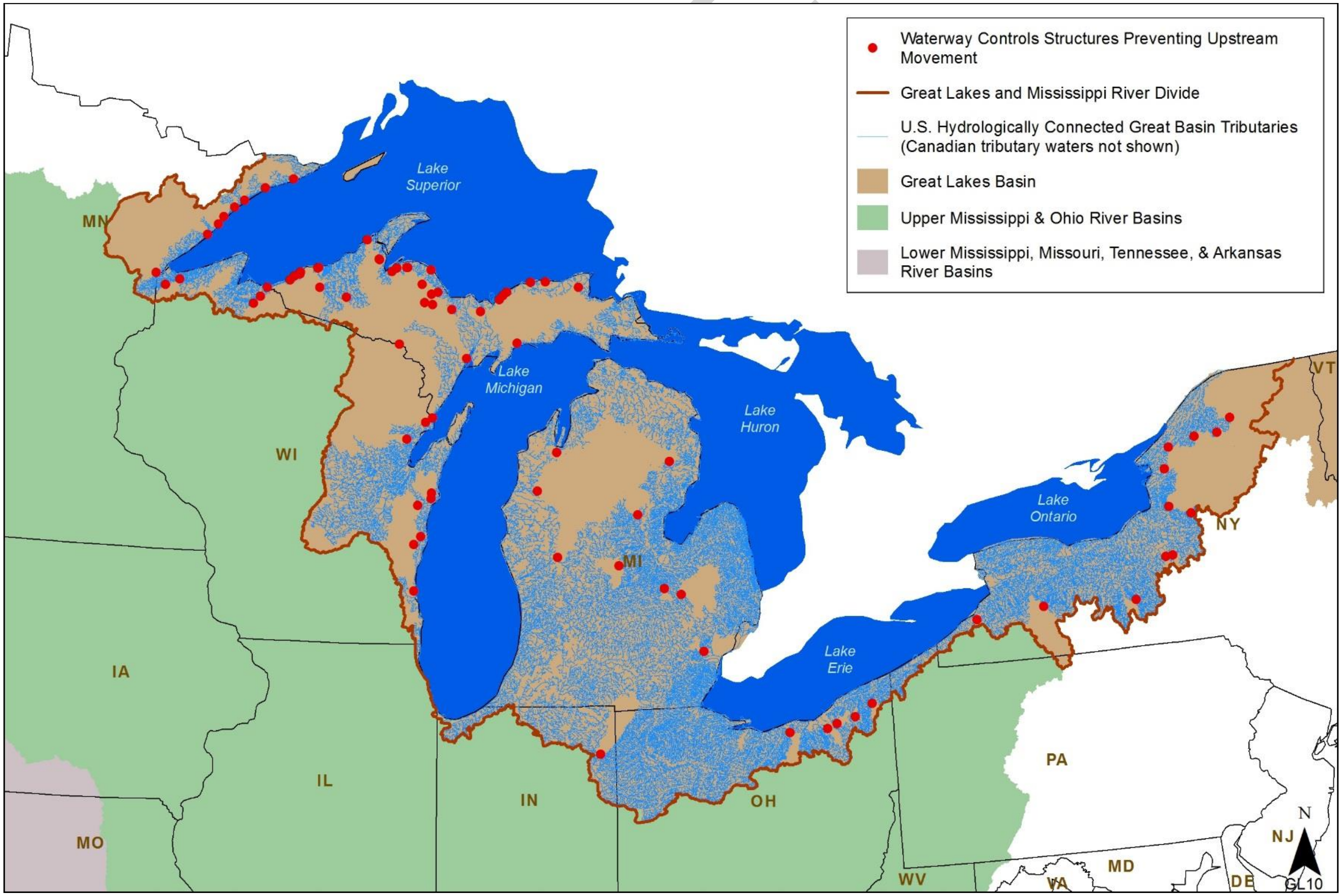


Figure 5-5 Tributaries of the Great Lakes Basin Potentially Accessible to Asian Carp (Red circles represent the locations of dams that only prevent upstream movement. Canadian tributaries and tributary segments upstream of dams are not shown.)

5.3.4 Sociopolitical Consequences of Asian Carp Establishment in the Great Lakes Basin

For the purpose of the GLMRIS-BR risk assessments, social consequences refer to the services that the environment provides for human use, regardless of any associated economic consequences. Swimming, fishing, beach activities, hunting, and recreational boating are all examples of social uses. Sociopolitical consequences may result if an ANS becomes established in a new area and subsequently affects the perceived quality of resources in that area. For example, jumping Silver Carp may reduce the quality of the boating experience in areas where there are high carp densities. Political consequences refer to the potential implementation of new regulations and restrictions to address prevention or control of ANS. For example, to control the spread of Asian carp, new regulations may be developed and implemented that would require more onerous regulations on bait usage and transport. These new regulations could represent a new inconvenience to users. New or expanded actions by Great Lakes state governments to eradicate or control the spread of Asian carp if they were to establish in the Great Lakes are also examples of sociopolitical consequences.

To date, the invasion of Asian carp has resulted in several sociopolitical consequences. For the sociopolitical consequence evaluation, this focus is on the following:

- Legislative and regulatory actions,
- Asian carp as a nuisance species,
- Safety,
- International and tribal considerations, and
- Asian carp management expenditures.

5.3.5 Legislative and Regulatory Actions Related to Asian Carp

One sociopolitical consequence at the federal level was the USFWS listing of the Asian carp as injurious to wildlife species under the Lacey Act, which suggests that there is serious concern about the impact of these species (Text Box 5-8). The Lacey Act listing means that Asian carp have been "demonstrated to be harmful to either the health and welfare of humans, interests of forestry, agriculture, or horticulture, or the welfare and survival of wildlife or the resources that wildlife depend upon" (50 CFR Part 16). Under the Lacey Act listing, Asian carp cannot be imported or transported between states, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the United States by any means without a USFWS permit. Another action at the federal level was the congressional mandate to permanently close the Upper St. Anthony Falls Lock and Dam in an effort to prevent the spread of invasive carp up the Mississippi River (Figure 5-6). This action suggests the significant federal concern about Asian carp establishment in the GLB.

Text Box 5-8 Federal Sociopolitical Consequences Related to Asian Carp

- The listing of Asian carp as injurious to wildlife pursuant to the Lacey Act (USFWS 2013).
- Closure of Upper St. Anthony Falls Lock and Dam to prevent Asian carp invasion of upper MRB.
- Regulations on the import and sale of Asian carp.

a)

b)

Figure 5-6 Closure of St. Anthony Falls Lock and Dam in Minnesota: (a) St. Anthony Lock and Dam (Photo Credit: USACE) and (b) Representative Ellison in Support of Closure (Photo Credit: CSPAN)

5.3.6 International and Tribal Considerations

At the international level, the Government of Canada has expressed significant concern about Asian carp moving into the GLB via the CAWS due to the potential effects of the species on fisheries and recreational activities in Canadian waters (Cudmore and Mandrak 2011). Canadian waters make up a significant portion of Lakes Superior, Huron, Erie, and Ontario, as well as their associated tributaries (Figure 5-7).

A binational risk assessment of Asian carp (Bighead and Silver Carp only) in the Great Lakes, conducted by the USGS and Fisheries and Oceans Canada, rated the ecological consequences of Asian carp in Lakes Michigan, Huron, Erie, and Ontario as high, with moderate certainty (Cudmore et al. 2012). The risk assessment cost $475,000 CND (Canadian National Dollars), and $17.5 million CND has been provided to Fisheries and Oceans Canada to prevent the arrival and establishment of Asian carp (Burden 2016). Measures to prevent Asian carp establishment include research, education and outreach, early warning surveillance monitoring and response, and pathway management and regulation. For example, Canada is currently engaging in public education to prevent human-mediated spread (Figure 5-8). In addition, Fisheries and Oceans Canada is engaged in research on bubble and sound

Figure 5-7 Approximate Boundaries for Canadian and U.S. Waters of the Great Lakes

Figure 5-8 Asian Carp Management Sign from the Toronto Waterfront

barriers that could supplement electric barriers or be used as a portable defense at specific rivers or streams to prevent the movement of Asian carp to spawning habitat. Fisheries and Oceans Canada is also researching the potential for Asian carp movement through the Welland Canal, which connects Lake Ontario to Lake Erie, and the St. Mary's River, which joins Lakes Huron and Superior.

Under negotiated treaty settlements with the U.S. Government, federally recognized Native American tribes co-manage fisheries with federal and state governments to meet sustainable target levels of harvest for treaty species (Figure 5-9). Several treaty-managed species that are of subsistence and of commercial fishing importance to the tribes, such as crappie and Largemouth Bass, are documented to have been negatively affected by the invasion of Silver Carp in the MRB (Solomon et al. 2016; Aycock 2016; Phelps et al. 2016). If Asian carp establishment in the GLB "substantially frustrates achieving the harvest goals and objectives within the 1836 Treaty waters, [their establishment] could result in reopening the

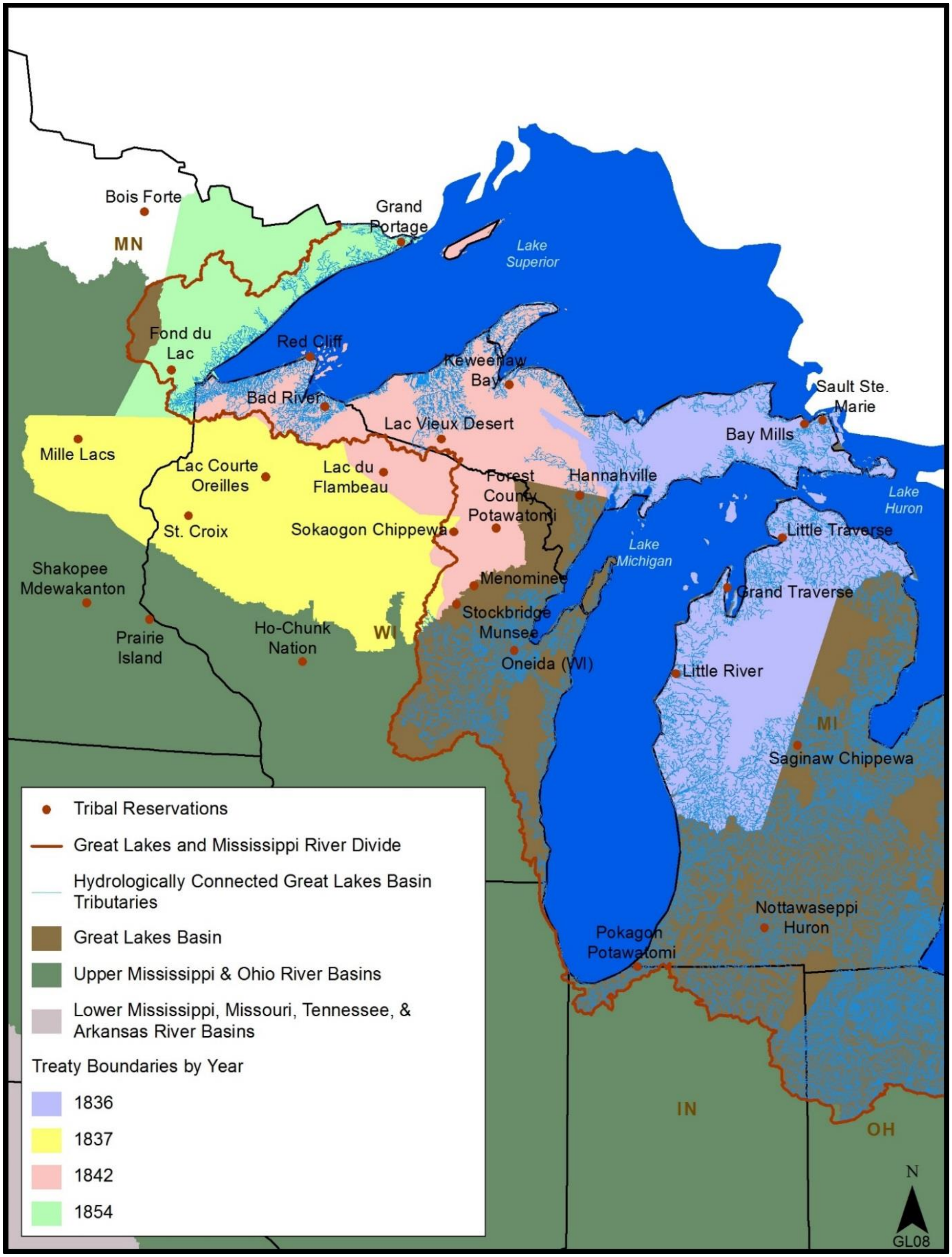


Figure 5-9 GLB Tributaries Located in Treaty Ceded Lands, Which Could Be Accessible by Asian Carp (Tributaries upstream of dams are not shown because they are presumed to be inaccessible to Asian carp.)

terms of [a 2000 and 2007 Consent] Decree and cause each of the parties to spend considerable resources to renegotiate the terms of the Decree[s]" (USFWS 2016).

The 1836 "Treaty Boundaries by Year" highlighted in purple in Figure 5-9 are addressed by the 2000 and 2007 Decree noted above. Text Box 5-9 presents a summary of potential international and tribal consequences of Asian carp establishment in the Great Lakes.

Text Box 5-9 International and Tribal Consequences Associated with the Establishment of Asian Carp in the Great Lakes Basin

- Invasion of Canadian waterways by Asian carp.
- A binational risk assessment (USGS and Fisheries and Oceans Canada) rated the ecological consequences of Asian carp in Lakes Michigan, Huron, Erie, and Ontario as high, with moderate certainty.
- Fishery resources within each Great Lakes Treaty boundary are co-managed by federal, state, and tribal governments. Significant changes in the population of treaty species could initiate the renegotiation of treaty terms and obligations (USFWS 2013).

5.3.7 International Boater Safety and Reduction in the Perceived Value of Aquatic Resources

Other sociopolitical consequences are primarily related to Asian carp as nuisance species and the resulting reduction in the perceived value of aquatic resources and boater safety. As described below, all of these impacts have been documented in the MRB. Studies of these impacts, while sparse, are the most relevant information available to assess the potential sociopolitical consequences of Asian carp establishment in the GLB.

If Asian carp were to become a nuisance, it may reduce the public's perceptions of the quality of the Great Lakes as a place for recreational activities. In fact, mail-in surveys of towns along the Illinois River revealed that residents of towns located near river reaches with high Asian carp densities had lower participation in recreational fishing compared to residents in towns with low carp populations (Spacapan et al. 2016). Although differences in participation cannot definitively be attributed to Asian carp, 59% of respondents stated that they had changed their use of the river because of Asian carp (Spacapan et al. 2012).

Boater safety also appears to be reduced by the jumping behavior of Silver Carp, as 56.9 and 94.3% of respondents from river towns near Asian carp populations reported being hit by a jumping Silver Carp in 2010 and 2011, respectively, and almost 20% of respondents reported being injured by a jumping Asian carp in 2011 (Spacapan et al. 2016) (Figure 5-10). Many respondents to a survey of 31 marinas along the Illinois River also indicated recent changes in pleasure boating and skiing, greater safety precautions, and boat modifications due to the presence of Asian carp (Newcomb 2016). In addition, several respondents noted a reduction in marina usage due at least in part to Asian carp.

Because of the impacts documented in the MRB, there is significant concern about Asian carp establishment among residents of Great Lakes communities and commercial interests, like charter boat operators, whose business depends on the Great Lakes ecosystem services. In 2014, Michigan State University conducted an Internet survey of 500 randomly chosen Michigan residents to better understand public opinion on Asian carp and to assess support for potential options for managing the species if they

Figure 5-10 Silver Carp Jumping in the Fox River, Illinois (Photo Credit: USFWS)

were to establish in the Great Lakes (Gore et al. 2015). A majority of respondents overall (77%), and in coastal counties (79%), had a preference that Asian carp not establish in Michigan state waters (Gore et al. 2015). The survey authors noted that the desire for strong control measures appeared to increase with the individual's belief that Asian carp were a potentially harmful species. Therefore, as the public's knowledge and awareness of Asian carp increases, public concern and the desire for control measures targeting these species is likely to increase significantly.

The concern by commercial fishing (Figure 5-11) interests is exemplified by an August 2, 2016, press release by the Ohio Environmental Council in which charter boat captains call for closure of Asian carp paths to the Great Lakes (Ohio Environmental Council 2016). Dave Spangler, vice-president of the Lake Erie Charter Boat Association, said "Invasive species are bad for business and bad for the environment. Once Bighead and Silver Carp arrive, it will be almost impossible to remove them and they are not waiting on Congress to take action […] Last year on Lake Erie, charter boat captains lost thousands of dollars' worth of business from harmful algal blooms and the effects on our businesses will only worsen with the addition of Bighead and Silver Carp." Recreational fishing groups have also weighed in. The American Sportfishing Association (ASA) "supports the legislation to stave off economic and environmental consequences of aquatic invaders and continues to monitor and support such efforts" (ASA 2017). Text Box 5-10 presents a summary of documented nuisance and safety impacts associated with the establishment of Asian carp in the MRB.

Figure 5-11 Commercial Fishing Vessel in the Great Lakes (Photo Credit: USACE)

Text Box 5-10 Sociopolitical Consequences of Asian Carp Establishment in the Great Lakes Basin Related to Asian Carp as a Nuisance Fish

Reduction in the Perceived Value of Aquatic Resources

- Residents of towns located near river reaches with high Asian carp densities had lower participation in recreational fishing compared to residents in towns with low carp populations.
- 59% of survey respondents stated that they had changed their use of the river because of Asian carp (Spacapan et al. 2012, 2016).
- A reduction in marina usage due at least in part to Asian carp was noted by several survey respondents.
- A majority of Michigan survey respondent's preferred that Asian carp not establish in Michigan state waters (Gore et al. 2015).

Safety Issues Related to Collision with Water Users

- A majority of respondents from river towns near Asian carp populations reported being hit by a jumping Silver Carp (Spacapan et al. 2016).
- Almost 20% of respondents reported being injured by a jumping Silver Carp in 2011 (Spacapan et al. 2016).
- A survey of 31 marinas along the Illinois River indicated recent changes in pleasure boating and skiing, greater safety precautions, and boat modifications due to the presence of Asian carp (Newcomb 2016).

5.3.8 New and Increased Asian Carp Management Expenditures in the United States and Canada

Another documented sociopolitical impact following Asian carp establishment in the MRB is the expensive and labor-intensive monitoring programs and barriers to movement that have been instituted in several states to monitor and control the spread of Asian carp. Similar efforts could be created or expanded in Great Lakes states if Asian carp were to establish in the GLB. To better understand the labor and monetary expenditures associated with Asian carp establishment, questionnaires and interviews with the state environmental agencies of Wisconsin, Ohio, New York, Pennsylvania, Indiana, and Minnesota, as well as the Government of Canada and the Province of Ontario, were conducted. Information was requested on whether the states had developed management plans for existing Asian carp populations in their states and whether they had response plans if Asian carp were to establish in the GLB. They were also asked to describe the contents of these plans and estimate the associated costs.

For states with Asian carp currently established in state waters, efforts to manage Asian carp include education, monitoring (e.g., eDNA monitoring and fish surveys), Asian carp removal, regulatory changes, and the physical modification of waterway connectivity. Most states have implemented education programs to help the public identify Asian carp and to report them to state agencies when found. While states prohibit the possession, import, or sale of Asian carp, additional regulatory changes specific to Asian carp have been implemented. For example, Indiana has altered fishing regulations to encourage the public to fish for Asian carp (Fischer 2016). To prevent accidental introductions, restrictions on live bait use in lakes have been implemented in Minnesota (Frohnauer 2016). Ohio has spent $100,000 implementing a comprehensive bait facility inspection program specifically geared toward the detection of Asian carp, and print and billboard advertisement outreach campaigns targeting anglers (Navarro 2016).

For states that have Asian carp within state waters, there has been a substantial investment in Asian carp monitoring using fish surveys and eDNA. Even states that do not have established Asian carp populations have implemented eDNA monitoring (Grazio 2016; Morgan 2016; McGlynn 2016). In addition, Ohio has spent $100,000 in an early detection and monitoring program for Asian carp in the Lake Erie Basin, Ohio River, and Muskingum River (Navarro 2016).

The most expensive state efforts have been active measures to reduce the population or restrict the spread of Asian carp within state waters. For example, Indiana and Ohio have both constructed physical barriers totaling more than $10 million dollars in construction costs to eliminate hydrologic connections to the GLB (Figure 5-12). Indiana constructed a berm at Eagle Marsh to prevent the movement of Asian carp into the GLB, which cost approximately $4.4 million dollars (Fischer 2016). Ohio has undertaken several projects to prevent the movement of Asian carp (Navarro 2016):

- Grand Lake St. Mary’s ($1,000,000): project should be completed in 2016.
- Ohio Erie Canal ($3,000,000): USACE will complete the final design for closing this connection on September 29, 2016.
- Little Killbuck Creek ($6,000,000): The final design will be completed in 2017 and closure implemented thereafter.

a)

b)

Figure 5-12 Examples of Expenditures To Prevent the Establishment of Asian Carp (a) Eagle Marsh Barrier (Photo Credit: USGS); (b) Overfishing Efforts (Photo Credit: Illinois DNR)

The State of Minnesota also has invested in research to develop sonic deterrents and fish barriers that could be used to restrict the movement of Asian carp. As of now, only Illinois has a large Asian carp removal program. This program is funded primarily by GLRI and costs $1,400,000 (ACRCC 2016) annually to maintain. Overall, $61,000,000 was spent in 2014 to prevent the movement of Asian carp into the GLB (Chapman et al. 2016).

The management activities described above demonstrate the significant past and ongoing management costs to states resulting from the establishment of Asian carp. Several states have also developed response plans describing new measures to monitor and combat the spread of Asian carp if they were to establish in their state or in the GLB. Many of the proposed response measures for the GLB are similar to past management actions in the MRB. Based on existing state response plans, the actions are centered around the following:

- *Outreach, education, and communication (e.g., interagency committee coordination, websites)* – Such efforts would be implemented to help the public identify Asian carp, describe relevant regulations, and describe the potential impacts of establishment (Clapp et al. 2010; Ohio DNR-DOW 2014; Invasive Carp Work Group 2014).

- *New regulations on fishing, bait transfer, vessel maintenance and discharges* – The direct effects of fishing restrictions on the public will likely be in the form of bait transport restrictions such as restricting the use of bait to waters where it was collected (Clapp et al. 2010; Ohio DNR-DOW 2014) and requiring the cleaning/treatment of all gear used in invaded waterways, or restrict gear from being used in multiple water bodies (Clapp et al. 2010).

- *Modify existing locks and dams, fish passage structures, and weirs to prevent the spread of Asian carp* – The current Minnesota Asian carp management plan indicates that modifying lock and dam operations may be used to slow the spread of Asian carp from the Mississippi River into the Minnesota and St. Croix Rivers (Invasive Carp Work Group 2014). New York State is conducting a FS for disconnecting the Champlain canal from the Hudson River (McGlynn 2016).

- *Expanded or newly implemented costly new monitoring and overfishing activities following Asian carp establishment in the GLB* – Monitoring and eDNA sampling in tributaries, bays, and lakes are expected to increase in response to Asian carp entering Lake Michigan (Clapp et al. 2010; Invasive Carp Work Group 2014; Ohio DNR-DOW 2014); physical removal of Asian carp may also be undertaken.

- *New research activities* – Expenditure on investigations into the ecosystem effects of Asian carp and research into containment or control technologies (Ohio DNR-DOW 2014).

5.3.9 Summary of Sociopolitical Consequences of Asian Carp Establishment in the Great Lakes Basin

Overall, multiple states and Canada could initiate costly new management activities or greatly expanded existing management activities following Asian carp establishment in the GLB, given the significant stakeholder concerns about impacts on commercial and recreational activities. Prevention of ANS establishment is always preferred to post-establishment control because of the difficulty or impossibility of controlling or eradicating ANS once established. This is particularly true of Asian carp due to the following traits identified in Kolar et al. (2005):

- High fecundity,
- Efficient and voracious food consumption,
- Rapid growth,
- Competitive abilities relative to other filter feeders, and
- High environmental tolerance and adaptation to a wide variety of habitat conditions.

Due to these physiological traits, Asian carp populations are capable of growing rapidly under suitable conditions. For example, population growth in the Illinois River is exponential, and Asian carp account for the vast majority of fish biomass in certain reaches (Sass et al. 2010). While overfishing is a potential option to manage Asian carp if they were to establish in the Great Lakes, this would be a particularly difficult and expensive management strategy given the size and habitat diversity of the GLB. The GLB covers a surface area of 295,754.3 mi^2 (766,000 km^2) and includes 5,000 tributaries flowing into the Lakes, and more than 1,000 mi (1,609.3 km) of shoreline (Figure 5-13). Depending on the extent to which Asian carp spread over this vast region, any attempt to eradicate or significantly reduce Asian carp populations, once established, would likely be extremely expensive and potentially unsuccessful. Consequently, actions focused on the more geographically limited area of BRLD would likely require less overall effort, coordination, and expense compared to combating Asian carp on multiple fronts within the GLB. Text Box 5-11 presents a summary of potential management expenditures associated with the establishment of Asian carp in the MRB.

5.4 Economic Consequences of Asian Carp Establishment in Lake Erie

Using a combination of best-available ecological and economic information, an analysis was completed in order to identify the economic consequences that could be realized in Lake Erie in the event of Asian carp establishment. These potential consequences are identified for Lake Erie's commercial, recreational, and charter fisheries, and are expressed as changes to people's well-being (NED account) and regional economy (RED account) (see Section 5.4.5, Overview of Differences between NED and RED). Given that there are numerous uses and users of the GLB that are economically important to the nation and the Great Lakes region, the GLMRIS-BR analysis quantitatively addresses only a small subset of the total economic consequences that could be realized throughout the basin. As discussed in the following sections, further ecosystem modeling for the remaining Great Lakes and tributaries, as well as an extensive economic data collection effort would be required to complete a comprehensive consequences analysis. The ecosystems, types of uses and users (fishing, boating, etc.), magnitude of use, and several other relevant factors vary between the remaining Great Lakes and tributaries. Although most of this required information is not available, the existing ecological and economic information for Lake Erie did afford the GLMRIS-BR Study team the opportunity to evaluate a portion of the potential economic consequences given Asian carp establishment in this lake. The GLMRIS-BR analysis for Lake Erie provides a preliminary, albeit uncertain, indication of the type of consequences that could be realized if Asian carp did transfer and establish in the GLB.

In addition to the limited scope of the economic analysis, it is important to note that the GLMRIS-BR alternatives are only designed to reduce the probability of ANS establishment through the CAWS aquatic pathway. They do not address or mitigate the consequences of ANS establishment in the Great Lakes. Therefore, the economic consequences of Asian carp establishment are the same for all of the GLMRIS-BR alternatives.

5.4.1 Total Values Versus Changes in Values

The GLMRIS Report (USACE 2014a) provided useful information on the total amounts of some key activities in the Great Lakes. Information on the total levels of these activities provides vital evidence on their importance. However, unless the introduction of Asian carp were to eliminate an activity, what is most useful to planners and decision makers facing investment decisions is information on how any activity changes when Asian carp become established. Figure 5-14 illustrates some of the important concepts that are considered when estimating these changes. On the far left of the diagram, a change in Asian carp populations is posited (e.g., from zero to establishment level) in a given water body. The next step in the linkage would be to understand how this change in Asian carp would affect the ecosystem in which they become established. Often, such knowledge requires previous experiences with Asian carp establishment or sophisticated ecosystem models. Next, any changes in the ecosystem need to be linked to resulting changes in the suite of ecosystem services provided by the GLB, and more specifically, how these ecosystem services change in response to changes in Asian carp. Finally, changes in ecosystem

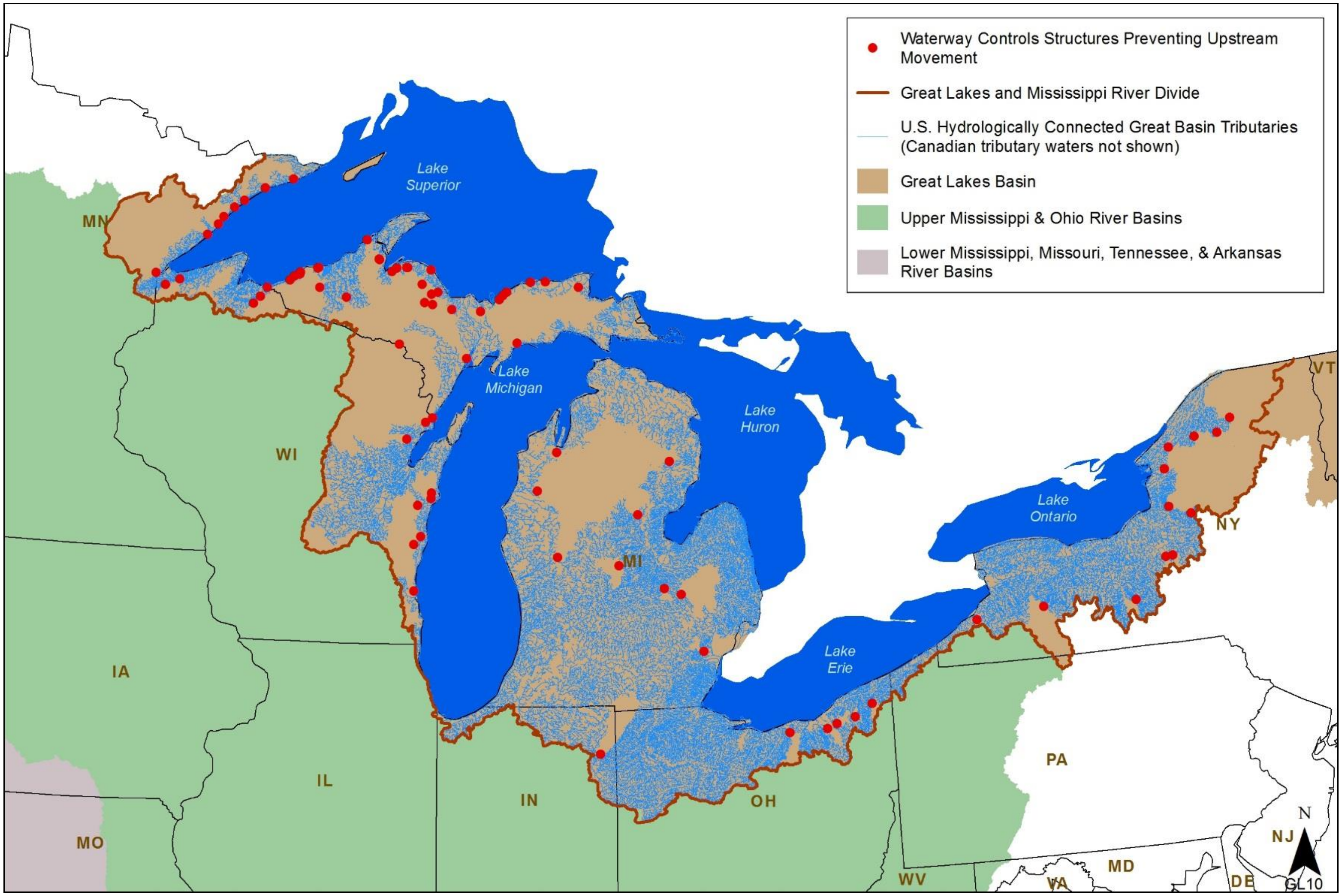


Figure 5-13 Tributaries of the Great Lakes Basin Potentially Accessible to Asian Carp (Red circles represent the locations of dams that only prevent upstream movement. Canadian tributaries and tributary segments upstream of dams are not shown.)

Text Box 5-11 Sociopolitical Consequences of Asian Carp Establishment in the Great Lakes Basin Related to Management Expenditures

- Modification of locks and dams, fish passage structures, and hydrologic connections (Clapp et al. 2012; Invasive Carp Work Group 2014; Ohio DNR-DOW 2014; Pennsylvania Fish and Boat Commission 2011).
- Implementation or expansion efforts to physically remove Asian carp (Clapp et al. 2012; Invasive Carp Work Group 2014; Pennsylvania Fish and Boat Commission 2011).
- Increased monitoring and environmental DNA sampling in tributaries, bays, and the main lake (Clapp et al. 2012; Invasive Carp Work Group 2014; Ohio DNR-DOW 2014).
- Increased regulation on imported bait and restriction on use of collected bait to waters where it was collected (Clapp et al. 2012; Ohio DNR-DOW 2014).
- Increased federal and state funding for research on new technologies to eradicate or prevent further expansion of Asian carp populations (Invasive Carp Work Group 2014; Pennsylvania Fish and Boat Commission 2011).
- Monitoring and research ecosystem effects of Asian carp (Clapp et al. 2012; Invasive Carp Work Group 2014).
- Continued or expanded public education programs regarding Asian carp (Clapp et al. 2012; Invasive Carp Work Group 2014; Ohio DNR-DOW 2014; Pennsylvania Fish and Boat Commission 2011).

[4] Aquatic Invasive Species (AIS) Action Plan: Bighead and Silver Carp Complex. 2011. Pennsylvania Fish and Boat Commission Natural Diversity Section. Available at: http://www.fishandboat.com/Resource/SpeciesofSpecialConcern/Documents/ais-action-asian-carp.pdf

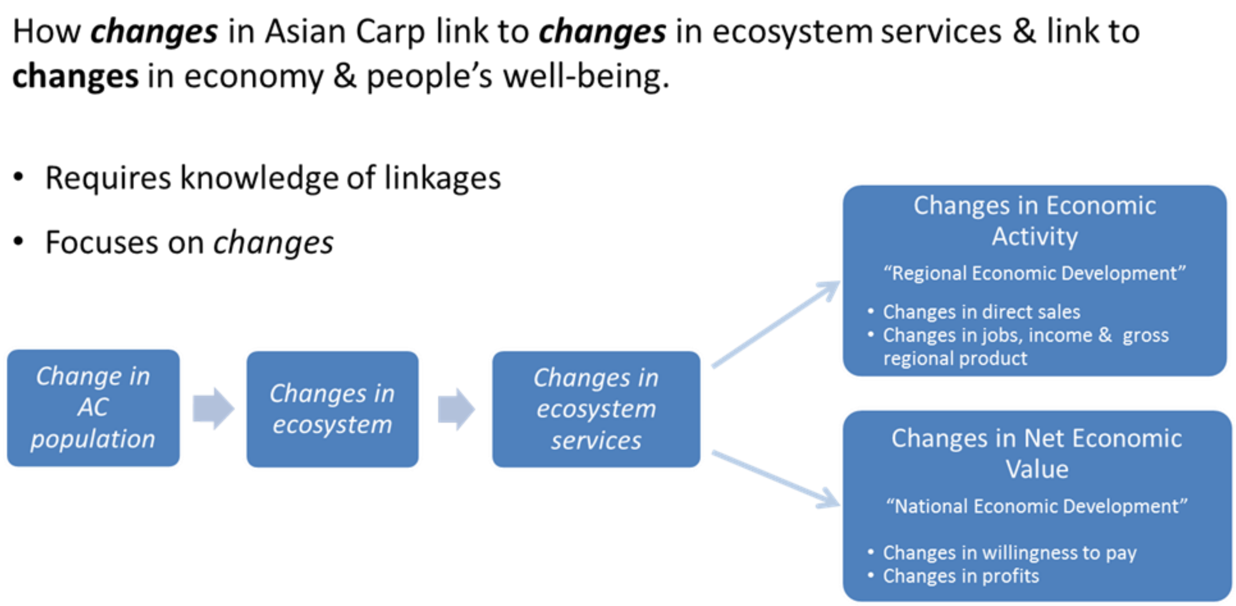


Figure 5-14 Illustration of Linkages between Asian Carp Establishment and Economic Outcomes

services can be mapped into changes to the regional economy (as considered by the RED account) and changes to people's well-being (NED account).

5.4.2 Economic Activities Potentially Affected by Asian Carp Establishment in the Great Lakes Basin

Figure 5-14 shows how Asian carp establishment and any changes in Asian carp populations can alter the ecosystem, change ecosystem services provided, and thus affect economic activity and value. However, connecting Asian carp to these economic effects requires specific information on the many ways that Asian carp could affect the ecosystem and ecosystem services. Since Asian carp have not established in the Great Lakes, scientific understanding of these linkages is limited and characterized by high levels of uncertainty. Nevertheless, some possible ways that Asian carp could affect the economy can be outlined even without a full understanding of all potential effects.

There is a range of possible ways Asian carp could affect the economy and human uses of water bodies. An illustrative listing of these is provided in Table 5-3. The table rows represent a variety of human uses that have the potential to be affected by Asian carp, while the columns show the Great Lakes and their tributaries. Connecting waters such as Lake St. Clair would also be affected, but are implicit in the table.

Table 5-3 Several Uses of the Great Lakes and Tributaries That Could Be Affected if Asian Carp Establish[a]

Lake Michigan	Lake Superior	Lake Huron	Lake Erie	Lake Ontario
Commercial fishing	Commercial fishing	Commercial fishing	Commercial fishing[b]	Commercial fishing
Recreational fishing	Recreational fishing	Recreational fishing	Recreational fishing[b]	Recreational fishing
Recreational boating	Recreational boating	Recreational boating	Recreational boating	Recreational boating
Charter fishing	Charter fishing	Charter fishing	Charter fishing[b]	Charter fishing
Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments
Subsidence fishing	Subsidence fishing	Subsidence fishing	Subsidence fishing	Subsidence fishing
Beach going	Beach going	Beach going	Beach going	Beach going
Property values	Property values	Property values	Property values	Property values
Lake Michigan tributaries	**Lake Superior tributaries**	**Lake Huron tributaries**	**Lake Erie tributaries**	**Lake Ontario tributaries**
Recreational fishing	Recreational fishing	Recreational fishing	Recreational fishing	Recreational fishing
Recreational boating	Recreational boating	Recreational boating	Recreational boating	Recreational boating
Charter fishing	Charter fishing	Charter fishing	Charter fishing	Charter fishing
Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments	Pro-fishing tournaments
Subsistence fishing	Subsistence fishing	Subsistence fishing	Subsistence fishing	Subsistence fishing
Property values	Property values	Property values	Property values	Property values

[a] Not a comprehensive list. For simplicity, connecting waters such as Lake St. Clair have been omitted.
[b] The three fishing activities on Lake Erie for which changes are quantified using NED and RED analyses.

Some of the possible effects of Asian carp in the Great Lakes can be inferred from the effects of Asian carp invasions in other systems. In some systems where Asian carp have invaded, they represent a large part of the biomass of those systems and have had large adverse effects on some parts of the food web, such as some types of zooplankton and some plankton-eating fishes. It is also possible that besides altering the biomass of other species, an Asian carp invasion could alter the size distributions and length-weight relationships of other species (e.g., resulting in many smaller fish rather than fewer larger fish). Therefore, key commercial activities potentially affected by Asian carp include commercial fishing by state-licensed and tribal operators and charter fishing operations (Table 5-3). Other aspects of the fisheries potentially affected by Asian carp include recreational angling on the Great Lakes and tributaries, as well as related fishing tournaments. Subsistence fishing could also be affected by Asian carp.

Figure 5-15 shows the species of key economic interest to the commercial, recreational, and charter fisheries in each of the Great Lakes. For commercial fisheries, any species that constitutes more than 10% of the harvest value is listed; the key commercial species are either whitefish or Yellow Perch, depending on the lake. For recreational and charter, the key species groups are somewhat similar across lakes; the

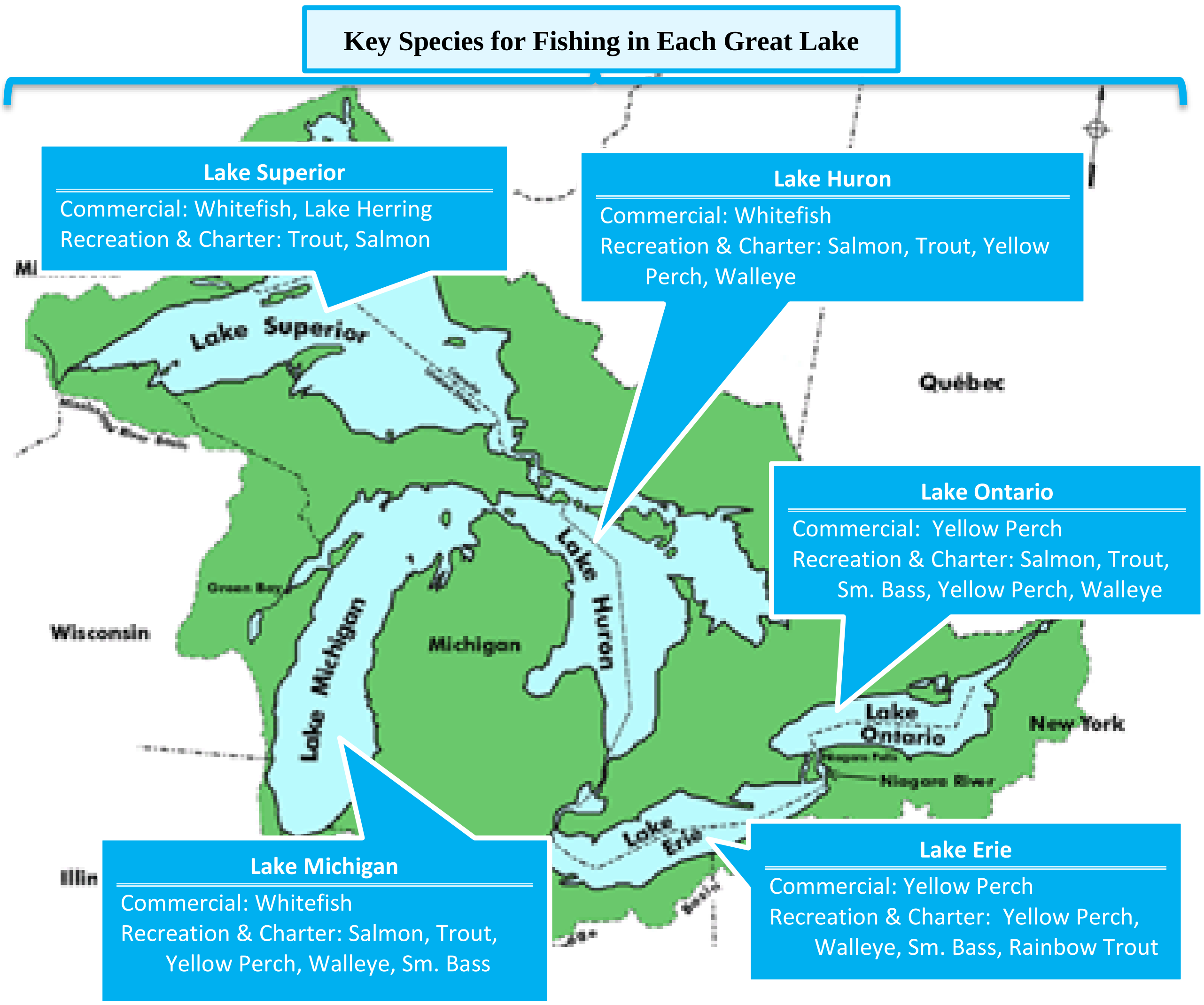


Figure 5-15 Key Species for Fishing in Great Lakes

various coldwater salmon and trout species (and in some places Walleye) are key targets in deeper waters and on runs up tributaries, and Yellow Perch, Walleye, and Smallmouth Bass are key targets in shallower areas such as nearshore zones and bays. In all the lakes other than Lake Erie, the various salmon and trout species attract the most recreational and charter fishing effort. Because key economic species, as well as their relative importance, vary across lakes, and because Lake Erie is different from the other lakes, any ecological and economic models for Lake Erie fisheries may not be applicable to the other lakes.

Non-fishing activities potentially affected by Asian carp include recreational boating, other shoreline activities, and uses of coastal and riparian properties (Table 5-3). Although some Great Lakes fishing occurs from private boats, potentially half of all Great lakes boating does not involve fishing. For example, it is also well established that Asian carp behave differently than other fish, particularly in their jumping behavior – the noise of boats can cause them to jump into the air, putting boaters at risk of injury. Boating could be affected through equipment damage and personal injuries from jumping fish and through losses in enjoyment of boating due to the other impacts of Asian carp. Asian carp also have the potential to affect significant non-fishing shoreline recreational activities including swimming and beach going (Table 5-3). Coastal and riparian properties and their values would be affected if the willingness of people to live near these water bodies was altered in any way by Asian carp; for example, these property values could be altered due to the changes in the availability or quality of recreational activities such as fishing, swimming, and boating, as well as unforeseen adverse effects on water quality (Table 5-3).

There are many unknown or less-understood possibilities associated with Asian carp establishment in the GLB. For example, as with any invasive species, it is possible that establishment of Asian carp could bring with it new or altered risks of diseases. Because of the changes Asian carp induce in the food web, they might have unforeseen impacts on nutrient levels, which in turn affect water quality. Effects on water quality would then have impacts on a range of human uses such as fishing, beach going, and other shoreline recreation; boating; and the ways that people use properties on or near affected water bodies. All of these potential changes could have economic impacts by altering public perception or use of resources in the Great Lakes and their tributaries.

5.4.3 What Can Be Quantified

To assist planners and decision makers it would be useful to know how Asian carp would affect the broad range of uses and activities in the GLB (Table 5-3), if at all (i.e., how the ecosystem services change with establishment of Asian carp, as illustrated in Figure 5-14). This requires some scientific studies or credible information linking Asian carp to changes in these ecosystem services. However, such information is not available for most of the activities in the GLB and the more than 5,000 Great Lake tributaries, which may be especially susceptible to Asian carp establishment (USFWS 2013). As described below, ecological modeling data on changes in fish communities following Asian carp establishment were only available for Lake Erie (excluding tributaries). Therefore, the evaluation of the economic consequences of Asian carp is limited to Lake Erie, and does not address the remaining Great Lakes or GLB tributaries. The economic information required to link ecological changes in Lake Erie to economic changes was available for three activities: commercial, charter, and recreational fishing in Lake Erie (excluding its tributaries). Thus, given the best-available information, the economic consequences of Asian carp could only be quantified for commercial, charter, and recreational fishing in Lake Erie. This means that only a small fraction of the total economic activity in the GLB (shown in Table 5-3) could be quantitatively evaluated for the GLMRIS-BR.

To characterize the effects Asian carp could have on the Lake Erie fishery, information is required to predict the changes in the fishery, as described above. Any economic effects Asian carp have on the fishery will depend on how Asian carp could affect commercially viable fish species. The NOAA-GLERL Lake Erie food web model, hereafter referred to as the NOAA food web model, used Ecopath with Ecosim (Christensen and Walters 2004) to simulate how fish species biomass in Lake Erie changes with the introduction of Asian carp (Zhang et al. 2016). The results of this model were then utilized by the GLMRIS-BR economics team. *The NED and RED analyses convert expected changes in biomass and harvests in these fisheries into changes in economic values to people and changes in economic impacts on the economy.*

5.4.4 Summary of Key Species and Lake Erie NOAA Model

The NOAA model includes more than 45 separate model categories in the food web to represent plankton, benthos, and fishes. The model was run under multiple scenarios developed by the NOAA authors to reflect different assumptions about the diet of Asian carp, their plankton consumption efficiency, and the vulnerability of Asian carp to predation. Using the biomass output from the model, the percent difference in biomass of the species group between baseline conditions (no Asian carp) and under each Asian carp establishment scenario was calculated. These scenarios are presented in Table 5-4. The results of the NOAA model indicate that the introduction of Asian carp in Lake Erie adversely affects some species groups under all scenarios examined.

The key species for recreational fishing effort in Lake Erie are Walleye (48% of effort), Yellow Perch (29%), Rainbow Trout (Steelhead, 20%), and to a lesser extent Smallmouth Bass (3%). For charter trips, the effort is mainly for Walleye (79%), with some effort for Yellow Perch (18%) and minor amounts of effort for Rainbow Trout (Steelhead) and Smallmouth Bass. In the Lake Erie commercial fishery, there were 20 species of fish that were caught that have some dockside value from 2009 to 2013. However, about two-thirds of the harvest value is for Yellow Perch and no other species accounts for more than 8% of the harvest value.

Table 5-5 presents the percentage changes in biomass for key recreational and charter species in Lake Erie based on the NOAA model. The table shows that for the key species of economic value, the impacts of Asian carp are varied. In some of the scenarios where a species group like shiners were substantially negatively affected by Asian carp (e.g., scenarios 2, 4, and 6), species such as adult Yellow Perch and adult Walleye are positively affected – their abundance is expected to increase with Asian carp because of changes in the food web predicted within the NOAA model. Note that in these same scenarios, another key recreational species, Rainbow Trout, is expected to decrease. Thus, the outcome of the economic analyses will be driven by changes in biomass predicted by the NOAA model for the key economic species, rather than for all possible species.

The analysis of changes in the Lake Erie fishery can be cast within the context of Figure 5-14 – which illustrates how to link Asian carp to changes in ecosystem services and then to changes in the economy and people's well-being – by altering it as in Figure 5-16. In Figure 5-16, changes in Asian carp populations in Lake Erie are linked to changes in other fish populations in Lake Erie using the NOAA ecological model. Given the changes in fish populations, existing data and studies are used to estimate changes in recreational and charter fishing trips and to changes in commercial fish harvests. These changes are then the inputs into the NED analysis of changes in well-being and the RED analysis of changes in economic activity.

Table 5-4 NOAA Model Scenarios

NOAA Model Scenarios[a]	Scenario Descriptions
Scenario 1	Low plankton vulnerability to consumption by Asian carp (i.e., lower Asian carp feeding efficiency); high Asian carp P/B[b] (1.08); salmonid predation on Asian carp assumed to occur; Asian carp do not feed on fish larvae
Scenario 2	High plankton vulnerability to consumption by Asian carp (i.e., higher Asian carp feeding efficiency); high Asian carp P/B (1.08); salmonid predation on Asian carp assumed to occur; Asian carp do not feed on fish larvae
Scenario 3	Low plankton vulnerability to consumption by Asian carp (i.e., lower Asian carp feeding efficiency); low Asian carp P/B (0.6); Salmonid predation on Asian carp assumed to occur; Asian carp do not feed on fish larvae
Scenario 4	High plankton vulnerability to consumption by Asian carp (i.e., higher Asian carp feeding efficiency); low Asian carp P/B (0.6); salmonid predation on Asian carp; Asian carp do not feed on fish larvae
Scenario 5	Low plankton vulnerability to consumption by Asian carp (i.e., lower Asian carp feeding efficiency); low Asian carp P/B (0.6); no salmonid predation on Asian carp; Asian carp do not feed on fish larvae
Scenario 6	High plankton vulnerability to consumption by Asian carp (i.e., higher Asian carp feeding efficiency); high Asian carp P/B (1.08); salmonid predation on Asian carp; Asian carp feed on fish larvae
Scenario 7	High plankton vulnerability to consumption by Asian carp (i.e., higher Asian carp feeding efficiency); low Asian carp P/B (0.6); no salmonid predation on Asian carp; Asian carp feed on fish larvae
Scenario 7 + 1SD	To characterize uncertainty for scenario 7, each species' average biomass was increased by 1 standard deviation, derived from the NOAA model's uncertainty simulations
Scenario 7 - 1SD	To characterize uncertainty for scenario 7, each species average biomass was decreased by 1 standard deviation, derived from the NOAA model's uncertainty simulations

[a] See Section 5.3.1, Data Sources for Asian Carp Consequence Evaluation, for further description of NOAA model and scenarios.
[b] "P/B" = ratio of production to biomass.

5.4.5 Overview of Differences between NED and RED

This economic consequences analysis discusses two distinct economic concepts that relate to changes in the fishery due to Asian carp. The USACE refers to these as NED (national economic development) and RED (regional economic development). More generally in economics, changes in RED are referred to as changes in economic impacts and changes in NED are referred to as changes in economic value or changes in economic welfare, commonly known as well-being (Freeman et al. 2014). Economic impacts measure changes in regional economic activity such as economic output (e.g., sales), incomes, and jobs (Watson et al. 2007). Economic values measure changes in people's and businesses' well-being net of their costs (Freeman et al. 2014). Notably, the two types of economic values are typically not directly comparable, and should not simply be added together because they measure different concepts. Following

Table 5-5 Percentage Changes in Biomass for Key Recreational and Charter Species in Lake Erie (based on NOAA model)

NOAA Model Scenarios	Biomass Change (%)			
	Yellow Perch	Walleye	Smallmouth Bass	Rainbow Trout (Steelhead)
Scenario 1	1%	2%	0%	0%
Scenario 2	17%	12%	13%	−20%
Scenario 3	1%	2%	0%	0%
Scenario 4	11%	8%	7%	−15%
Scenario 5	1%	2%	0%	−1%
Scenario 6	11%	8%	7%	−19%
Scenario 7	−13%	−13%	22%	−2%
Scenario 7 + 1SD	13%	1%	36%	14%
Scenario 7 - 1SD	−38%	−27%	8%	−18%

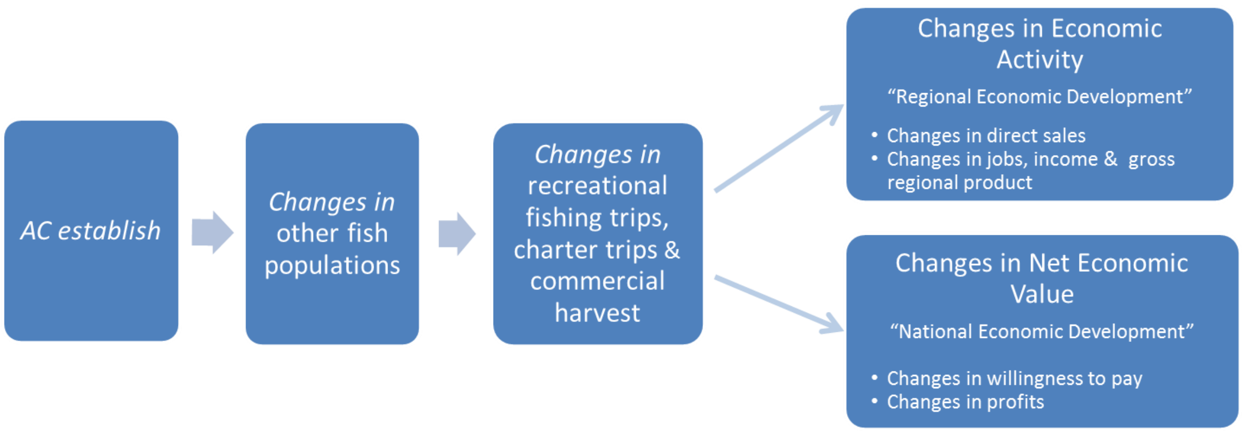


Figure 5-16 Linking Asian Carp Establishment to Changes in the Fishery and to the Resulting Changes in NED and RED

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies promulgated in 1983 (U.S. Water Resources Council 1983), this consequence analysis provides information on both NED and RED. The differences between changes to the NED and RED accounts are further illustrated in Figure 5-17, as they apply to commercial, recreational, and charter fishing. These concepts and applications are explored further in the following sections.

5.5 NED Analysis: Economic Consequences of Asian Carp Establishment in Lake Erie

5.5.1 NED Approach Overview

The theory underlying this NED approach is that establishment of Asian carp will affect existing biomass stocks of key commercial and recreational fish in the Great Lakes as simulated by the NOAA model.

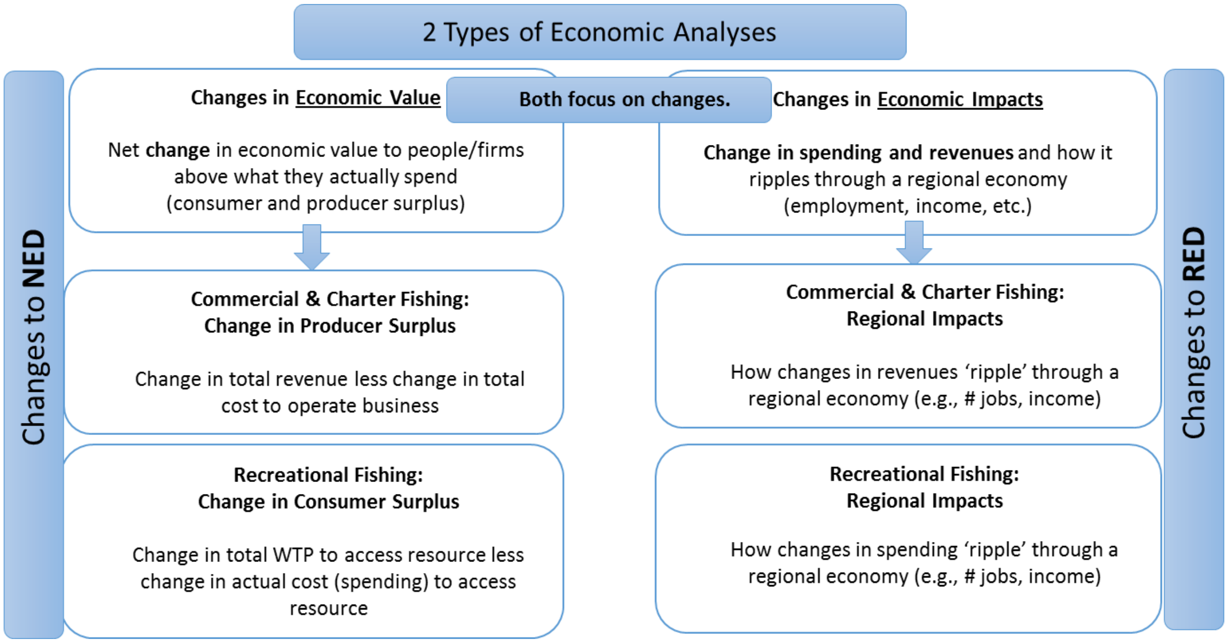


Figure 5-17 Economic Consequences – NED and RED Analysis Completed for Each Fishing Activity (Commercial, Recreational, and Charter)

These biomass changes may differ for each of the scenarios modelled in Table 5-4. These biomass changes will have a direct bearing on commercial fishing harvests and recreational fishing days, which in turn affect the net economic value of commercial, charter, and recreational fishing in the Great Lakes (Figure 5-18). To measure the changes in these economic values, the approach follows standard theory from benefit-cost analyses and microeconomics and measures the changes in the producer and consumer surplus for commercial, charter, and recreational fishing in the Great Lakes (Freeman et al. 2014). Here, changes in producer surplus are measured by estimating the changes in profits (revenues less costs) to commercial fishing and charter fishing operations. Consumer surplus is the amount a consumer is *willing to pay* for a good or service *in addition to* what they have to pay. For recreational fishing, this is measured by the area under a demand curve for recreational fishing that relates the time and money costs of travel to fishing sites to the number of fishing trips anglers take (Haab and McConnell 2002). In addition, these same recreation demands can be related to the quality of fishing as measured by fish catch rates. Then when catch rates change, these demand curves shift and provide estimates of how trips respond to fishing quality and how consumer surplus changes (Melstrom and Lupi 2013; Kotchen et al. 2006). In applying the economic theory, data needed to estimate changes in recreational and charter fishing days when fish biomass changes and the values for fishing days and other key parameters were derived from other studies and existing Lake Erie data, an approach called benefits transfer (Johnston et al. 2015).

As discussed above, the NED approach takes as an input for each scenario the estimated change in fish biomass for many different species and specie groups that come from the NOAA-GLERL modelling group (Zhang et al. 2016). Other inputs include fishing trip data from state and federal data sources, historical commercial harvest dockside values from state and federal sources, consumer surplus values for recreational fishing trips from the literature, and response of fishing trips to changes in biomass from the literature. The approach produces final outputs for the NED analysis as well as inputs to the RED analysis, as outlined in Figure 5-18. For commercial fishing, the NED analysis output is the change in profits from commercial fishing and the RED analysis input is the sum of the expected change in value of the catch by species, valued at the dock-side (producer prices). For charter boat fishing, the NED output is

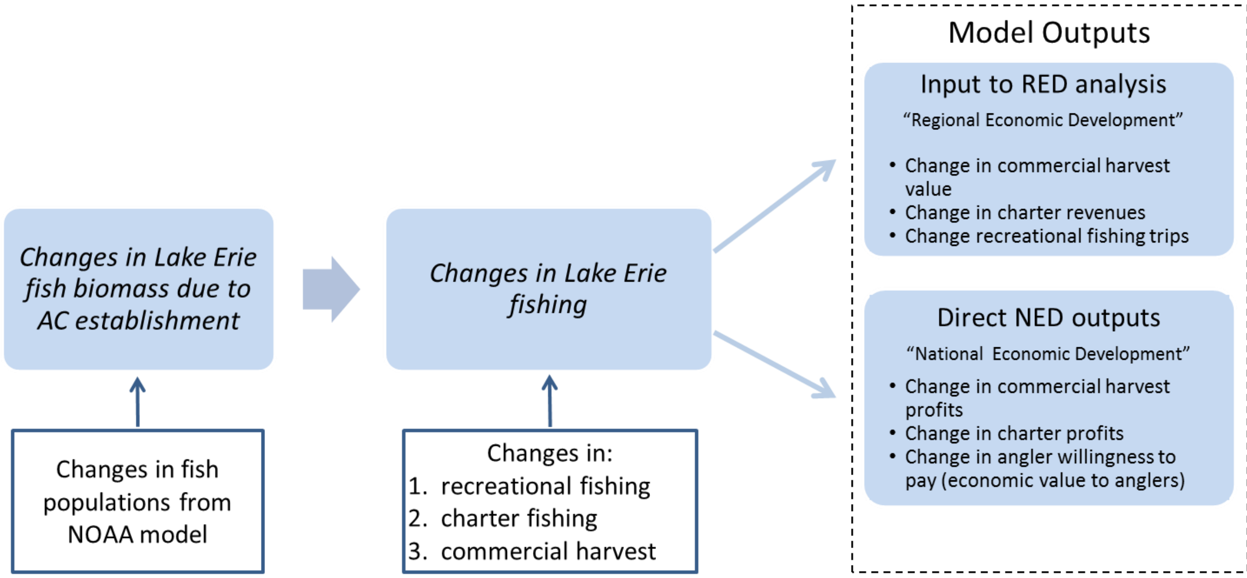


Figure 5-18 GLMRIS Fishery NED Model Inputs and Outputs for NED and RED Consequence Analysis for Lake Erie[3]

the total expected change in the profits of sales for charter boat fishing services and the RED input is the change in the value of the sales. Finally, the NED output data for recreation fishing is the consumer surplus value to recreational anglers, and the RED input is the change in the number of recreational fishing trips.

A complete description of the methods and data sources for calculating NED and RED can be found in Appendix D, Economics.

5.5.2 Summary of NED Analysis Results

Table 5-6 summarizes the NED values for the economic consequences analysis. In scenarios 1 through 7, NED losses to the three types of fishing only occur in scenario 7, where there are predicted declines in Yellow Perch, Walleye, and to some extent Rainbow Trout. In scenarios 1 through 6, the NED results reflect gains for anglers and for charter and commercial operators because the ecological models predict increases in Yellow Perch, Walleye, and in some cases Smallmouth Bass. In scenarios 1 through 6, the ecological model sometimes predicted declines in Rainbow Trout, but they are not a part of the commercial fishery. Compared to other species in the charter and recreational fisheries, Rainbow Trout do not attract a large enough share of the fishing effort for their losses to offset the predicted gains in the other species.

The last two scenarios in Table 5-6 reflects the consideration of some of the uncertainties involved and show the potential for larger gains or larger losses depending on the range of standard deviations in predicted biomass changes from the ecological model. Although the NED aims to quantify economic consequences of Asian carp for the few areas from Table 5-3 where there is available ecological information, the range of these values and the fact that they span both positive and negative values

[3] This illustration of the GLMRIS Fishery NED model inputs and outputs for NED and RED analyses shows how changes in fish biomass due to Asian carp are linked to changes in fishing ecosystem services, which are then linked to changes in the economy and people's well-being.

Table 5-6 Summary of Changes in NED Values for Lake Erie Fisheries[a]

NOAA Model Scenarios	Change in Commercial Fishing Profits	Change in Charter Fishing Profits	Change in Recreational Fishing Value to Anglers
Scenario 1	$3,600	$4,300	$821,400
Scenario 2	$26,800	$29,100	$2,619,600
Scenario 3	$1,600	$3,400	$562,300
Scenario 4	$13,200	$19,300	$1,263,400
Scenario 5	$1,600	$3,400	$503,100
Scenario 6	$13,200	$19,200	$581,200
Scenario 7	($44,500)	($28,900)	($6,186,100)
Scenario 7 + 1SD	$68,000	$9,200	$6,161,600
Scenario 7 - 1SD	($157,000)	($67,100)	($18,533,800)

[a] All scenarios are relative to the "no Asian carp" baseline scenario.

highlights the substantial amount of uncertainty over the economic consequences of Asian carp for the fishery. See Appendix D, Economics, for a complete presentation of the results of the NED analysis.

5.6 RED Analysis: Economic Consequences of Asian Carp Establishment in Lake Erie

5.6.1 RED Approach Overview

This RED analysis estimates the expected changes in regional economic activity of eight Great Lakes states should Asian carp establish in Lake Erie. As described in the GLMRIS-BR fisheries NED consequence analysis, the establishment of Asian carp in the GLB could change the availability of fishing resources in the invaded waters, thereby altering the direct revenues and expenditures associated with the region's commercial, recreational, and charter fishing activities. This RED analysis explores how estimated changes in direct revenues and expenditures reverberate to the larger economy in terms of sales, employment, earnings, and gross regional product – a subnational measure of gross domestic product. This tendency for a direct change in economic activity to give rise to secondary changes in transactions has been called a multiplier effect and has been well documented in the economics literature (Coughlin and Mandelbaum 1991).

The Civil Works Regional Economic System (RECONS) model, developed by the USACE Institute for Water Resources, was utilized to complete this RED analysis. RECONS is the only USACE-certified RED model for agency-wide use (Institute for Water Resources 2016) and is a well-established economic impact assessment model based on the same standard economic impact modeling methods used by academic economists.

The NED analysis involved the estimates of changes in commercial harvest value, change in charter revenues, and change in recreational fishing trips. Such impacts give rise to larger changes in aggregate economic activities as shown in Figure 5-19. Unlike the NED analysis, the RED analysis only measures the change in private exchange of money and does not include changes in non-priced social benefits.

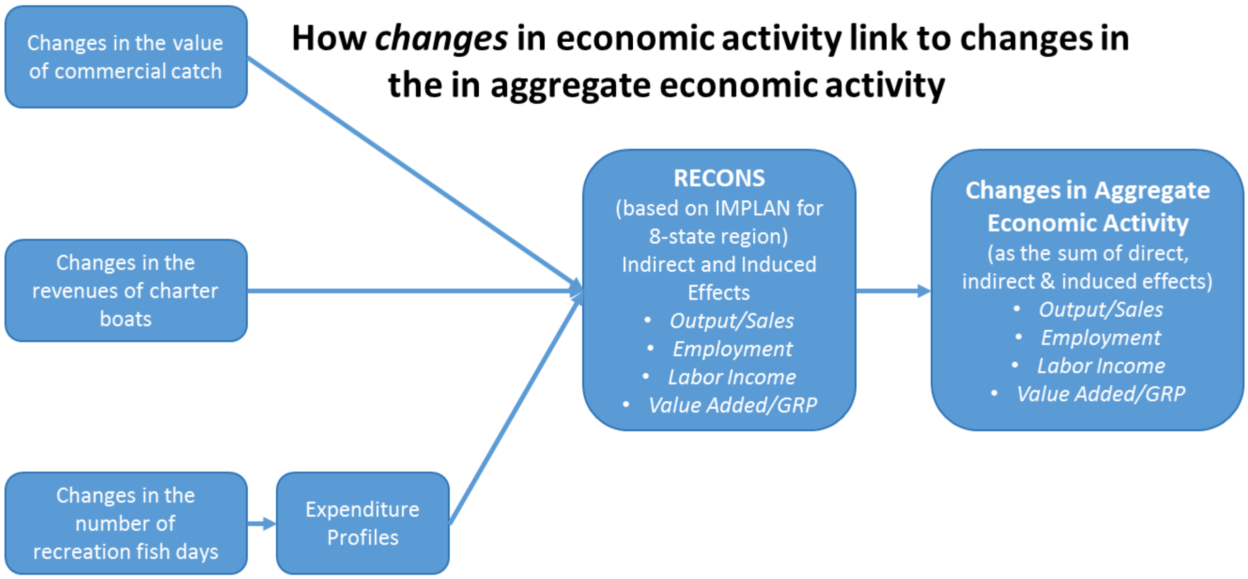


Figure 5-19 Regional Economic Analysis Flowchart (GRP = gross regional product)

5.6.2 Summary of RED Analysis Results

Table 5-7 presents a summary of the NED values for the economic consequences analysis. For the first six Ecopath with Ecosim model scenarios, results suggest that introduction of Asian carp may actually increase commercially viable biomass. Although invasive, the Asian carp population is expected to transition to be a core component of the Great Lake's biomass over time. Through this interaction, the biomass of some species in Lake Erie will increase while the biomass of other species will decrease. Thus, when assuming the Asian carp do not feed on the larvae of indigenous fish, the model suggests that in most cases the species that are most relevant for commercial and recreation fishing increase in adult populations. This increase in desired biomass would, in turn, result in an increase in commercial catch and an increase in angler participation in hiring charter boats for recreational fishing and other recreational fishing. Other anglers are also expected to increase visits for fishing, and in turn, increase fish-recreational expenditures. Hence, the expected changes in aggregate economic activity are expected to be positive, but mostly negligible.

Unlike the first six scenarios, Scenario 7 assumes that Asian carp feed on indigenous fish larvae, resulting in large declines in commercial and recreation biomass. This would have the adverse effect on commercial fishing revenues, charter boat fishing revenues, and recreational fishing trips. Scenario 7 also afforded the opportunity to gauge the precision of impact estimates by measuring the dispersion of point estimates. Hence, in addition to estimating the expected change in biomass, a measure of uncertainty in predictions was also measured and reported as the expected biomass plus and minus 1 standard deviation; the range encompassing plus and minus 1 standard deviation of an unbiased prediction asserts that there is at least a 68% chance that the actual outcome will be within that range. This wide variation in expected changes in aggregate economic activities suggests a high degree of uncertainty in the results.
See Appendix D, Economics, for a complete presentation of the results of the RED analysis.

Table 5-7 Results Summary – Regional Economic Impacts of Asian Carp Establishment in Lake Erie on Commercial, Recreational, and Charter Fishing Industries in Great Lakes States[a]

NOAA Model Scenarios	Changes in Employment and Income (Direct and Secondary Effects)					
	Great Lakes Commercial Fishing Industry		Great Lakes Recreational Fishing Industry		Great Lakes Charter Fishing Industry	
	Employment	Income	Employment	Income	Employment	Income
Scenario 1	1	$24,100	50	$1,641,400	1	$44,900
Scenario 2	9	$177,400	159	$5,234,900	6	$301,100
Scenario 3	1	$10,600	34	$1,123,600	1	$35,200
Scenario 4	4	$87,400	77	$2,524,600	4	$200,300
Scenario 5	1	$10,700	31	$1,005,300	1	$34,900
Scenario 6	4	$87,600	35	$1,161,400	4	$198,700
Scenario 7	−15	−$294,200	−376	−$12,362,200	−2	−$128,800
Scenario7 + 1SD[b]	23	$450,000	374	$12,313,100	27	$1,445,900
Scenario7 - 1SD	−52	−$1,038,500	−1,126	−$37,037,400	−32	−$1,703,500

[a] Great Lake States include Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. Direct effects account for changes to directly affected industries. Secondary effects include indirect and induced effects (changes to supporting industries and household/consumer spending associated with the labor income changes for workers in affected industries). Positive values indicate increases in employment and labor income; negative values indicate decreases in these economic measures. Dollars values were rounded to the nearest hundred and reflect 2016 price levels. Data compiled from using GLMRIS Fisheries RED Model (RECONS modification).

[b] 1SD = 1 standard deviation.

5.7 Summary and Conclusions of Economic Consequences of Asian Carp Establishment in Lake Erie

The results of the economic consequences analysis provide a strong indication of the uncertainty of the economic consequences should Asian carp become established in Lake Erie. They also provide some indication of the potential magnitude of changes to the NED and RED accounts for commercial, recreational, and charter fishing. Assuming that Asian carp do not feed on indigenous larvae, the expected economic changes to fishing-related activities ranges from negligible to positive based on food web modeling. However, should Asian carp feed on indigenous larvae, the impacts are more pronounced and negative. The extent of the impact on fishing-related activities is uncertain, because the predicted impact on lake biomass is highly variable.

Measuring the potential effects of Asian carp establishment in the GLB poses significant challenges. To minimize conjectures, this study only considered geographies and activities for which data and science provides an objective opportunity for estimates. Considerations in this analysis are limited to changes in people's well-being and the regional economy given Asian carp effects on commercial, charter, and recreational fisheries. Other potential sources of impacts that could not be quantified include recreational water uses, lake-side commerce and tourism, and possibly property values of those residents who choose to locate near or on the lake for fishing activities. In addition, impact assessments were limited to Asian carp establishment in Lake Erie, because current food web modeling of ANS has only been applied to this lake. Therefore, it is critical to recognize that the full spectrum of potential sources of Asian carp related economic consequences has not been explored.

5.8 Environmental Consequence Evaluation of *A. lacustre* Establishment in the Great Lakes Basin

As explained in Section 5.2, Consequence Assessment Approach, the GLMRIS-BR evaluation re-examined only the potential environmental impacts of *A. lacustre* in the GLB, particularly focusing on the potential for interaction with protected mussels. The environmental consequence evaluation consisted of (1) a review of new literature related to ecological consequences, (2) an evaluation of the potential for *A. lacustre* to reach habitats in which protected species are present, and (3) an evaluation of the potential to adversely affect protected mussels if it were to occupy the same habitat.

The ecological consequences of *A. lacustre* and its potential to adversely affect protected mussels were evaluated by reviewing the literature for ecosystem-wide or species-specific impacts in areas previously invaded by *A. lacustre*. Evaluating the potential interaction of *A. lacustre* with protected mussels was a multistep process. First, a list of state and federally listed mussels and their location within the Great Lakes States (Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) was compiled. The protected freshwater mussel locations were taken from state and federally sponsored species[4] databases and included endangered, threatened, and species of concern. There are no listed mussels in the Great Lakes themselves. Using these data, an ArcGIS® map was created showing the tributaries with protected species records that have a continuous aquatic connection to the Great Lakes (Figure 5-20). Finally, to characterize the potential for upstream movement by vessels and natural movement within the tributary, geographic information system (GIS) layers showing the location of dams were obtained from the National Inventory of Dams. Vessels are the primary means of upstream transport for *A. lacustre* (Grigoriovich et al. 2008).

5.8.1 Results of Environmental Consequence Evaluation of *A. lacustre*

A total of 15 locations were identified as having connections to reaches with federally protected freshwater mussel species (Table 5-8). Most of these locations have dams or some other obstruction that would prevent *A. lacustre* from reaching endangered freshwater mussel populations upstream (Figure 5-20).

However, four areas were identified as possible pathways that would permit *A. lacustre* to move from the Great Lakes to the river reach where protected freshwater mussels have been reported (Table 5-9): (1) Saint Martin Bay, at the mouth of the Pine River, Minnesota; (2) Point Huron, Michigan; (3) the mouth of the Detroit River, Lake Erie; and (4) Ontario Center, New York on Lake Ontario.

While *A. lacustre* could be transported from the CAWS to the four (4) locations identified by vessel traffic, it is unlikely that commercial vessels would move upstream into these rivers to actually reach native freshwater mussel habitat. Therefore, *A. lacustre* would have to move upstream by recreational vessels, natural movement, or some combination of the two. Water velocity would likely prevent

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4 USFWS—https://www.fws.gov/MIDWEST/Endangered/clams/index.html; Illinois—https://www.dnr.illinois.gov/ESPB/Documents/2015_ChecklistFINAL_for_webpage_051915.pdf; Indiana—http://www.in.gov/dnr/naturepreserve/files/fw-Endangered_Species_List.pdf; Michigan—http://mnfi.anr.msu.edu/data/specialanimals.cfm/.

Table 5-8 Locations That Connect to Rivers Where Protected Freshwater Mussel Species Have Been Collected

ID	State	Bay/Port Name	Location	Connecting River(s)	River(s) with Records of Protected Mussels
1	WI	Green Bay		Fox River	Little Wolf, Wolf Rivers
2	MI	Benton Harbor	Near Silver Beach, St. Joseph, MI	St. Joseph River	Portage, Pigeon Rivers
3	MI	Grand Haven	Near Grand Haven Park	Grand River	Maple, Flate Rivers
4	MI	Manistee	East Lake	Manistee River	Pine River
5	MI	Saint Martin Bay			Pine River
6	MI	Cheboygan	Lake Huron	Cheboygan River	Maple River
7	MI	Oscoda Charter Township	Near Au Sable Charter Township	Van Etten Creek	Pine River
8	MI	Saginaw Bay		Saginaw River	Pine, Tittababassee Rivers
9	MI	Point Huron, Lake Huron	Point Huron near Sarnia, MI	St. Clair River	Black, Pine Rivers-Mill Creek
10	MI	Mouth of Detroit River	Lake Erie Metro Park area	NA[a]	Clinton, Detroit, Huron Rivers
11	MI	Maumee Bay	Near Toledo	Maumee River	Swan, Sugar Creeks-Blanchard, St. Joseph Rivers
12	OH	Muddy Creek Bay	Sandusky Bay	Sandusky River	Tymochtee Creek
13	OH	Fairport Harbor	Painesville	NA	Grand River
14	OH	Conneaut	Lake Erie, Conneaut Township Park	NA	Conneaut Creek
15	NY	Ontario Center	Ontario Center, Lake Ontario	NA	Mill Creek

[a] NA = not applicable.
Sources: Minnesota – http://files.dnr.state.mn.us/natural_resources/ets/endlist.pdf; New York – http://www.dec.ny.gov/animals/7494.html; Ohio – http://wildlife.ohiodnr.gov/species-and-habitats/state-listed-species; Pennsylvania – http://www.naturalheritage.state.pa.us/Species.aspx; Wisconsin – http://dnr.wi.gov/files/PDF/pubs/er/ER001.pdf.

upstream movement (e.g., crawling, swimming) by this species in free-flowing reaches where dams are not present. Therefore, it was concluded that the majority of the endangered native freshwater mussel populations identified in this report cannot likely be reached by *A. lacustre*, if the species were to reach the Great Lakes through the CAWS.

In addition, while several authors have expressed concern about the rapid expansion of *A. lacustre* (Grigoriovich et al. 2008), and this species has been documented to reach high densities in localized areas, no published research was found on the environmental effects of *A. lacustre.* Therefore, no evidence was found that this species has had adverse ecosystem or species-specific impacts from previously invaded systems (Text Box 5-12).

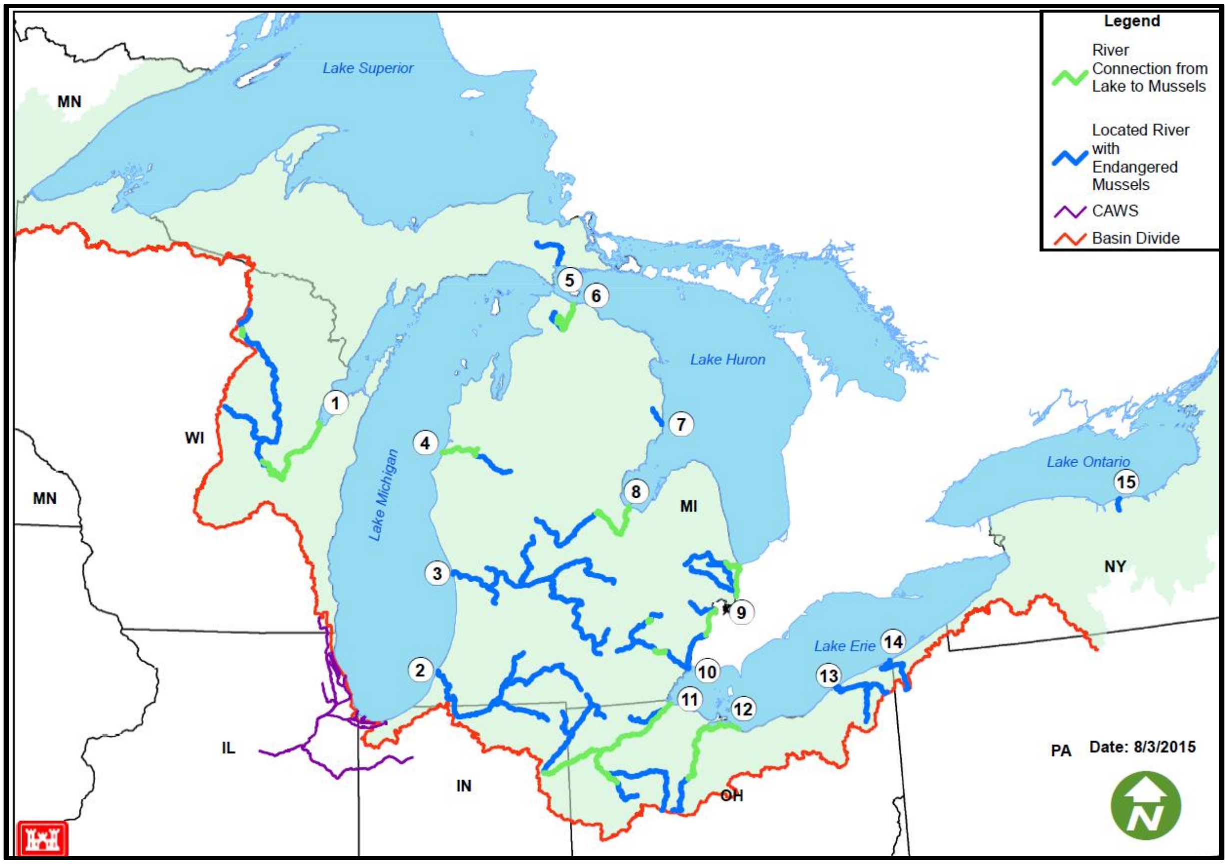

Figure 5-20 Locations of River Mouths with Connections to Upstream Locations Where Protected Freshwater Mussel Species Have Been Located

5.8.2 Summary of Environmental Consequence Evaluation for *A. lacustre*

In summary, this report assessed the potential for *A. lacustre* to reach locations within rivers for which records of protected native freshwater mussel species exist, as well as the potential consequences of establishment. After exiting the CAWS, *A. lacustre* could reach waterways that connect to habitat for protected freshwater mussel species. However, *A. lacustre* would face several impediments to upstream dispersal before arriving at river reaches where endangered freshwater mussels potentially occur. These include the presence of dams, as well as the limited capacity of this species for upstream movement by natural means. If *A. lacustre* were to reach protected freshwater mussel habitat, no literature was found during compilation of this report to suggest that *A. lacustre* has ecologically impacted native freshwater mussels or other species following introduction. However, there is uncertainty, because no known recent research has been conducted on this species and its potential impacts. As mentioned earlier, *A. lacustre* serves as a surrogate for hitchhiking ANS.

Table 5-9 Dams Present in Waterways That Connect to Rivers Where Protected Mussel Species Have Been Found

ID[a]	State	Connecting Location within the Great Lakes	Can *A. lacustre* Reach River(s) of Interest?
1	WI	Green Bay	No, dams present
2	MI	Benton Harbor	No, dams present
3	MI	Grand Haven	No, dams present
4	MI	Manistee	No, dams present
5	MI	Saint Martin Bay	Yes
6	MI	Cheboygan	No, dams present
7	MI	Oscoda Charter Township	No, dams installed
8	MI	Saginaw Bay	No, dams present
9	MI	Point Huron, Lake Huron	Yes
10	MI	Mouth of Detroit River	Yes, but dams restrict access within the system
11	MI	Maumee Bay	No, dams present
12	OH	Muddy Creek Bay	No, dams present
13	OH	Fairport Harbor	No, dams present
14	OH	Conneaut	No, dams present
15	NY	Ontario Center	Yes

[a] Each ID number corresponds to the ID label in Figure 5-20.

Text Box 5-12 Environmental, Economic, and Sociopolitical Consequences of *A. lacustre* Establishment in the Great Lakes Basin

Environmental

- Documented to be locally abundant in Illinois River System
- No impacts documented in literature
- Unlikely to reach protected mussel species in the GLB

Economic

- None Anticipated

Sociopolitical

- None Anticipated

Chapter 6 Alternative Formulation*

6.1 Overview

This chapter of the report includes the followings sections:

- Section 6.2, **Measures**, describes how the ANS control measures were identified, evaluated, and screened to develop a final list of controls for further consideration in GLMRIS-BR.

- Section 6.3, **Measures for Alternative Formulation**, identifies the remaining ANS control measures that serve as the building blocks for the alternative plan formulation.

- Section 6.4, **Location**, explains why BRLD was selected as a control point to prevent the upstream transfer of MRB ANS to the GLB, and describes the analysis conducted to assess the potential for flood bypasses.

- Section 6.5, **Alternative Formulation Strategy**, explains the strategy used to formulate the alternatives.

- Section 6.6, **Alternative Plan Evaluation Criteria**, describes the GLMRIS-BR criteria developed to evaluate alternative effectiveness, cost, and impacts.

- Sections 6.7, **Alternative Plan 1: No New Federal Action,** through Section 6.12, **Alternative Plan 6: Lock Closure Alternative,** describe the components of each alternative and their operation and then provide an evaluation of the alternative based on the evaluation criteria.

6.2 Measures

A management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives. Management measures are the building blocks of alternative plans and are categorized as structural and nonstructural (USACE 2000). This study's objective is to prevent the upstream transfer of ANS from the MRB to the GLB through the CAWS in the vicinity of the BRLD through the planning period of analysis.

This section outlines the process used to screen out ANS control measures and describes the measures retained, which then serve as building blocks for the formulation of plans (also known as alternatives) in the vicinity of the BRLD.

In April 2012, USACE published the *Inventory of Available Controls for Aquatic Nuisance Species of Concern – Chicago Area Waterway System* (USACE 2012d; referred to here as the ANS Control Paper) (http://glmris.anl.gov/controls/). This paper identified 96 ANS controls that could potentially be applied to prevent ANS transfer via aquatic pathways. As noted previously in this report, USACE has interpreted the term *prevent* to mean the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution. USACE used the following criteria to determine whether a control should be included in the paper:

1. The control is potentially effective at preventing the transfer of the ANS of Concern–CAWS via aquatic pathways;

2. The control, if used according to specified conditions, will pose minimal risk to human health and safety; and

3. The control is currently available or is under research and development (R&D).

The team identified eight organism categories as the "Organisms of Concern–CAWS" and expanded its research to include controls effective for these groups of species: algae, annelid, bryozoans, crustacean, fish, mollusk, plant, and protozoan. As the GMLRIS study progressed, viral hemorrhagic septicemia (VHS), a virus, was added to the list of ANS of Concern. However, the ANS Control Report does not include a separate discussion of virus-specific controls. Upon review, certain controls in the ANS Controls Report were found to be effective on VHS. The ANS Control Paper is posted on the GLMRIS website, glmris.anl.gov/controls/.

After USACE identified the high- and medium-risk ANS of Concern for GLMRIS, the revised species list was used to screen the ANS controls down to a smaller subset that could be used as measures in GLMRIS-BR alternatives. As noted previously, the GLMRIS Report (USACE 2014a) qualitatively assessed fish, Bighead and Silver Carp, and a crustacean, *A. lacustre*, as medium-risk MRB ANS for establishment in the GLB. The screening criteria for the GLMRIS Report (USACE 2014a) that reflect the focus of preventing the establishment of MRB ANS in the GLB are the following:

- Remove all ANS controls that are *not* potentially effective against the high- and medium-risk ANS in various life stages.
  - The original list of ANS of Concern included controls for plants, algae, fish, bryozoans, mollusks, and protozoa. The controls were screened out, and only those that were potentially effective for the various life stages of fish and crustaceans were retained.

- Remove all the biocides for industrial use that are *not* used for conventional municipal drinking water or wastewater treatment.
  - The overarching plan formulation strategy was to formulate plans based on proven technologies backed by research and field application; therefore, nonconventional biocides were removed. Using these technologies was thought to reduce the uncertainty associated with an alternative's effectiveness and also potentially expedite design and regulatory permitting.

- Remove the controls under R&D that may *not* be available within the ANS time period for arrival to the pathway.
  - The three MRB ANS have all arrived at the aquatic pathway. Each has been detected in the Dresden Island Pool, immediately downstream of BRLD. Therefore, the control must be implementable.

Note, however, that controls identified as effective may not be effective at controlling all growth forms or life stages of a particular organism. For example, a piscicide (such as rotenone) nonselectively kills all juvenile and adult fish but does not affect fish eggs.

Additional research has been conducted since the January 2014 release of the GLMRIS-BR Report (USACE 2014a) and the April 2012 release of the GLMRIS ANS Controls Report (USACE 2012d). Therefore, ANS controls previously screened out due to R&D considerations were reassessed for GLMRIS-BR formulation. A new screening criterion was developed for GLMRIS-BR:

- ANS controls that were considered R&D for the GLMRIS Report, but for which additional progress since the GLMRIS Report (USACE 2014a) indicates they warrant further consideration, will be reexamined to determine whether they should be considered as a measure.

Additional research had been completed on the following swimmer ANS controls since the release of the GLMRIS Report (USACE 2014a): CO_2, noise, and hydroguns. The screened results are presented in Table 6-1. The screening occurred in November 2015 to allow adequate time to formulate and evaluate alternatives to meet the project schedule. The measures, screened from this analysis, have been screened from use in this feasibility report. The screening of an individual R&D control is not an indication that the measure would not be considered at a different location or this location after additional research addresses uncertainties.

A flowchart of the process of measure screening is presented in Figure 6-1.

For the purposes of GLMRIS, ANS controls were classified into two categories of measures: structural and nonstructural. Structural measures require the construction of a permanent feature in the waterway and take a longer time to implement. Examples include but are not limited to an electric dispersal barrier, speakers attached to the channel walls and bottom emitting complex noise, and bubble curtains. Nonstructural controls do not require the construction of a permanent feature in the waterway and can generally be implemented fairly quickly. Examples include but are not limited to targeted overfishing and telemetry. The MRWG continues to refine and develop the nonstructural measures used in the IWW Study Area in part based on yearly monitoring results informing future actions; therefore, screening of nonstructural measures has been completed by the MRWG.

6.3 Measures for Alternative Formulation

An alternative consists of a combination of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints (USACE 2000). This section of the report provides an explanation of each of the ANS control measures used to formulate the GLMRIS-BR alternatives.

Alternatives were developed by combining the following ANS control measures:

- Nonstructural measures
  - Monitoring, public education and outreach, integrated pest management, piscicides, manual and mechanical removal and R&D

- Structural measures
  - Engineered channel
  - Water jets
  - Electric barrier
  - Complex noise
  - Flushing lock
  - Lock closure
  - Boat launches
  - Temporary mooring area

Although the engineered channel is not an ANS control measure, it is an inherent measure for alternatives that include structural controls. Refer to Section 6.3.2, Structural Measures, for a description of the benefits that an engineered channel provides for structural and nonstructural controls.

Table 6-1 GLMRIS-BR Measure Screening Results

Deterrent/ Barriers	November 2015 Screening for GLMRIS-BR Plan Formulation	Deters Swimmers	Deters Floaters	Deters Hitchhikers
Accelerated Water Velocity	**Screened Out** - ***Safety*** concerns due to rapidly flowing water in a navigation channel leading into a lock.	x	x	x
Acoustic Fish - Continuous Wave	**Screened Out** - Due to ***R&D*** nature of the technology and unknown effectiveness.	x		
Acoustic Fish - Pulsed Pressure Wave (Hydro Gun)	**Screened Out** - Due to ***R&D*** nature of the technology. Field tests failed to deter fish, and hydro gun function was unreliable.	x		
CO2	**Screened Out** – ***R&D.*** Tested in confined treatment areas and riverine backwaters. Largely untested in large river systems and navigation locks. Research continues.	x	x	x
Treatment Areas - Ozone, Cl, Hot Water, etc.	**Screened Out – *R&D.*** Novel and largely untested in confined treatment areas, large river systems, and navigation locks. Research continues.	x	x	x
Physical Barrier (Permanent Lock Closure)	**Retained** – Effective and available for use.	x	x	x
Sensory Deterrent System - Electric Barrier	**Retained** - Effective and available for use.	x		
Sensory Deterrent System - Acoustic Air Bubble Curtain with Underwater Strobe Lights[a]	**Screened Out** - Due to ***R&D*** nature of the technology in this application. Known to be less effective than an electric barrier.	x		
Sensory Deterrent System - Complex Noise	**Retained** - Sound has been implemented at other locations. USACE is able to design and construct this control. Researchers are working on ways to exploit avoidance behavior by designing a complex noise field that will continue to repel fish over time.	x		
Engineered Channel	**Retained –** Effective at **i**mproving monitoring, removal efforts, and serves as a platform for future research and development testing and reduces the time and cost to implement future barrier technologies.	Improves control effectiveness	Improves control effectiveness	
Water Jets	**Retained** – Physical model demonstrated potential effectiveness at removing entrained small model fish from barges using available technologies that require minimal construction and operation investment.	Very small and stunned swimmers	X	
Flushing Lock	**Retained –** Effective at sweeping floating organisms out of the lock chamber and has been implemented at other locations. Numerical model demonstrated water could be exchanged in Brandon Road Lock with modified port structure, which requires minimal construction and operation investment. Physical model will demonstrate how to optimize operations.		X	

[a] Demo project recommended in *Dispersal Barrier Efficacy Study: Interim IIIA – Fish Dispersal Deterrents, Illinois & Chicago Area Waterways Risk Reduction Study and Integrated Environmental Assessment*, USACE, 2010d was never implemented.

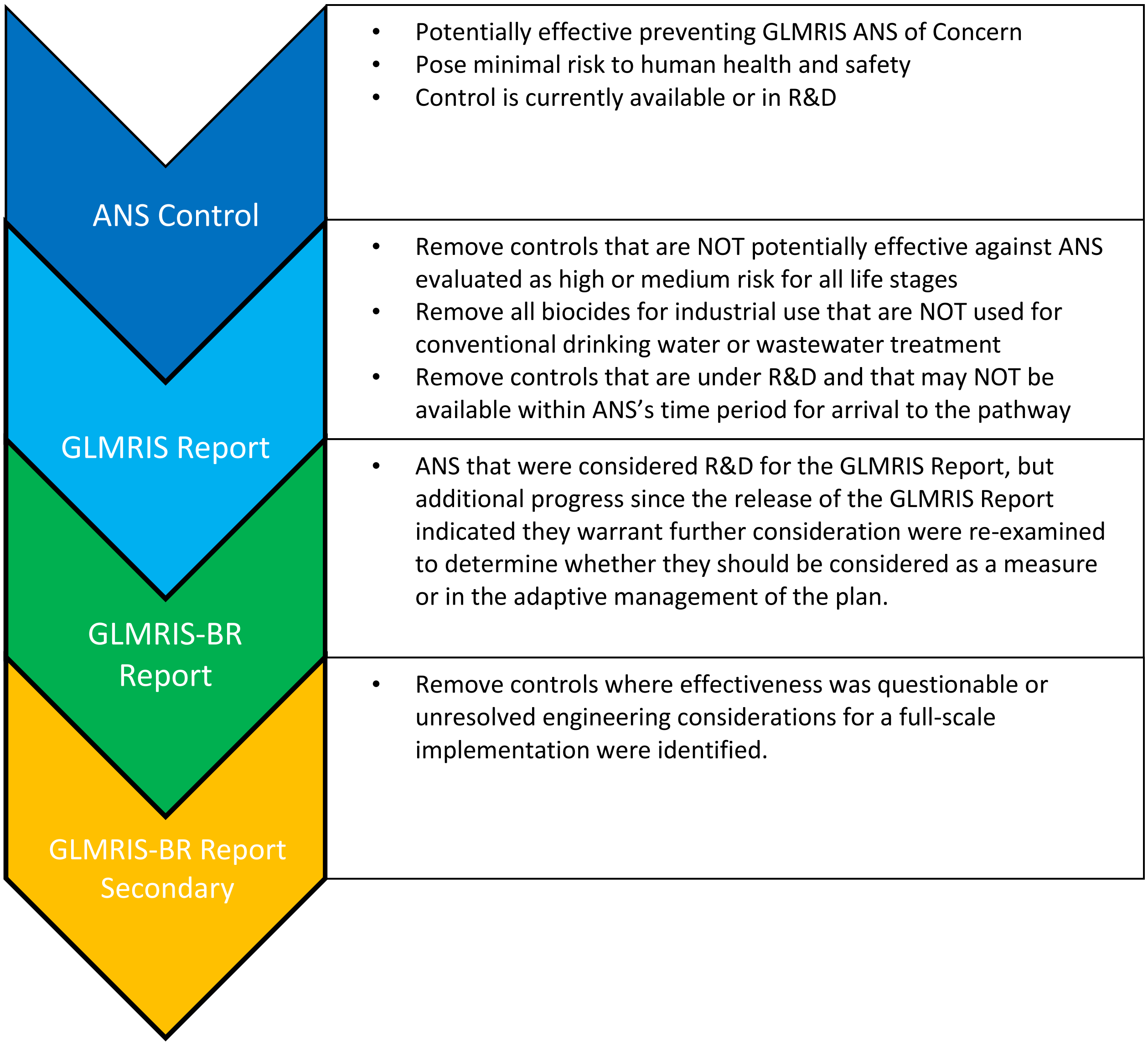

Figure 6-1 GLMRIS-BR Measure Screening Flowchart

6.3.1 Nonstructural Measures

The ANS Controls Report, in combination with project descriptions from 7 years of Asian carp Action Plans (formerly the Asian Carp Control Strategy Framework) and Monitoring and Response Plans, guided the development of the nonstructural measures for GLMRIS-BR. These nonstructural measures can be categorized as follows: (1) monitoring, (2) public education and outreach, (3) integrated pest management, (4) piscicides, (5) manual and mechanical removal, and (6) R&D. Each of the categories can be tied back to specific nonstructural measures identified in either the Action Plan or Monitoring and Response Plan. These plans are reviewed annually by the ACRCC and MRWG to gain efficiencies and efficacy for subsequent years' plans. The development of nonstructural measures will mirror this process and rely on the judgment of relevant federal and state agencies to guide active management of nonstructural measures in the future to meet the changing site conditions surrounding BRLD.

Monitoring could be used to determine the presence and abundance of Asian carp in the waterway and the presence of *A. lacustre*. Manual or mechanical removal could be used to reduce the population front and also as a monitoring tool for Asian carp. Education and outreach could serve to reduce the likelihood ANS will be transferred via human-mediated means and thereby reduce the alternative's residual risk. Developing integrated pest management approaches to controlling ANS transfer from the MRB to the GLB is a shared responsibility between federal, state, and local agencies that control ANS within the IWW Study Area. Historic monitoring data inform future monitoring and control efforts of all ANS life stages in the development of an integrated pest management approach for this section of the waterway. Incorporating R&D of monitoring, control, and removal tools currently being used will improve their efficacy. Further discussion on each nonstructural measure retained is included in Table 6-2.

6.3.2 Structural Measures

A number of structural measures were developed that require construction of a permanent feature in the waterway. A description of the structural measures retained for alternative formulation follows.

Engineered Channel

The engineered channel would be constructed of concrete and have a rectangular cross-section; see Figure 6-2. The channel would extend from the downstream lock gates about 2,300 ft (701 m) south. In order to maintain the existing channel dimensions, rock and sediment would need to be removed from the channel bottom and side slopes prior to the installation of the concrete channel. As a result, the engineered channel would not affect the clearance of vessels; it is designed to maintain the current water depth, 13–14 ft (3.9 m). The approximate width is 232 ft (70.7 m). The walls of the engineered channel would be high enough to address overtopping during a flood, with a 2% chance of occurring in any given year, commonly known as a 500-yr flood discharge. Setting the channel height at the 2% event effectively limits the flood bypass of ANS past the controls installed within the engineered channel. If an engineered channel is not constructed through the entire approach channel, then the banks on either side of the approach channel would be raised to meet the flood bypass design requirement. The engineered channel serves as a platform for structural ANS controls and therefore was incorporated into alternatives containing structural measures.

The engineered channel provides a defined location to establish an ANS control point and a focus for the installation of additional ANS controls. The engineered channel also improves the efficacy of structural and nonstructural measures, and provides a platform for evaluating future technologies and potentially incorporating them. Specifically, the engineered channel increases the likelihood of detection using sonar and hydroacoustic monitoring gears and simplifies clearing of fish within the channel. It provides a smooth surface environment devoid of the crevices and outcroppings found in an excavated or natural channel where fish and other ANS can potentially hide from monitoring equipment and during fish-clearing events.

For the complex noise measure, the smooth surface reduces shielding of sound waves and increases the likelihood that target frequencies and decibel levels will be achieved. For alternatives that include an electric barrier, the engineered channel would be designed with insulation to help minimize stray current that may escape the channel and affect neighboring land uses, navigators, and lock and ANS control personnel. This proposed channel design includes increasing the depth of the channel bottom beneath the area where the electric barrier is placed to accommodate insulation in the channel bottom, while the walls are thick enough to accommodate designed insulation. The engineered channel also provides a solid surface on which to install the water jets and mount the required water supply lines.

Table 6-2 Categories of Nonstructural Measures for Asian Carp and *A. Lacustre*

Nonstructural Measure	Asian Carp Description	*A. Lacustre* Description
Education and Outreach	For all life stages, educating the public to not spread aquatic invasive species from an infested waterway to another by properly disposing of unused bait, not transferring bait between basins, emptying bilge and live wells, and inspecting/cleaning outside of vessels before leaving a waterway to reduce likelihood of accidental introduction. Also, educating the public on species identification and reporting protocols.	Educating the public to not spread aquatic invasive species from an infested waterway to another by inspecting/cleaning outside of vessels, nets, and other equipment before leaving a waterway; properly disposing of unused bait; not transferring bait between basins; emptying bilge and live wells to reduce likelihood of accidental introduction.
Nonstructural Monitoring	For all life stages, nonstructural monitoring would provide early notification of spread but not likely preclude transfer. Monitoring would include ACRCC management agencies. Early identification of new populations, if linked with aggressive response action, may limit spread and transfer. Measures include targeted and fixed-site netting as well as random and fixed-site electrofishing.	Nonstructural monitoring would provide early identification of spread but not likely affect transfer. Monitoring would include the involvement of local, state, and federal agencies.
Integrated Pest Management	For all life stages, measures such as rapid response actions (i.e., targeted intensive fishing efforts using multiple gears, such as electrofishing, gill/trammel nets, minifyke nets, and the like) could be used in localized areas. Also includes the active management of risk by continuing to refine actions based on monitoring data. Includes collaboration of Illinois DNR, USFWS, EPA, NOAA, and USCG on actions.	Measures such as targeted intensified monitoring efforts could be used in localized areas.
Piscicides	For adults and larvae, piscicides may be effective in localized areas, but maintaining needed concentrations in large or flowing water bodies is costly and requires intensive effort. Most piscicides are nonspecific controls that will affect nontarget species. Fish carcasses would require collection and disposal. An additional requirement that limits application is Illinois Administrative Rule 890, which states piscicides (e.g., rotenone, antimycin a) can be received, possessed, and applied only by a Division of Fisheries Biologist. For eggs, piscicides may not be effective. Some piscicides may target eggs (e.g., antimycin a); however, Asian carp may be insensitive to these piscicides.	Maintaining target pesticide dosage in large or flowing water bodies while limiting exposure to the desired treatment area is challenging.

Table 6-2 (Cont.)

Nonstructural Measure	Asian Carp Description	*A. Lacustre* Description
Manual or Mechanical Removal	For adult life stage, controlled harvest and overfishing may be effective in maintaining low numbers of large fish in localized areas, potentially slowing the advance into new areas. Overfishing would occur in areas where Asian carp are abundant within the IWW. Harvest techniques would utilize large mesh gill and trammel nets to reduce bycatch of native fish species; however, these nets are ineffective for harvesting juvenile and larval fish and eggs. All manual or mechanical removal would require the involvement of the designated natural resource agency. The captured fish would require appropriate management or disposal.	Not applicable.
R&D	Monitoring, control, and removal tools currently being applied and relevant research to improve their efficacy.	

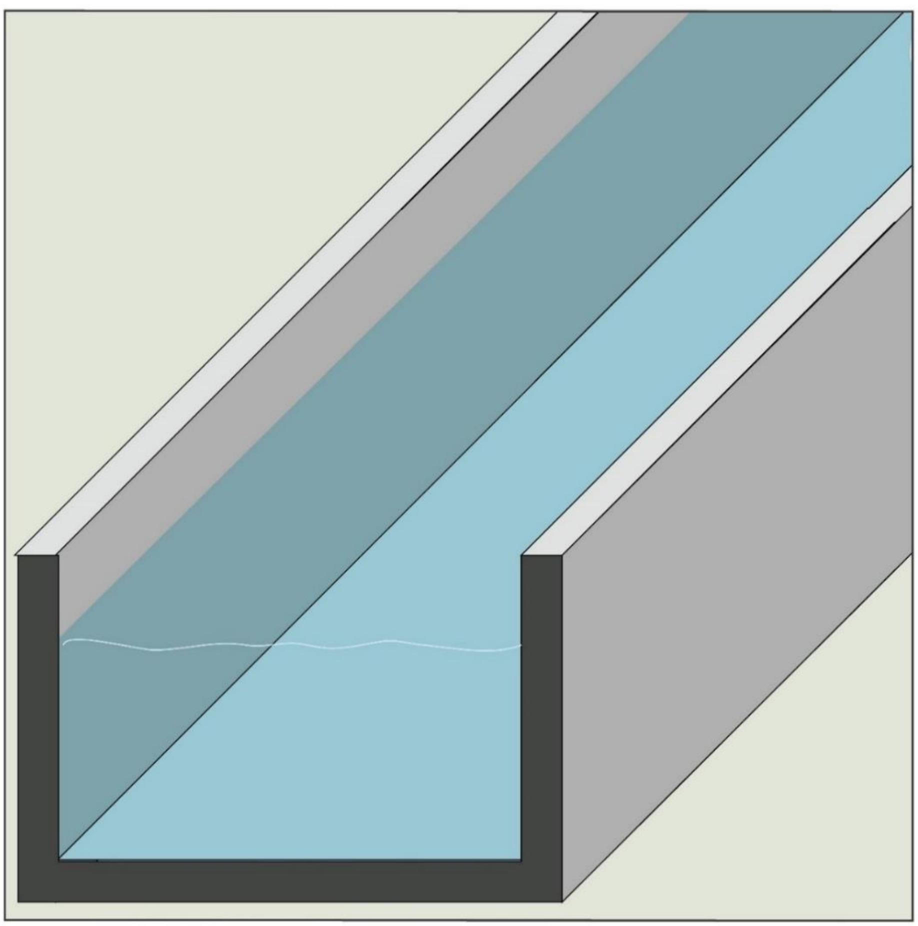

Figure 6-2 Schematic of an Engineered Channel

The navigation industry has expressed its concern about navigating entry into the downstream end of the approach channel because of winds and the currents created by flow over the dam and the power plant intake. The need for navigation aids for the downstream approach to the engineered channel would be evaluated during the design phase of the project, which would include consultation with the navigation industry.

Electric Dispersal Barrier

An electric dispersal barrier creates an electric field in the water that repels fish and may stun fish depending on fish size and water temperature. A barrier will not control the passage of floating ANS (e.g., plants, spores, and eggs) or species that are known to be hitchhikers. At the time of this evaluation, the electric barrier was determined to be the most effective technology for preventing fish passage, not including physical barriers.

In alternatives containing an electric barrier, the barrier would be located at the downstream end of the engineered channel (Figure 6-3) to minimize safety concerns for navigation and operations personnel and the influence of the electric barrier on the lock structure. An electric barrier consists of steel electrodes mounted across the bottom of the approach channel and is powered by on-land power generation and distribution equipment.

Electric barriers are complex electrical and mechanical systems that must periodically be powered down for maintenance. These shutdowns are required in order to perform necessary tasks such as replacement of parts, tune-ups, cleaning, and the like. Electric barriers are also susceptible to power outages and generator failures. When an electric barrier is inactive, fish can pass if the electric barrier is the only swimmer ANS control measure. When maintenance is required or there is a power failure, the BR Lock

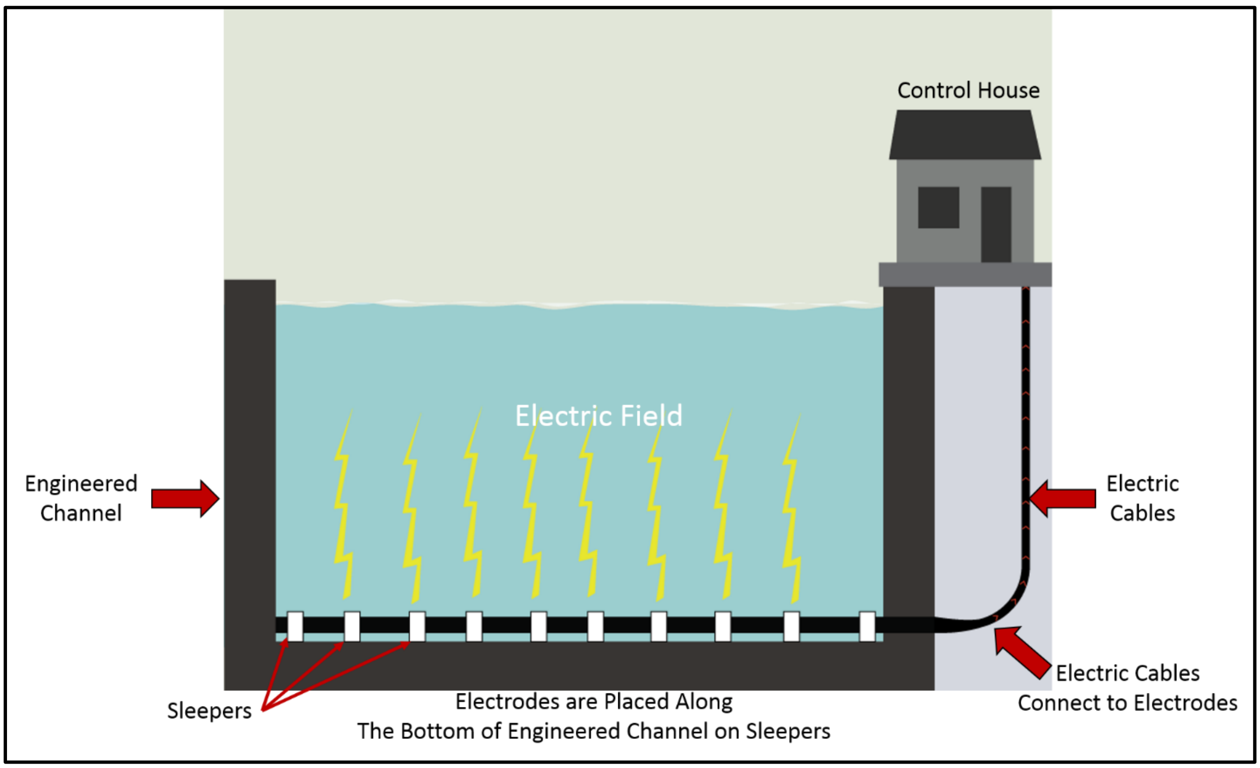

Figure 6-3 Schematic of an Electric Barrier within an Engineered Channel

would remain closed until response crews have cleared fish from the approach channel and electric barrier area, and the electric barrier is operating.

For alternatives that include an electric barrier, the design includes an engineered channel in order to minimize stray current and the probability that small fish will utilize any reduced electric field strength near irregularities in the channel walls to pass through the electric fields. Refer to Section 6.3.2, Structural Measures, Engineered Channel, above for more information.

It is expected that the electric barrier at BRLD would have operating parameters similar to those of the CSSC-EB. Refer to Section 4.5.2, Infrastructure – CSSC Electric Dispersal Barrier System, for more information on electric barrier effectiveness, small fish passage, barge entrainment, and vessel-assisted transport through the electric barrier system, and other factors that may have an impact on barrier effectiveness. The effectiveness of electric barriers is sensitive to fish size and the water temperature. For the operating parameters of the current CSSC Barriers IIA and IIB, research has shown the barriers will immobilize fish approximately 4 in (10.2 cm) in length or longer at a water temperature of 68°F (20°C). At a water temperature of 86°F (30°C), the same operating parameters will immobilize fish approximately 5.5 in (14.0 cm) in length or longer. As the water temperature decreases, smaller fish can be deterred using the same operating parameters. Research is currently underway on fish deterrence in water temperatures less than 68°F (20°C). See Section 6.3.2, Structural Measures, Water Jets, for a description of water jets, a measure proposed to reduce the likelihood that small or stunned fish would pass through the electric barrier due to vessel-induced entrainment.

If a fish is immobilized by the electric barrier and remains afloat, a relatively low reverse flow at the surface could move it across the barrier. See Appendix E, Hydrology and Hydraulics, for information on conditions when flow is reversed in the downstream approach channel to BRL.

There are several safety concerns related to operation of electric barriers: the potential for the electrified water to generate sparking within or between barges or other vessels; potential risks to people who may contact the electrified water; potential risks created by on-land ground currents; potential risks from exposure to airborne electromagnetic fields; and electrical hazards to which workers on-site may be exposed. Operation of the electric barrier also has other potential side effects, such as accelerated corrosion of metal in the vicinity and interference with other nearby electronic equipment. After conducting an evaluation to assess safe operating parameters in coordination with USACE, the USCG may implement special rules and a Safety Zone and Regulated Navigation Area to mitigate the risks of the electric barrier at BRLD. Based on the evaluation and coordination with the USCG, the navigation community, and lock operators, USACE may need to either turn off or lower the output power of the electric barrier as a vessel approaches, travels through the channel, and/or during lockages of the vessels to bring the field strength in the water to a safe level and reduce the stress on the barrier electrical system.

Complex Noise

Complex noise, which is delivered to the waterway through underwater speakers, deters fish movement, but does not control the passage of floating ANS (e.g., plants, spores, and eggs) or ANS known to be hull foulers. The characteristics of the complex noise would be selected to deter target fish species. Speakers for this measure would be installed below the water's surface within the engineered channel (Figure 6-4). The narrow and shallow engineered channel provides an environment that increases the likelihood of insonifying the channel through a design to achieve the target sound profile throughout the water column while minimizing the sound emitted above the water's surface, with target frequencies and decibel levels. The speakers may also be placed in the BR Lock chamber pending further study.

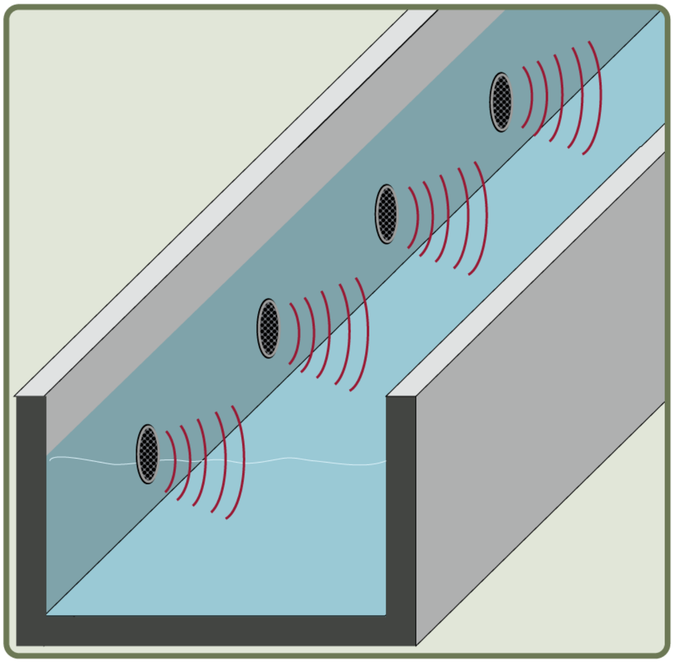

Figure 6-4 Speakers in an Engineered Channel

Complex noise would likely operate when a vessel is moving upstream toward the approach channel to move fish away from the lock doors, and would likely continue to operate while upstream-moving vessels are in the approach channel and when the lock doors are open. Actual operations are subject to continued study and evaluation. It is expected the speakers would not operate continuously so as to reduce the potential for habituation by the targeted ANS. Additional research is needed to assess the potential for habituation and the required target sound characteristics that will best deter Asian Carps and fish with similar hearing capabilities.

Refinement of the complex noise measure is expected to occur as the study progresses. Future steps include (1) mapping ambient sound within the approach channel and lock under various scenarios (e.g., opening/closing of miter gates, vessels traversing, and vehicle bridge operations); (2) establishing audiograms for Asian carps; (3) identifying the target decibels/frequencies needed to elicit behavioral avoidance response in Asian carps; (4) numerically modeling the channel to inform the design of the speaker array; (5) assessing the time required to deter fish from the channel downstream of the lock gate; and (6) assessing the compatibility of complex noise with the other control features.

In 2017, USACE and the USGS mapped the ambient sound of Brandon Road Lock using known sound profiles and controlled sound sources. The trial is funded by GLRI. Speakers were installed on an anchored vessel that moved to predetermined locations after projecting known sound sequences into the channel. The underwater sound emitted through the speakers as well as the sound of lock operations and vessel movement was monitored over a 7-day period. Limited hydroacoustics data was collected during the sound mapping effort to observe impacts on Asian carps movement, although these fish are not currently abundant immediately below BRLD, and native fish movement. The acoustic data collected during the field trial is being processed to develop a sound propagation model. The model would be used to design underwater noise systems for locks in navigation channels. Brandon Road Lock and Dam staff coordinated with crews on the water to ensure vessels moved safely during periods of barge traffic or lock operation, and ensured there were no impacts to navigation. This effort also informs engineering considerations and identifies potential impacts on navigation for similar future deployments.

Subject to the availability of funds, a subsequent trial would be completed in 2018. The data collected during the second trial would be used to (1) fine-tune the acoustic model and (2) further develop the behavioral response of Asian carps under flow fields.

Water Jets

Water jets were developed as a control technology to address the passage of small fish and floaters due to vessel movement. While jets do not repel fish on their own, they may increase the efficacy of fish deterrents by reducing the potential for inadvertent transport past an ANS control point such as an electric barrier or a complex noise field.

Based upon field-testing and observations, tows transiting through an ANS control point in the upstream or downstream direction may facilitate the upstream movement of fish and floating ANS through an ANS control point (Figure 6-5). Upstream-moving vessels passing through an ANS control point may inadvertently trap fish and floating ANS in the spaces between barges (Figure 6-6) and transport these ANS across an ANS control point. Barge entrainment and vessel movement pushing fish upstream have been shown to be possible, but the frequency and probability are unknown. Down-bound tows create a return current within the channel, which moves in the opposite direction the tow travels (upstream) (Figure 6-5). Depending on the size and speed of the tow and the length of the controlled area, a down-bound tow's return current could transport fish or floating ANS staged at the downstream extent of an ANS control area (Bryant et al. 2016).

Water jets would be installed along the bottom of the engineered channel at the downstream end of the approach channel (Figure 6-7). Water would be pumped from the Dresden Island Pool (i.e., downstream side of Brandon Road Lock) with a grinder pump positioned adjacent to the navigation channel (Figure 6-8). The grinder pump was selected to reduce the likelihood of introducing ANS into the channel by minimizing survival of ANS through the pumping system. The stream of water emitted by the jets would be designed to dislodge fish from the recesses and eddies formed by the moving tow and to remove fish and floating ANS at the downbound extent of the ANS control point but not strong enough to affect vessel traffic.

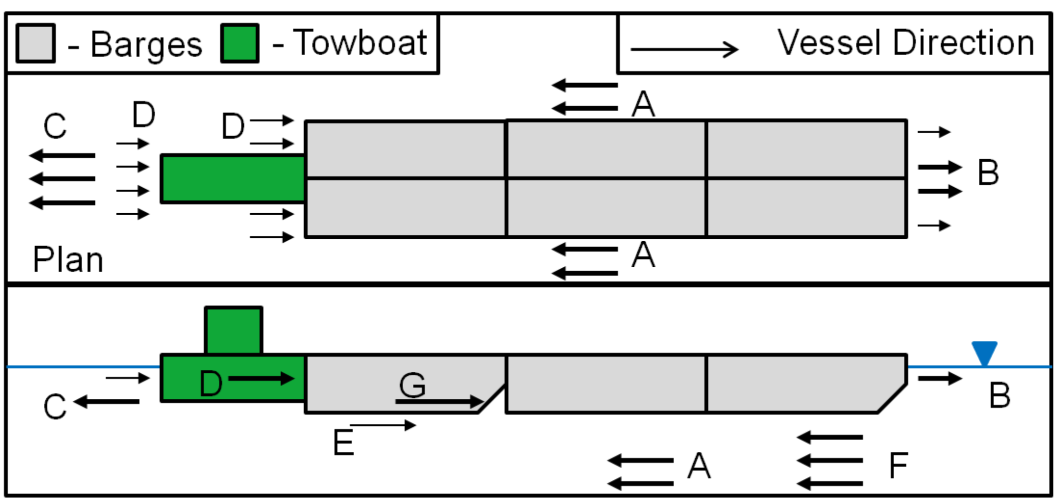

Figure 6-5 Water Motions around Tows Moving Left to Right in Confined Channels (A = return velocity; B = bow wave; C = propeller jet; D = wake flow; E = flow in boundary layer along hull; F = displacement flow at bow between hull and channel bottom having short duration; and G = pocket recirculation.) (Source: Bryant et al. 2017)

Figure 6-6 Spaces between Barges Where Fish and Floating ANS May Be Entrained

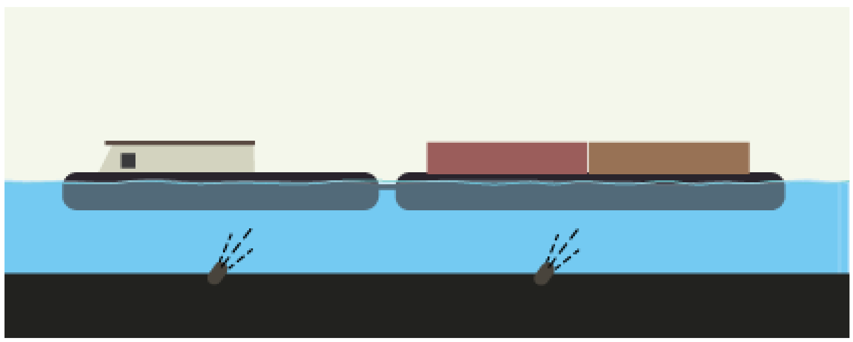

Figure 6-7 Schematic of Water Jets That Would Be Positioned Facing the BR Lock in Order to Maximize Effectiveness (the number of water jets is arbitrary, and the drawing is not to scale)

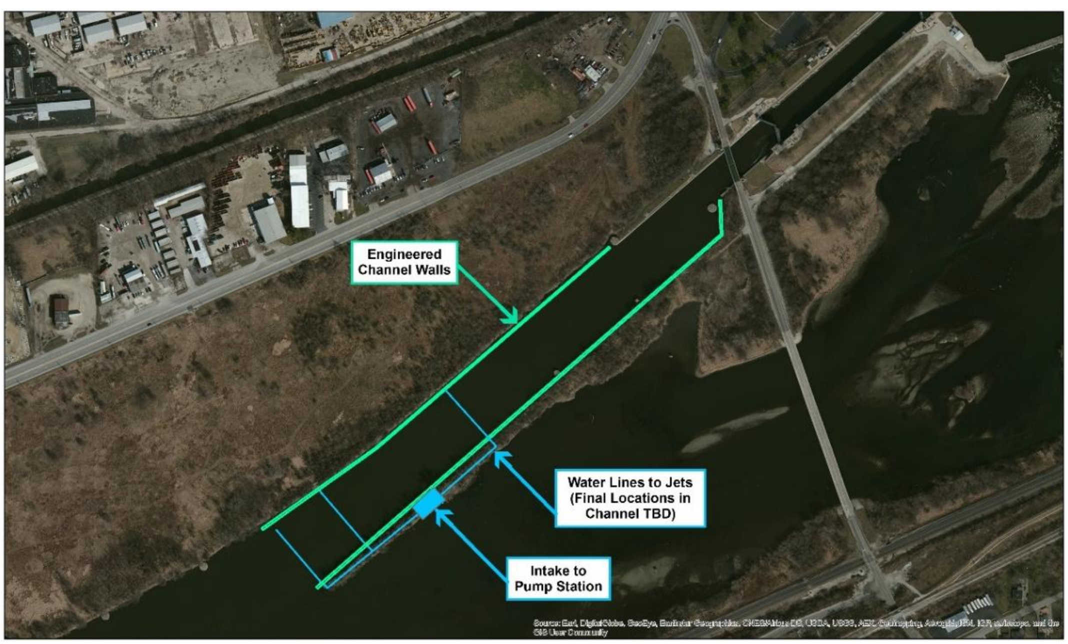

Figure 6-8 Conceptual Layout of Water Jet System in BR Downstream Approach Channel

This conceptual design was in part based on a scaled physical model study conducted to inform the design of possible measures to address fish entrainment at the CSSC-EB. The model study examined multiple jet configurations to determine optimal placement within the approach channel to reduce fish entrainment between barges due to vessel-induced currents. The experiments included altering the jet discharge velocity, the placement of the jets in the channel in relation to vessels, nozzle orientation, and the number of jets.

The results indicated that a jet array oriented at 67.5° from the vertical with a 12-in (30.5-cm) nozzle showed the greatest effectiveness for removing the greatest number of fish for a 2 × 3 barge configuration traveling at 2.5 mph (4 km/hr). At higher vessel speeds (4–5 mph [6.4–8 km/hr]), the jets were unable to remove all fish. The study concluded the biggest contributing factor to the lower minimum effectiveness was likely the increased vessel speed. The increased vessel speed reduced the exposure time so the model fish were not subjected to the flushing action of the jets long enough to be removed from the space between the barges (Bryant et al. 2017).

Future study is needed to address vessels moving at higher speeds, upstream vessel movement pushing fish past an ANS control point, configurations of possible ANS passage due to downbound tows and water availability to operate the system. To address vessels moving at higher speeds, a possible design consideration would be to increase the effective length of the jet array. The increased length may provide greater flushing activity to clear more fish. To address upbound vessels pushing fish past the control point and downbound return currents, water jets may be used to clear the center of the channel prior to vessel passage. The jets would be activated in advance of vessels approaching the control point.

In fiscal year 2017, USACE anticipates developing and completing a field-testing program with other federal agencies to determine the feasibility and effectiveness of water jets for mitigation of fish entrainment and passage due to vessel-induced currents. The tests will be conducted in the CSSC in the vicinity of the CSSC-EB to the extent possible. The intent is to temporarily install a water jet system in the water of the canal, place fish or models for fish in areas near a barge tow where they are or will become entrained, and then monitor what happens as the barge tow passes over the water jets. These results would help inform the design for the BR approach channel.

Flushing Lock

The flushing lock (Figure 6-9) addresses the transfer of floating life stages of ANS, such as floating plants, larvae, and egg, in the lower pool to the upper pool by flushing them out of the lock when the lower miter gates are opened to allow entry of an upbound tow. The flushing lock will not deter fish or hitchhikers. The force with which water will flush through the lock will not be sufficient to detach organisms attached to vessel hulls.

Lock expansion from a length of 600 to a 1200 ft (182.9 to 365.8 m) lock was considered. However, at this location on the Illinois Waterway, it was determined a larger lock would not benefit the overall system given no expansion changes would occur at the locks immediately upstream or downstream of Brandon Road Lock. This determination was made based on a preliminary, qualitative analysis of the existing traffic characteristics and the commonality of traffic between Brandon Road L&D, Dresden Island L&D, and Lockport Lock.

The flushing lock is a modification to the existing lock-filling and -emptying system. The existing ports will be sealed, and new ports will be drilled into the lock walls at a spacing based on the current USACE standard lock design. An additional set of ports would be cut in at the upstream end of the lock. The extra set of ports would improve the water exchange in a stagnant area identified during field observations and modeling.

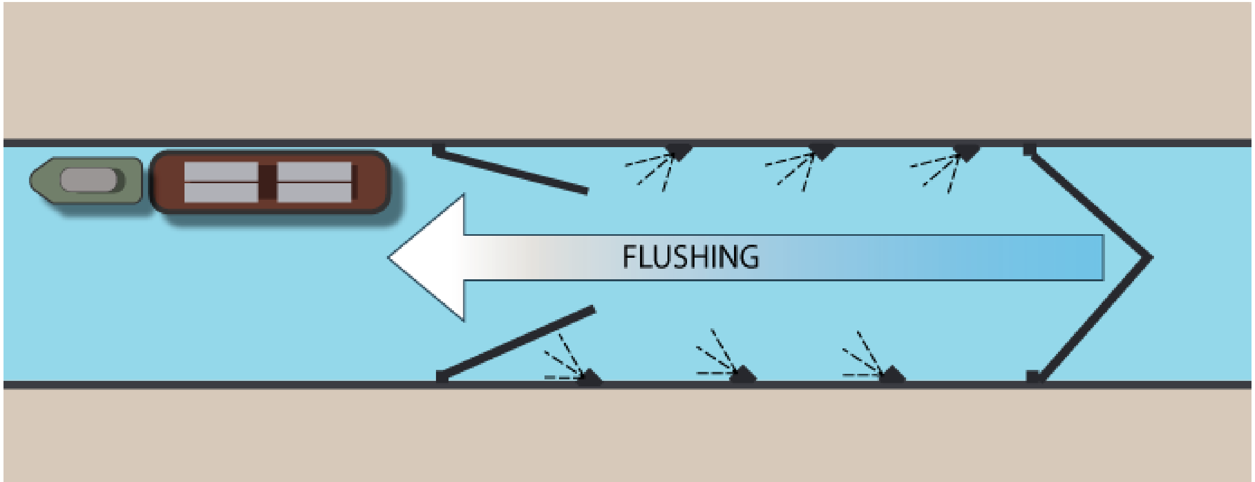

Figure 6-9 Schematic of Flushing Lock (the number of ports is arbitrary, and the drawing is not to scale)

The proposed design is based on 3-D numerical modeling that evaluated five flushing designs to determine which would be the most effective while minimizing the possible impacts on navigation (Appendix E, Hydrology and Hydraulics). This design provides an approximate 8-minute time savings for standard lock filling and emptying based on prior modeling of the standard port design and has previously been evaluated for navigation safety.

The operation for the flushing lock assumed that vessels would be staged downstream on the right descending bank when water from the upper pool (Brandon Road Pool) is diverted through the lock's modified filling and emptying culverts and through open downstream miter gates. This introduction of water would result in exchanging the water volume in the lock chamber.

The assumptions for operation are based on a review of the modeling results and the consideration of navigation impacts. The assumed flushing duration is 15 minutes. The time savings for filling and emptying offsets a portion of the time required for a 15-minute flush and additional steps required for vessel maneuvering and flushing operations. For this study, the lock is assumed to be flushed prior to upstream lockages (Figure 6-10) and consecutive downbounds (Figure 6-11).

Pending availability of water, the flushing lock may not necessarily occur for every lockage or the flushing duration may be shortened during low-flow months of July through December, except during rain and flood events. Flushing operations would be linked with physical monitoring of the upstream pool to optimize the use of this feature. Spawning occurs during high-flow events; therefore, the floating life stages of Asian carp, eggs and larvae, are anticipated to be present when sufficient water is available in the Brandon Road Pool. If there is insufficient water, then the frequency or flushing time will be reduced. Additional analysis is required.

Further development of the flushing lock would include the construction of a scaled physical model. The model would allow for the optimization of the flushing frequency and duration to maximize effectiveness while minimizing impacts on navigation.

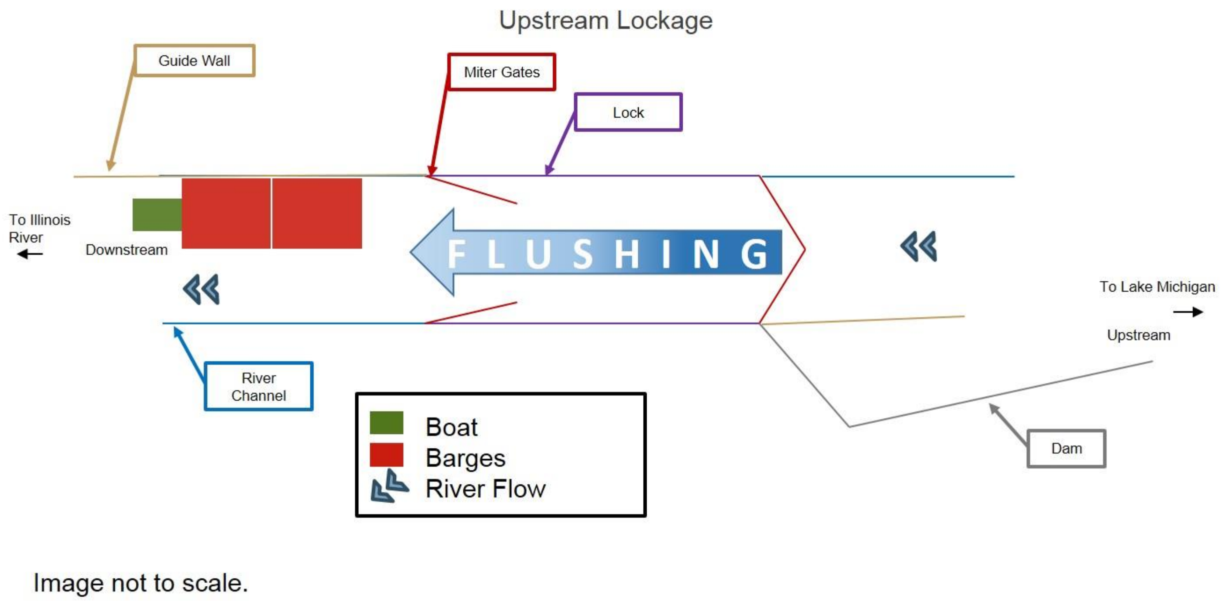

Figure 6-10 Upstream Lockage

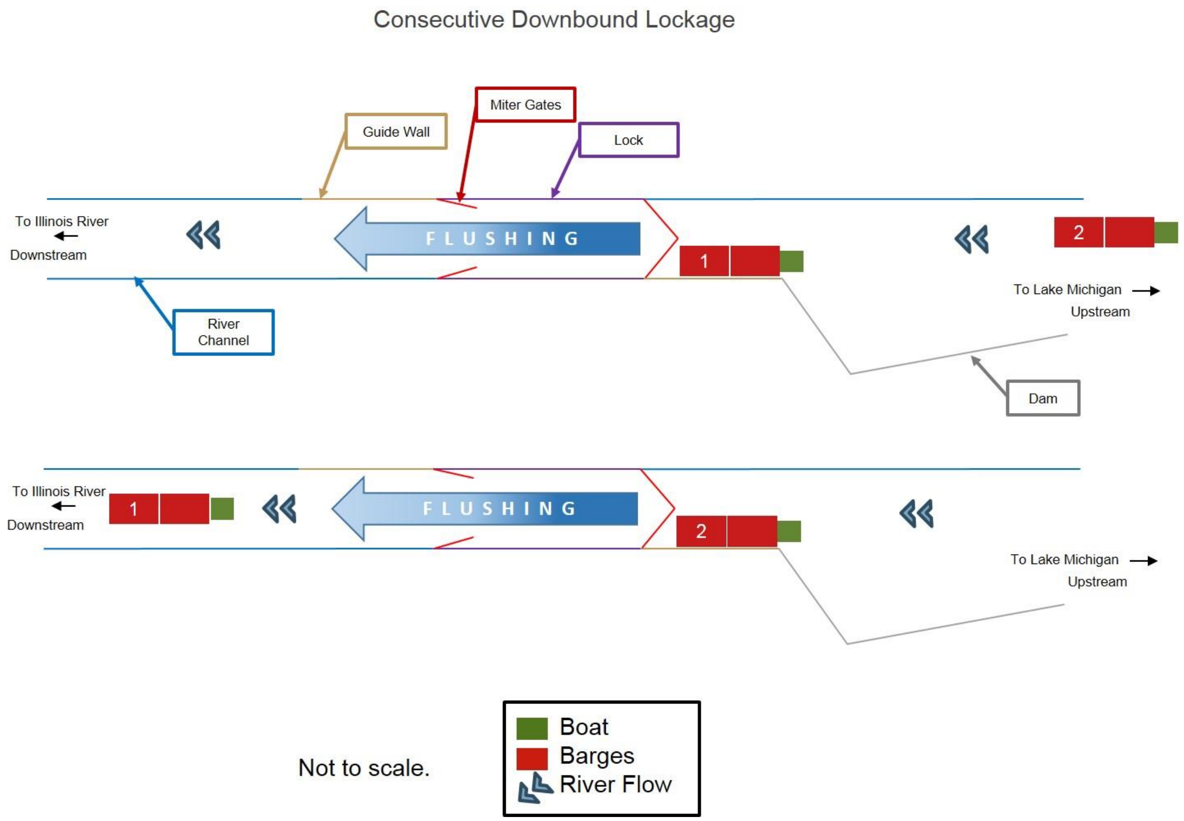

Figure 6-11 Consecutive Downbound Lockages

Lock Closure

Lock closure is the most effective measure for controlling the passage of swimming, floating, and hitchhiking ANS. Lock closure would permanently terminate navigation through the BR Lock. The Great Lakes would no longer be connected to the inland waterways or provide navigation access to the Gulf of Mexico. The Des Plaines River would continue to flow through and over the BR Dam according to its current operation procedure. The dam has sufficient capacity to pass floodwaters. The lock is not needed for this purpose.

The lock closure measure would include a permanent concrete wall that ties into the Brandon Road Lock's upstream emergency concrete gate sill to structurally separate the upper pool from the lower pool (Figure 6-12). At this location, the permanent wall is upstream of the culvert intakes. The concrete wall would span the total lock width of 110 ft (33.5 m) and would match the height of the existing lock walls. The level of flood protection of the existing lock walls is well above the 0.2% exceedance event.

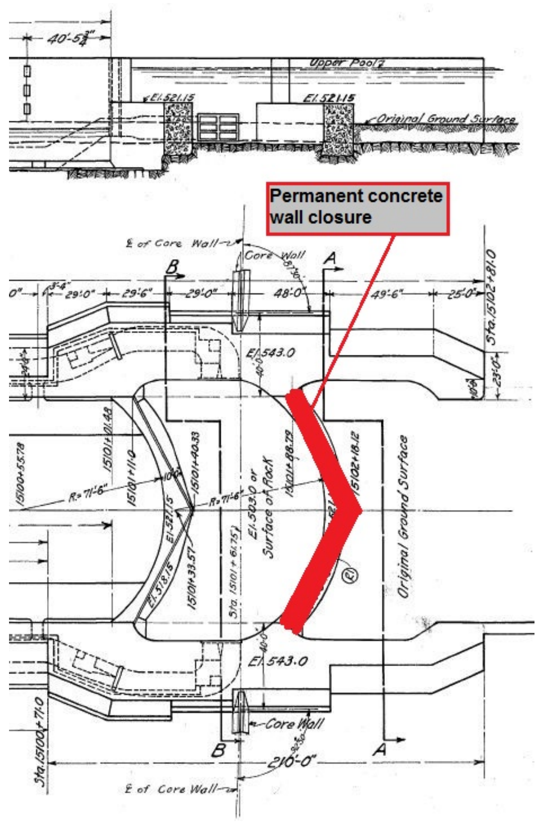

Figure 6-12 Permanent Lock Closure: Concrete Wall

Boat Launches

The availability of space to launch boats and park boat trailers, vehicles, and other ancillary equipment adjacent to the Dresden Island and Brandon Road Pools was identified as a limiting factor for a rapid contingency response and also would affect the efficiency of crews performing nonstructural activities within this portion of the waterway. The addition of boat launch locations would also assist with these actions and with crews performing inspection, maintenance, and safety actions around the BRLD.

The upstream launch into Brandon Road Pool will be built on the land owned by USACE for lock operations. It will include a new roadway up to the water's edge, since the current slope is not easily drivable. The launch itself will be a gravel ramp to the water with a floating wooden dock.

The downstream launch into Dresden Island Pool would be built at one of two locations, depending on whether the alternative included an engineered channel. For alternatives that do not include an engineered channel, the launch would be constructed on the isthmus of land adjacent to the approach channel (Figure 6-13). A gravel road with secure gate access would lead from Brandon Road to a parking area and a boat launch into the approach channel. For the alternatives that include an engineered channel, the boat launch would be built further downstream, just south of the approach channel outlet (Figure 6-14).

The boat launches would be constructed on property owned by USACE. Public use of the boat launches would not be permitted. All boat launches are sited on a USACE-operated facility that requires access restrictions for security and safety because of proximity to lock facilities.

Figure 6-13 Boat Launch Locations for Alternatives That Do Not Include an Engineered Channel

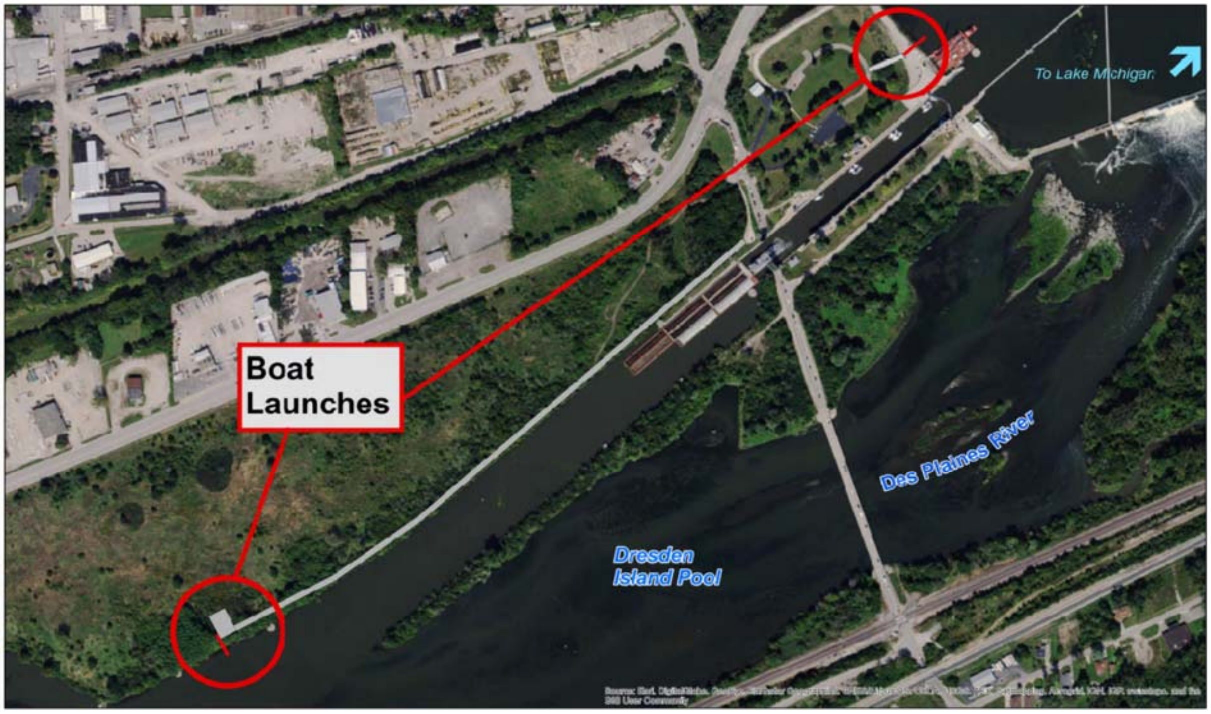

Figure 6-14 Boat Launch Locations for Alternatives That Include an Engineered Channel

Temporary Mooring Area

A temporary mooring area is included in alternatives that include an electric barrier. If operators need to reconfigure prior to going through BR Lock because of safety requirements or considerations associated with the electric barrier, the current refleeting area is approximately 8 mi (12.9 km) downstream of BRLD, as shown in red in Figure 6-15. To reduce navigation delays, alternatives with an electric barrier include a temporary mooring area approximately 2 mi (3.2 km) downstream, as highlighted in yellow on Figure 6-15. This area would be dredged to a depth of 14 ft (4.3 m) and includes four mooring cells that are river structures to secure and guide barges. The mooring cells are constructed of steel sheet piling and filled with concrete. The mooring area will not be supervised or secured. Alternatives with an electric barrier also include the repair of the mooring cells located immediately upstream of BRLD.

6.4 Location

This section of the report discusses why the BRLD was selected at the downstream control point to prevent the passage of MRB ANS. The GLMRIS Report identified the BRLD as the downstream control location for three alternatives (USACE 2014a). When formulating alternatives that included structural measures, the GLMRIS-BR PDT assessed whether the BR Dam, like the lock, was a viable upstream aquatic pathway for MRB ANS. There is a 24-ft (7.3-m) difference in water elevation from the downstream side of the dam to the upstream side of the dam for a flood level that has a 0.2% chance of occurring in any given year, commonly known as a 500-yr flood discharge, which effectively limits upstream transfer (see Figure 6-16) for all storm events up to and including the 500-yr flood.

Figure 6-15 Aerial View of Current Refleeting Area and Proposed Temporary Mooring Area

The average velocity exiting the head gates is approximately 28 ft/s (8.5 m/s) (Figure 6-17). After reviewing the head differential between the lower and upper pools during the 500-yr flood event and witnessing the discharge from the head gates as well as learning the average exiting velocity during flood events, the panel of experts convened for the Asian carp expert elicitation concluded the dam was not a viable aquatic pathway for swimmers. The dam is not a viable pathway for floaters because water is always flowing downstream from the dam when the head gates are open and no vessels traverse the dam, so it is not a viable aquatic pathway for hitchhikers, as well.

Potential aquatic pathways at Brandon Road are less complex and geographically expansive than the potential pathways at upstream control points such as the Lockport LD. During large storm events, flood operations lower the CSSC by passing flow to the Des Plaines River through the Lockport Controlling Works located just upstream of the Lockport LD. The Controlling Works creates a potential aquatic pathway around Lockport. Additional aquatic pathways exist at or near the Lockport LD including Deep Run Creek, as well as other locations on the Des Plaines River during high-flow conditions. See Appendix E, Hydrology and Hydraulics for more information.

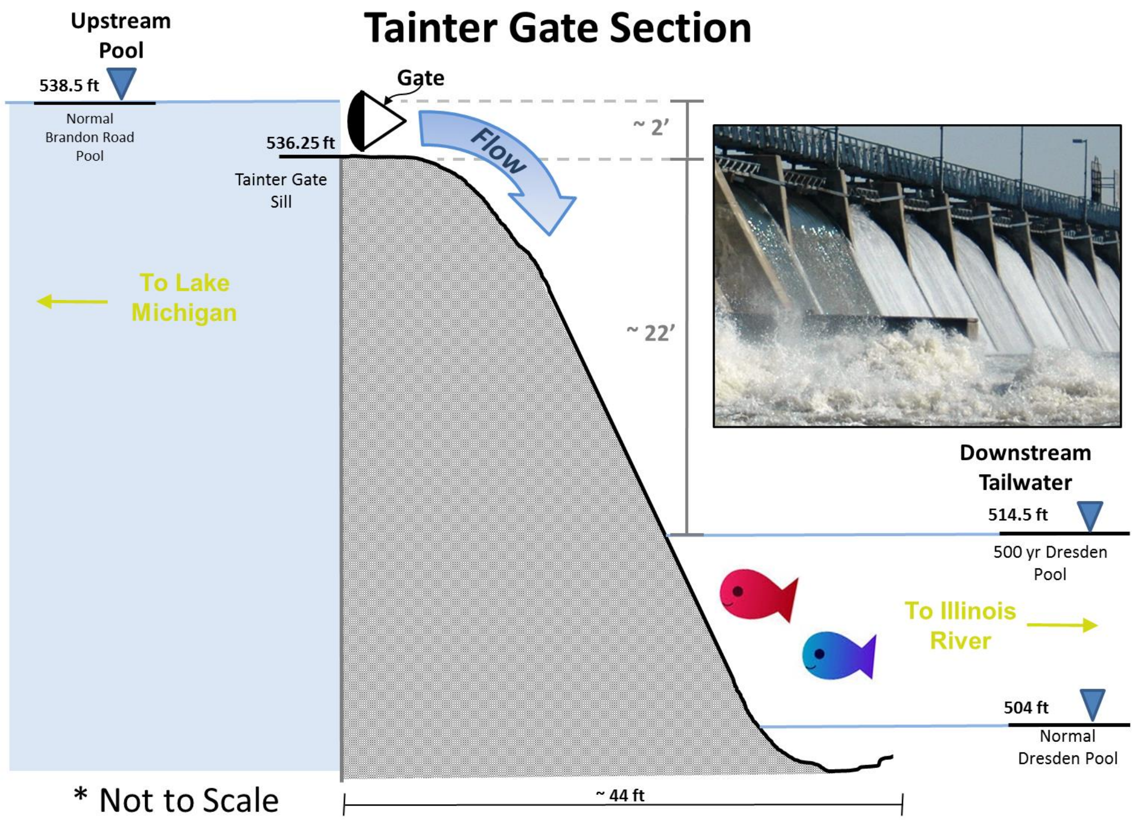

Figure 6-16 Cross-Section of the BR Dam (not to scale)

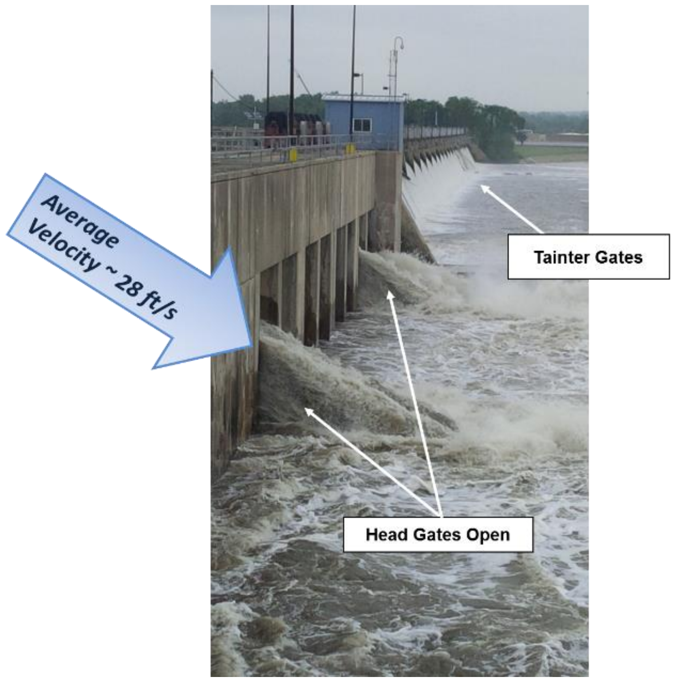

Figure 6-17 Water Exiting the BR Dam Head Gates

A hydrographic analysis of the tributary watersheds in the CAWS and upper IWW was completed to determine whether alternative pathways exist that could allow MRB ANS to bypass a control point at Brandon Road. The analysis identified six pathways that could connect the Des Plaines River below BRLD to the Des Plaines River above BRLD during the 500-yr flood event. The bypasses create an aquatic connection during the 500-yr event, but in some cases, the aquatic pathway would include infrastructure such as culverts, retention basins, and storm sewer passages. Based on the results of this hydraulic and hydrologic investigation, these locations were screened out for implementation of an ANS control point because an aquatic pathway between the MRB and the GLB is estimated to be created at or above the 500-yr flood event, which is the design event for GLMRIS. Additional information regarding the bypass analysis is included in Appendix B, Planning.

6.5 Alternative Formulation Strategy

This section describes the strategy used to formulate the GLMRIS-BR alternatives using the retained structural and nonstructural measures. According to USACE planning guidance, an alternative consists of structural and/or nonstructural measures that meet, fully or partially, one or more study objectives subject to study constraints. Equal consideration must be given to structural and nonstructural measures during the planning process. A range of alternative plans shall be identified and screened and refined in subsequent iterations throughout the planning process. In addition, alternatives that could be implemented under the authorities of other federal agencies, state, and local entities and nongovernment interest should also be considered (Section 2-3(c), pages 2–4).

The plan formulation strategy developed for GLMRIS-BR is as follows:

1. Alternatives will comprise effective ANS control measures for swimmers, floaters, and/or hitchhikers.

2. Life safety shall be emphasized. Measures will be screened where life safety cannot be mitigated, or it is uncertain how to mitigate for life safety impacts.

3. ANS control measures must be available for use 24 hours per day, 7 days per week.

4. Multiple controls addressing the same mode of transport will be included in an alternative if the additional control addresses a deficiency in the first control, or if the two controls act to enhance the alternative’s effectiveness or provide redundancy when used in combination.

5. Each alternative that allows for continued navigation will attempt to minimize impacts on navigation.

To assess the full range of alternatives, the team identified the No New Federal Action and Lock Closure Alternatives. The No New Federal Action Alternative was anticipated to cause no additional impacts on waterway users and uses. The Lock Closure Alternative was anticipated to cause the greatest impact on waterway users and uses.

A nonstructural alternative was formulated to consider the risk reduction provided by a plan that would be implemented by USACE and other federal agencies. The nonstructural plan was formulated and refined to maximize its effectiveness and robustness.

The last group of alternatives were formulated with various structural controls. The goal of these alternatives was to maximize effectiveness by combining multiple structural controls that address known deficiencies in order to enhance the effectiveness of the entire alternative while minimizing impacts on waterway users and uses. Nonstructural measures, engineered channel, water jets, and flushing lock were included in all the alternatives comprised of structural controls. These alternatives are named the Technology Alternatives.

Maintaining a small ANS population downstream of BRLD was assumed to increase the effectiveness of these technology alternatives. The technology alternatives could be overwhelmed by large downstream populations challenging the control point. This could result in the involuntary passage of the control point by ANS. Therefore, manual and mechanical removal was considered to be an important measure to include. Monitoring the ANS population plays an important role in the operation of the controls and identification of where to conduct overfishing to minimize the population below BRLD. Public education and outreach may reduce the risk of ANS transfer through non-aquatic pathways, human-mediated transfer such as bait bucket transfer, and transferring ANS plant fragments from one water body to another on boats and equipment. Integrated pest management strives to coordinate the actions of all participating federal, state, and local agencies and nongovernmental organizations to develop plans that target all life stages of ANS while minimizing impacts.

The engineered channel was identified as being an intrinsic feature for the technology alternatives. The engineered channel would increase the likelihood of detection using sonar and hydroacoustic monitoring gears; reduce the potential shielding from electric current, sound waves, and other ANS control effects; simplify clearing of fish within the channel (e.g., piscicide application and netting); and increase the likelihood that target sound frequencies and decibel levels would be achieved throughout the channel. The engineered channel could also be designed to reduce stray current from the electric barrier, and it would provide a platform for evaluating future ANS controls and potentially incorporating them.

Vessel entrainment and the movement of fish due to vessel-induced current have been identified in model studies and field demonstrations to transfer model fish or small fish past an ANS control. Water jets have been identified and have been model-tested as a measure that can reduce this potential movement. Although water jets do not repel fish, they may increase the efficacy of a fish deterrent by addressing an identified vulnerability.

The Brandon Road Lock connects the MRB with the GLB and creates a viable pathway for upstream transfer. To address floating ANS that may enter the lock, the flushing lock exchanges the water in the lock. No other measure was developed to address floating ANS in the lock. As such, the flushing lock was included in each of the technology alternatives.

It is uncertain whether an electric barrier would operate continuously when vessels travel through the approach channel because of possible safety and operational constraints. The operational parameters of the electric barrier affect not only its effectiveness but also its impacts. At the time of the elicitation in 2015, the experts were told the intention was to operate the barrier continuously for alternatives that contained an electric barrier as the only swimmer control. Actual operating parameters would be developed after constructing the barrier and conducting a safety evaluation in coordination with USACE and possible USCG's implementation of a Safety Zone and Regulated Navigation Area to mitigate such risks associated with the electric barrier at BRLD. As such, the experts were told the actual operating parameters were uncertain due to possible life safety considerations and operating constraints. For the impacts analysis of alternatives with only an electric barrier, the electric barrier was assumed to operate continuously because the analysis required specific assumptions regarding operating parameters. For alternatives that include two swimmer controls, the electric barrier was assumed be turned off while vessels were approaching the downstream channel, while they were in the channel, and while they were in the lock. The second swimmer control was available during this time.

The final array of alternatives with the measures is presented in Figure 6-18.

6.6 Alternative Plan Evaluation Criteria

The four criteria specified in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* to screen alternatives are acceptability, completeness, effectiveness, and efficiency (U.S. Water Resources Council 1983). The four accounts were established to facilitate the evaluation and display of the effects of alternatives. Keeping in mind the overarching *Principles and Guidelines* criteria, study-specific screening criteria were developed for GLMRIS-BR: probability of establishment; relative life safety risk; system performance robustness; and costs including structural construction costs; nonstructural costs and Operations, Maintenance, Rehabilitation, Reliability and Repairs (OMRR&R) costs; and costs of impacts on navigation (NED). Table 6-3 identifies how each criterion is used for alternative evaluation per the *Principles and Guidelines* criteria.

6.6.1 Probability of Establishment in the GLB

The probability of establishment refers to the probability that Asian carp and/or *A. lacustre* will successfully transfer from the MRB to the GLB using one or more of the CAWS aquatic pathways and subsequently become established. Analysis of the probability of establishment is described in detail in Appendix C, Risk Assessment. The following paragraphs summarize the analysis and how it was used to evaluate the GLMRIS-BR Alternatives.

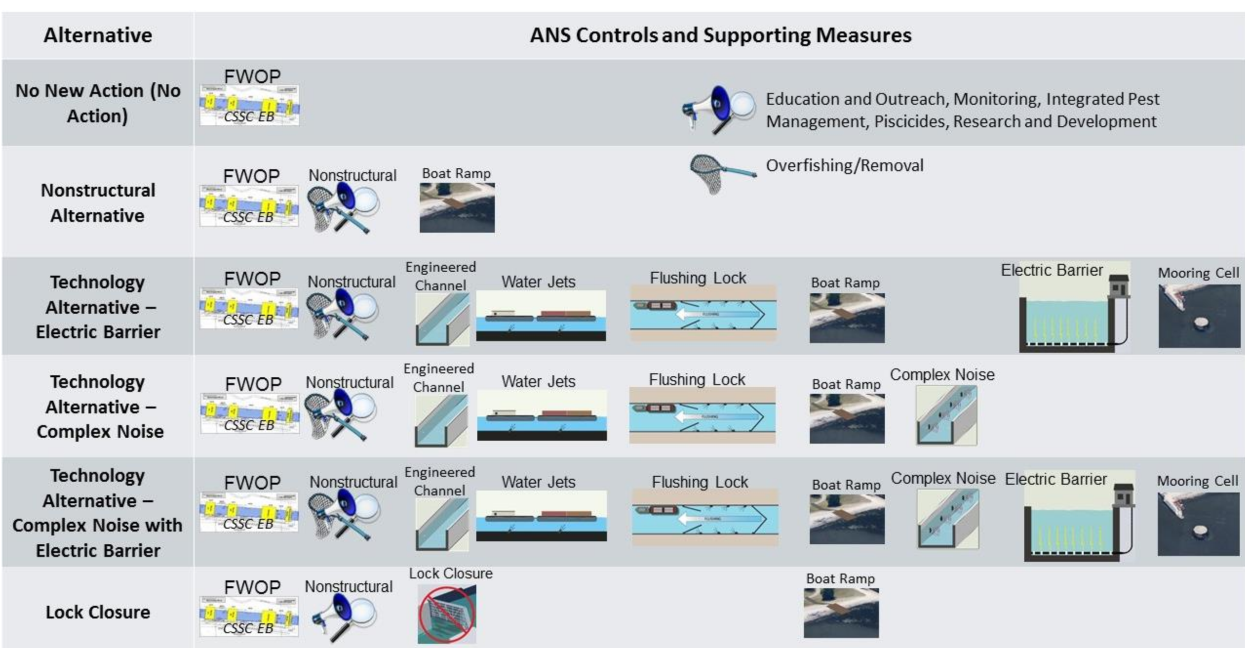

Figure 6-18 GLMRIS-BR Alternatives

Table 6-3 P&G Criteria and the GLMRIS-BR Specific Evaluation Criteria

Principles and Guidelines Screening Criteria	GLMRIS-BR Specific Evaluation Criteria
Acceptability	Relative life safety risks Social/political consequences of ANS Establishment (Chapter 5) Costs of impacts on navigation
Completeness	Probability of ANS establishment System performance robustness
Effectiveness	
Efficiency	Cost-effective/incremental cost analysis: following needed Probability of ANS establishment Estimated alternative costs Construction Nonstructural measures OMRR&R Costs of impacts on navigation Estimated implementation schedule (used to inform "costs of impacts on navigation")

Analysis of the probability of establishment serves two evaluation functions. First, it differentiates the relative effectiveness of the GLMRIS-BR Alternatives in preventing the establishment of ANS. Effectiveness is defined as minimizing the probability of establishment of Asian carp and the probability of establishment of *A. lacustre* in the GLB. The lower the estimated probability of establishment associated with an alternative, the greater the efficacy of that alternative. Second, it provides a quantitative input into the Cost Effectiveness and Incremental Cost Analysis (CE/ICA). Refer to Section 8.1.2, Cost Effectiveness and Incremental Cost Analysis for more information on CE/ICA.

The overall probability of establishment relies on a sequence of events that identifies the following five probability elements:

- *P(pathway)*. The probability that a complete aquatic pathway is available for interbasin transfer between the MRB and GLB through the CAWS aquatic pathway.
- *P(arrival)*. The probability of ANS arriving at the pathway in the Dresden Island Pool located upstream of Dresden Island Dam to below BRLD. Arrival is conditional on the existence of a pathway.
- *P(passage)*. The movement of ANS through the CAWS from the Dresden Island Pool to Lake Michigan. Passage is conditional on target ANS arriving at the pathway.
- *P(colonization)*. The probability of ANS establishing a sustainable breeding colony in Lake Michigan. Colonization is conditional on the passage of sufficient target ANS into the GLB.
- *P(spread)*. The probability of ANS spreading beyond Lake Michigan and into the other Great Lakes. Spread is conditional on the colonization of the species in the basin.

Note that each of the five probability elements (pathway, arrival, passage, colonization, and spread) was evaluated with the assumption that the previous establishment step had occurred. Figure 6-19 illustrates the probability elements in relationship to the IWW and its connections to the GLB.

Figure 6-19 Pathway, Arrival, Passage, Colonization, and Spread of ANS from the MRB to the GLB via the CAWS

The GLMRIS-BR PDT developed models following the logic of the sequence of events captured by these five elements to estimate the overall probability of establishment of Asian carp and *A. lacustre* in the GLB. Quantitative estimates of model inputs required to estimate the probability of establishment were obtained from subject matter experts (SMEs) in an expert elicitation. An expert elicitation is a commonly used process for obtaining informed judgments about an uncertain quantity from individuals who have expertise in the area of interest. An expert elicitation was used because no data exist for the required input and there is no reasonable expectation these data will become available in the near term if ever. An expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as “a fact.” Separate panels, consisting of SMEs for each species, were convened for Asian carp and *A. lacustre*.

Separate establishment models were developed for Asian carp and *A. lacustre*. The probability of establishment P(establishment) was estimated for each of the six alternatives. For Asian carp, six sets of estimates were obtained, one for each expert. Five sets of estimates were obtained for *A. lacustre*. Species-specific models were necessary because their modes of transport differ and because much information is available about Asian carp, while little information is available regarding *A. lacustre*. These establishment models were structured to represent the key dynamics of ANS establishment. They are summarized briefly below.

Asian Carp

The six-member panel did not provide direct estimates of the probability of Asian carp establishment in the GLB. They provided estimates of inputs that were used to estimate Asian carp establishment. The values for the establishment elements were elicited from the experts after detailed discussions of the efficacy of the various alternative components, current and future Asian carp population status, movements, and the CSSC electric dispersal barriers at Romeoville, as well as key factors affecting the probability of colonization and spread in the Great Lakes, such as predation, food availability, and reproductive habitat suitability. The probability that a complete aquatic pathway exists was stipulated by all the experts, so it did not have to be estimated. For Asian carp, the following establishment element inputs were elicited:

- *P(arrival).* The probability of a large, medium, or small Asian carp population arriving in the Dresden Island Pool located upstream of Dresden LD to downstream of BRLD was estimated for three different time frames.

- *P(passage)*. The annual number of fish passing through the system from below the BRLD to Lake Michigan was estimated based on the assumed size (large, medium, small) of the population that had arrived in Dresden Island Pool.

- *P(colonization)*. A colonization threshold for the cumulative number of fish required to pass through the CAWS within a given time frame in order to result in a sustainable colony of Asian carp was estimated. The model estimated the cumulative annual number of fish that might pass through the system and compared it to the threshold number of fish required to colonize. P(colonization) was calculated using repeated estimates of these inputs.

- *P(spread)*. The probability of Asian carp spreading beyond Lake Michigan and into the other Great Lakes given that a colony exists was elicited.

Elicitation experts characterize the uncertainty about these unknown quantities as probability distributions. Each expert provided a minimum, maximum, 33rd percentile, and 67th percentile value for each of the uncertain quantities elicited. These values were then used to create a cumulative distribution function (CDF) for each quantity elicited. These establishment input distributions were used in a Monte Carlo process to calculate the probability of establishment CDF using a model developed by the PDT. The model was certified for use by the USACE Ecosystem Restoration-Planning Center of Expertise (ECO-PCX). Using this model, six probability of establishment distributions, one distribution for each Asian carp expert, was generated for each of the six alternatives. See Appendix C, Risk Assessment, for more information regarding the elicitation process, the questions posed to the experts, and a description of the P(establishment) model results.

A. lacustre

Model development options for *A. lacustre* were limited by the minimal data available on this species. For example, no data were available on the density of *A. lacustre* on boat hulls or the number of *A. lacustre* required for colonization in the GLB. Consequently, the model structure used for *A. lacustre* differed from the one used for Asian carp. The model used to estimate P(Establishment) for *A. lacustre* was as follows:

$$P(\text{establishment}) = P(\text{pathway}) \times P(\text{arrival}) \times P(\text{passage}) \times P(\text{colonization}) \times P(\text{spread})$$

where the establishment probability elements are defined as follows:

P(pathway) = probability that a complete aquatic pathway is available for interbasin transfer (stipulated to be 1);

P(arrival) = probability that a population of *A. lacustre* will arrive at BRLD within a given time frame, given that there is a pathway;

P(passage) = probability that some number of *A. lacustre* will pass from below BRLD to Lake Michigan within a given time frame, given that *A. lacustre* arrives;

P(colonization) = probability that habitat is suitable and that *A. lacustre* will enter in sufficient numbers to colonize in Lake Michigan, given that *A. lacustre* pass through the system;

P(spread) = probability that *A. lacustre* will spread beyond Lake Michigan, given that *A. lacustre* establish a sustainable breeding colony.

Refer to Figure 6-19 for a depiction of the probability elements with relation to the project area.

Members of the expert panel provided direct estimates of each of the last four probabilities on the right-hand side of the equation. P(pathway) is known to equal one and was not elicited. As with Asian carp, the experts provided a minimum, maximum, 33rd percentile, and 67th percentile probability value for each of the four establishment elements evaluated. The four probabilities were used to construct the individual expert's CDF for the relevant quantity. Values of each probability were sampled from the relevant CDF using a Monte Carlo process and multiplied together to obtain an estimate of the probability of establishment of *A. lacustre* in the GLB. The *A. lacustre* establishment model developed by the PDT was certified for use by USACE ECO-PCX reviewers. Using this model, five P(establishment) distributions, one distribution for each expert, were generated for each of the six alternatives. See Appendix C, Risk

Assessment, for more information regarding the elicitation process, the questions posed to the experts, and a description of the P(establishment) model calculations.

Composite Expert and Results

When multiple estimates are available from multiple experts, it is common practice to aggregate the results of the expert elicitations into what is called a *composite expert*. All experts were considered equally credible, so a simple average of the CDFs was used to combine the individual estimates. This is one of the most commonly used means of combining CDFs. The composite expert value facilitates the comparison of the relative ranking of the six alternatives by lowest probability of establishment (most effective) to the highest probability of establishment (least effective). Comparing alternatives using CE/ICA was also simplified by using a single composite expert probability of establishment value for each alternative.

The composite expert represents the average of all six experts, and as such is not representative of any one expert. For example, the results of the P(establishment) analysis described in the No New Federal Action Alternative indicates a wide divergence in the P(establishment) estimates calculated for the experts. This variation resulted from disagreements among the experts about the quantitative input values used to characterize establishment and is indicative of the uncertainty about the establishment of ANS in the GLB. Combining the experts into a composite estimate, while important for GLMRIS-BR decision-making, does not adequately preserve this uncertainty. Therefore, to provide the reader with the most informative and transparent results, the P(establishment) model outputs are presented for both individual experts and the composite expert.

The estimates for each alternative are presented using a numerical summary that comprises the minimum, median, and maximum values as well as a box and whisker plot. The plot illustrates a distribution of the estimated values divided into quartiles. Figure 6-20 provides a legend for a box and whisker plot, with values represented in the following manner: (1) minimum value, (2) first quartile, (3) median, (4) third quartile, and (5) maximum value. While the establishment model provides five values for the composite expert, the CE/ICA was run only for the minimum, maximum, and median values. For the composite expert, the minimum and maximum are averages of the distribution of all the experts, not the minimum and maximum probabilities calculated for the individual experts.

As stated above, modeling the probability of establishment provided (1) a means of differentiating the relative effectiveness of the alternatives formulated to prevent the establishment of Asian carp and *A. lacustre* in the GLB and (2) quantitative inputs for CE/ICA. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as a *fact*. This is especially true given that the values elicited from the experts and, ultimately, the overall probability of establishment were characterized by significant uncertainty. It is not surprising that there is not clear consensus on the prediction of complex events such as the establishment of ANS, which has many sources of uncertainty. Table 6-4 identifies several sources of uncertainty related to the establishment of Asian carp and *A. lacustre*; these include uncertainty related to the success of alternative control measures, future movement patterns, the number of individuals needed for establishment in Lake Michigan, and the suitability of physical and biological conditions in the GLB for establishment and spread. Therefore, the results of the establishment model are better interpreted as measures of the relative effectiveness of the alternative plans when compared to the No New Federal Action Alternative.

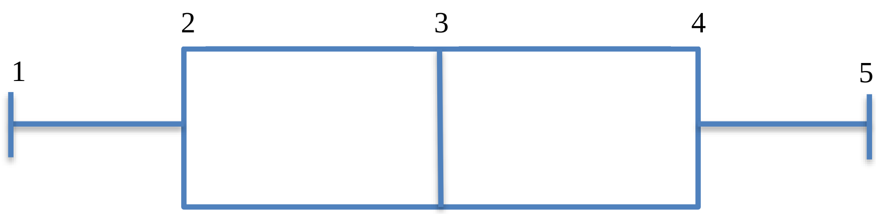

Figure 6-20 Example of Box and Whisker Plot

Table 6-4 Sources of Uncertainty in Estimating the Establishment Elements for Asian Carp and *A. lacustre*

Establishment Element	Asian Carp	Asian Carp
Arrival	• Why does the advance of the Asian carp population front toward Lake Michigan appear to have slowed? • Will water quality improvements facilitate the upstream movement of Asian carp to Dresden Island Pool? • Could several strong-year classes rapidly move the population front to BRLD? • Will the effectiveness of overfishing increase over time, and how will this affect the upstream movement of Asian carp? • Are conditions below BRLD suitable for large Asian carp populations?	• None; *A. lacustre* are documented to have arrived below BRLD.
Passage	• Could Asian carp spawn in the Des Plaines River? • How effective is the electric barrier in stopping small Asian carp? • What is the relative effectiveness of complex noise on Asian carp? • Would Asian carp acclimate to complex noise? • What Asian carp size classes will exist in Dresden Island Pool?	• Has *A. lacustre* already passed into Lake Michigan? • Would *A. lacustre* pass into Lake Michigan before lock closure can occur?
Colonization	• To what extent are tributaries in the GLB suitable for Asian carp spawning? • Would predation on young Asian carp significantly affect establishment in the GLB? • Would Asian carp enter the GLB intermittently or continuously?	• How suitable is habitat in Lake Michigan?
Spread	• What is the spatial extent of suitable Asian carp habitat in the Great Lakes?	• Will boats spread *A. lacustre* throughout the GLB?

6.6.2 Relative Life Safety Risk

This qualitative assessment uses the information gathered on each control and considers the potential life safety impacts each alternative could have on neighboring property uses and waterway users. The alternatives are rated in comparison to each other and are rated as low, moderate, and high life safety risk. The qualitative assessment considers the potential life safety impacts of each alternative on neighboring property uses and waterway users in and along the waterway for mariners, lock staff, and staff required to implement nonstructural measures or operate a technology alternative or Lock Closure control point. The ratings were based on input provided by USACE and input and questions raised by the navigation community and USCG.

Indirect effects associated with alternatives, including potential mode shifts from the waterway to area rails and roadways, are discussed in Chapter 7, Impacts of Alternative Plans. The Chapter 7 analysis discusses the potential impacts on life safety associated with those mode shifts.

6.6.3 System Performance Robustness

System performance robustness has been evaluated as an alternative's ability to accomplish/address the following:

1. *Ability to cycle in nonstructural measures* refers to whether the alternative can cycle in new nonstructural measures;

2. *Ability to cycle in structural measures* refers to whether the alternative can cycle in new structural measures;

3. *Number of structural control points* refers to the number of structural control points within the GLMRIS-BR Upper Illinois Waterway. The system currently has one structural control point, the CSSC-EB. If a new structural control point is added at BRLD, then the system would have two structural control points, thereby providing "defense in depth."

4. *Modes of transport* are the number of ANS modes of transport addressed by the alternatives. The modes of transport are swimming, floating, and/or hitchhiking. For example, if an alternative includes measures that deter swimmers and floaters, then the alternative addresses two modes of transport.

6.6.4 Estimated Alternative Costs

Estimated alternative costs are included as a criterion because the entire cost of an alternative must be assessed when evaluating whether it is cost-effective and incrementally cost-efficient. The costs are all based on the assumption that USACE completes the Chief's Report in January 2019, and the project is authorized in October 2020 and fully funded. All costs were rounded to the nearest hundred thousand for significant digit consistency. The estimated alternative costs include the total construction costs, annual nonstructural measure costs, and OMRR&R costs.

The construction costs include the costs for construction; lands, easements, rights-of-way, relocation, and disposal areas; preconstruction engineering and design; construction management; performance monitoring and adaptive management; and mitigation. OMRR&R costs were estimated based on knowledge of existing systems and estimated staffing requirements to operate the alternatives, and the occasional cost for significant maintenance and equipment replacement or rehabilitation. The nonstructural measure costs are estimated based on current estimates for this work and the assumed level of effort.

6.6.5 Estimated Implementation Schedule

The implementation schedule and estimated construction impacts were used to inform the impacts on navigation and the associated NED costs. The construction schedule outlines the estimated duration to construct each measure and the associated estimated duration the lock would be closed to accommodate construction activities. Estimated closure durations are based upon a conceptual level of design that has been completed at this point in the study.

6.6.6 Impacts on Navigation (NED Costs)

The impacts on navigation are included as an NED cost of the alternatives and were included as project costs in the CE/ICA analysis. The estimated impacts on navigation account for all project phases, to include: construction, and the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of ANS controls. The assumptions utilized for this quantitative evaluation of navigation impacts (NED costs) were developed with life safety as a primary consideration and account for the array of potential impacts that are expected during construction, and OMRR&R. However, the estimated impacts to navigation are subject to uncertainty. As the study continues and more information is obtained about how navigation would accommodate changes at BRLD, the assumptions will be refined.

Impacts to navigation vary for the range of project alternatives. The Sustained Current Activities (No New Action) and Nonstructural alternatives allow navigation to continue without further impacts. For the purpose of the navigation economic analysis, the following four technology alternatives were considered: Technology Alternative – Electric Barrier; Technology Alternative – Complex Noise; and Technology Alternative – Complex Noise with Electric Barrier. The technology alternatives with complex noise and an electric barrier were analyzed separately in order to estimate for the potential range of impacts on navigation given different operating parameters (continuous and intermittent). The technology alternatives do allow navigation to continue through BRLD, but include ANS control measures that impose impacts due to their construction and OMRR&R. The Lock Closure alternative is the only alternative that results in the permanent discontinuation of use of BRLD for navigation.

Estimated Changes to Standard BR Lock Operations Due to Construction, and OMRR&R due to Project Alternatives. Brandon Road Lock is part of the CAWS, and is heavily utilized for commercial cargo navigation. Each plan, aside from the 'No Action/Sustained Current Activities' alternative, includes a combination of nonstructural and/or structural ANS control measures. At this point in the study, only a conceptual level of design has been performed on each measure including basic site layout, quantities, and constructability concerns. Some of these ANS control measures, if implemented, would be expected impact navigation because of one or more of the following:

(1) *Construction of Structural ANS Control Measures* – The construction of ANS control measures for some of the alternatives would require temporary, scheduled lock closures. During these construction periods, the BR Lock would be unavailable. Based on best-available engineering information at the time of the economic analysis, the expected duration and frequency of these construction closures for each ANS control measure is presented in Table 6-5. This information was used to inform the estimates of the impacts to navigation (NED costs).

Table 6-5 Estimated Changes to Standard BR Lock Operations Due to Construction of ANS Controls (Description, Frequency, and Duration)[a, b]

<table>
<tr><th rowspan="3"></th><th colspan="5">Construction Component</th></tr>
<tr><th rowspan="2">Flushing Lock</th><th colspan="2">Engineered Channel & Water Jets</th><th rowspan="2">Speaker Placement for Complex Noise</th><th rowspan="2">Electrode & Parasitic Placement for Electric Barrier</th></tr>
<tr><th>Guide Wall</th><th>Walls & Floor</th></tr>
<tr><td>Estimated Closure Duration</td><td>24 hours</td><td>12 hours (during daylight)</td><td>1 hour</td><td>8 hours</td><td>8 hours</td></tr>
<tr><td>Estimated Frequency</td><td>Daily</td><td>Daily</td><td>6 days/week (open Sundays)</td><td>5 days/week</td><td>5 days/week</td></tr>
<tr><td>Number of Calendar Days Change Would be in Effect</td><td>40 days</td><td>30 days</td><td>800 days</td><td>45 days</td><td>22 days</td></tr>
<tr><th>Alternative</th><th colspan="5"></th></tr>
<tr><td>Sustained Current Activity (No New Action)</td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Nonstructural Alternative</td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Technology Alternative – Electric Barrier</td><td>×</td><td colspan="2">×</td><td></td><td>×</td></tr>
<tr><td>Technology Alternative – Complex Noise</td><td>×</td><td colspan="2">×</td><td>×</td><td></td></tr>
<tr><td>Technology Alternative – Complex Noise with Electric Barrier</td><td>×</td><td colspan="2">×</td><td>×</td><td>×</td></tr>
<tr><td>Lock Closure</td><td></td><td colspan="2"></td><td></td><td></td></tr>
</table>

[a] All changes to standard BR Lock operations were estimated based on the current level of design with the goal of minimizing impacts to navigation. During the PED phase, additional design and a value engineering (VE) study will be conducted with the goal of reducing the duration of construction impacts on navigation. Opportunities to schedule BR Lock construction (and required closures) at same times as other Illinois Waterway (IWRR) Lock schedule operation and maintenance lock (O&M) would be explored to minimize system IWW impacts to navigation.

[b] Construction methods were planned so a 165-foot channel width is always available. This is assumed to allow for navigation to transit without restrictions on tow configurations.

(2) *Modified Lock Operations Due to Nonstructural & Structural ANS Control Measures* – Once constructed, some ANS control measures would require changes to the use of BR Lock (e.g., no cutting of tows in the downstream approach channel; increases in time to transit the lock to accommodate lock flushing). Based on best-available engineering information at the time of the economic analysis, the changes to the standard operation of BR Lock are displayed in Table 6-6. This information was used to inform the estimates of the impacts to navigation (NED costs).

(3) *Maintenance, Repair, Rehabilitation, and/or Replacement of Structural ANS Control Measures* – Once constructed, some ANS control measures would require temporary, scheduled lock closures in order to maintain these features. During these periods, the BR Lock would be unavailable. Based on best-available engineering information at the time of the economic analysis, the expected duration and frequency of these maintenance closures for each ANS control measure is presented in Table 6-7. This information was used to inform the estimates of the impacts to navigation (NED costs).

Table 6-6 Assumed Changes to Standard BR Lock Operations Due to Operation of ANS Controls[a,b,c,d]

	ANS Control Measures	
	Flushing Lock	**Continuous Electric Barrier**
Assumed Changes	▪ Estimated time to flush lock is 15 minutes. ▪ All upbound traffic assumed to be tied off downstream of lock chamber during flushing. ▪ All upbound lockages would require flushing. ▪ For downbound lockages, any consecutive lockages in that direction would be flushed.	▪ New Restricted Navigation Area (RNA) in Downstream Approach Channel of Brandon Road Lock. ▪ Entire tow assumed to be outside RNA in order for someone to be on deck. ▪ Assume no tow reconfigurations or tie-offs permitted in RNA. ▪ Tows transiting RNA assumed be restricted to a maximum length of 550 feet. ▪ All reconfigurations or refleeting assumed to occur at one of the following: (1) new downstream mooring area or (2) location further downstream of BR Lock.
Alternative		
Sustained Current Activity (No New Action)		
Nonstructural Alternative		
Technology Alternative – Electric Barrier	×	×
Technology Alternative – Complex Noise	×	
Technology Alternative – Complex Noise with Electric Barrier	×	×
Lock Closure		

[a] All assumed changes to standard BR Lock operations were based on best-available engineering information at the time of the navigation economic analysis. Based on the best available information, the operation of the following ANS controls are not expected to impact navigation: nonstructural, engineered channel, water jets, complex noise, or operation of the electric dispersal barrier with no vessel traffic immediately downstream of the approach channel, in the approach channel, or in the lock.

[b] Every year, there would be a 1 in 3 chance of a single 5-day closure to accommodate potential ANS emergency response procedures. For No New Action Plan, these closures fall within the emergency response procedures for the exiting EB in Romeoville, Illinois.

[c] The actual operating parameters of the electric barrier and of vessels through this area assuming an electric barrier is operating during vessel transit cannot be established until after construction, operation and testing of the system. Operating assumptions were developed with the intention of being protective of life safety.

[d] During PED, a scaled physical model of the flushing lock would be used to optimize the operating parameters to maximize flushing effectiveness while minimizing navigation impacts.

Table 6-7 Estimated Changes to Standard BR Lock Operations Due to Maintenance, Repair, Rehabilitation, and/or Replacement (MRR&R) of ANS Controls[a,b]

Estimated	MRR&R Activities for ANS Controls
Estimated Closure Duration (to occur 25 years after implementation)	8 hours
Estimated Frequency	5 days/week
Number of Calendar Days Change Would Be in Effect	60 days
Alternative	
Sustained Current Activity (No New Action)	
Nonstructural Alternative	
Technology Alternative – Electric Barrier	×
Technology Alternative – Complex Noise	
Technology Alternative – Complex Noise with Electric Barrier	×
Lock Closure	

[a] Changes to standard BR Lock operations were estimated using best-available engineering information at the time of the navigation economic analysis. The following ANS controls are not expected to require additional MRR&R that would impact navigation: nonstructural, engineered channel, water jets, complex noise, or the flushing lock.
[b] A major rehabilitation of BR Lock is assumed to occur in year 2030, with an estimated closure duration of approximately 30 days. This would occur with or without implementation of a GLMRIS-BR project, and is therefore included in both the with-project and without-project conditions.

Estimated Impact of Project Alternatives on Navigation at BR Lock (NED Costs). Normally, fewer resources are required to move bulk commodities via waterways (waterborne transportation) than on land (i.e., via truck and rail). In these instances, the difference between the costs of moving commodities on land and the cost of moving them on a waterway is called 'transportation cost savings'. The NED benefits of navigation projects are the increases in transportation costs savings (increased efficiency of using the waterway to transport commodities).

However, the navigation economic analysis completed in support of GLMRIS-BR found that several of the alternatives include measures that would *reduce the efficiency* of moving commodities on the waterway, consequently *increasing transportation costs*. Therefore, the GLMRIS-BR project alternatives are expected to result in navigation NED costs rather than NED benefits. In other words, there would be an overall reduction in *transportation cost savings*. Project alternatives that impose greater impacts on navigation are those that yield greater navigation NED costs.

For each project alternative, increases in transportation costs (NED costs) are attributed to one or more of the following: reduced waterway efficiency; shifts from waterway to less efficient modes or routes; and/or shifts to less efficient origin-destination pairs. Each of these impacts on navigation are described below.

> ***Reduced Waterway Efficiency.*** Increases in transportation costs could be incurred if use of the waterway became less efficient (e.g., longer time to transit a lock).
>
> Due to changes in standard BR Lock operations to accommodate construction activities and the OMRR&R of ANS control measures, changes to transit time is anticipated. Transit time (Figure 6-21) is the sum of processing time and delay time. Processing time is the time related to the actual lockage process, which includes the following five components: approach, entry, chambering, exit, and turnback times. Delay time is the time period between when a vessel

Transit Time[a] = Processing Time[b] + Delay Time[c]

[a] Transit time is the sum of processing time and delay time.
[b] Processing time is the time related to the actual lockage process. Processing time accounts for five components: approach, entry, chambering, exit, and turnback times.
[c] Delay time is the time period between when a vessel arrives at the lock and when the lock is ready to being processing that vessel.

Figure 6-21 Transit Time

arrives at the lock and when the lock is ready to begin processing that vessel. Delay can occur because another vessel is utilizing the chamber or the chamber is out of operation.

Shifts from Waterway to Less Efficient Modes/Routes. Increases in transportation costs could be incurred as a result of shifts from the waterway to less efficient modes and routes.

Shifts to Less Efficient Origin-Destination Pairs. Increases in transportation costs could be incurred because of shifts of waterway (and associated overland traffic) to less efficient origin-destination combinations.

Uncertainty. Estimates of delay and total transit times at Brandon Road lock were developed for the Sustained Activities Alternative (future without project condition), and the action alternatives were developed using the Corps' certified navigation economic models (Waterway Investment Model and Navigation Investment Model) with best available economic data (e.g., USACE Waterborne Commerce Statistics Center and Lock Performance Management System); shipper response surveys (completed in support of the GLMRIS Report and GLMRIS-BR); and the best available engineering information about the construction and OMRR&R that would be required for the ANS controls. Uncertainty remains about what the actual processing, delay and total transit times would be if any of the project alternatives were implemented. Additional engineering and economic analysis, safety testing and evaluation, and coordination with navigation stakeholders and the USCG would be completed as the feasibility study continues and during the PED phase to better inform these estimates.

Additional information about the navigation economic analysis can be found in Appendix D, Economics.

6.7 Alternative Plan 1: No New Federal Action

The No New Federal Action Alternative includes the current and future actions of federal, state, and local agencies in combating ANS and serves as a comparison point for the remaining alternatives. Asian carp control and management activities within the Upper IWW and the CAWS are currently carried out by federal and state agencies. The USFWS, USGS, EPA, USACE, and Illinois DNR are funded by GLRI and agency base funds. As a conservative measure, the analysis assumes future Asian carp management activities are reduced from current levels because future actions are subject to the availability of future appropriations and allocation decisions. Activities considered lower priority would likely receive less effort in the future with more effort concentrated on higher priority activities. This alternative also assumes the continued operation of the existing CSSC-EB (Barrier IIA, Barrier IIB, and Permanent Barrier I) as well as associated monitoring and response actions by USACE and others to support CSSC-EB operations. Furthermore, the authorized 9-ft channel project for the IWW and the operation of the BRLD is assumed to continue through the planning period of analysis.

6.7.1 Probability of ANS Establishment

Figures 6-21 and 6-22 show the calculated P(establishment) for the No New Federal Action Alternative based on inputs provided by each expert and calculated P(establishment) for the composite expert. Tables 6-5 and 6-6 include the P(establishment) summary calculated for the composite expert. The figures and tables are grouped by Asian carp and *A. lacustre*. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as "a fact."

Asian Carp

Figure 6-22 shows the diversity in the estimates of P(establishment) of Asian carp by 2071 obtained from the characterizations of uncertainty in the model inputs provided by the six experts. The P(establishment) estimate calculated from expert 1's inputs suggests that Asian carp establishment in the GLB is virtually ensured. In contrast, estimates calculated from the inputs of experts 3, 4, and 5 suggest establishment is highly unlikely. Inputs from experts 2 and 6 lead to estimates between these extremes. The width of each box and whisker plot reveals the extent of the variation in possible values for P(establishment). Expert 2 results show a great deal of variation, while expert 3 and 4 show virtually no variation.

To facilitate discussion of the results and to enable the evaluation of the relative effectiveness of the plans in preventing the establishment of Asian carp, the composite expert distribution was calculated by averaging the CDFs for the six experts. By happenstance, the composite expert distribution most resembles that of expert 6 (Figure 6-22). The uncertainty about the composite expert estimate of the P(establishment) lies between 22% and 36% with a median value of 29% (Table 6-8).

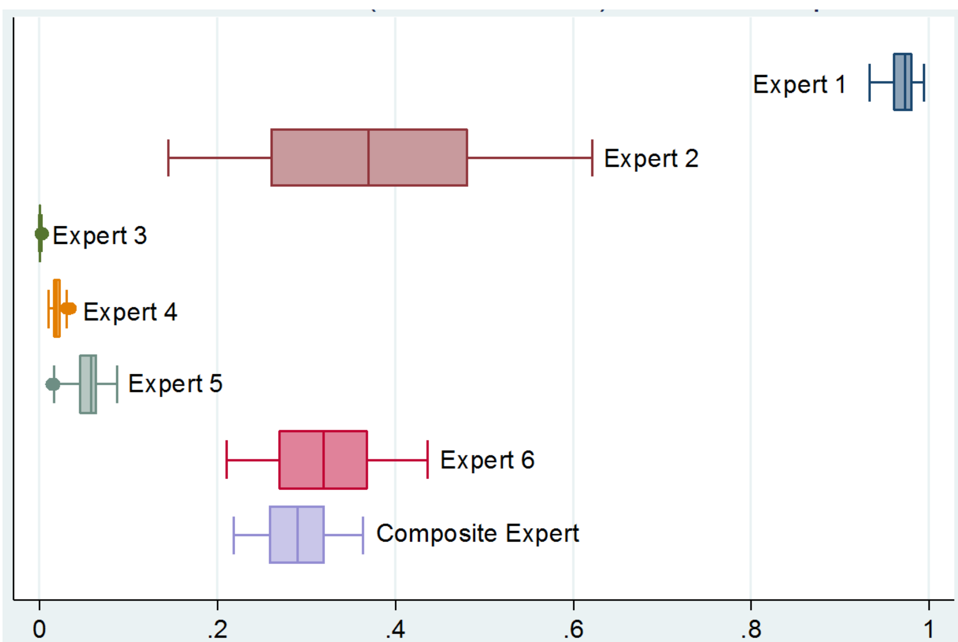

Figure 6-22 Asian Carp P(Establishment) 2071 Values for All Six Experts and the Composite Expert under the No New Federal Action Alternative

Table 6-8 Asian Carp P(Establishment) 2071 Values for the Composite Expert under the No New Federal Action Alternative

Alternative	P(Establishment)		
	Minimum	Median	Maximum
No New Federal Action Alternative	0.22	0.29	0.36

A. lacustre

Figure 6-23 and Table 6-9 show the diversity in the estimates of P(establishment) of *A. lacustre* by 2071 obtained from the characterizations of uncertainty in the model inputs provided by the five experts. The P(establishment) estimates calculated using inputs from expert 1 and expert 3 suggest the greatest probability of establishment, while data from expert 2 indicate a lower P(establishment). The median P(establishment) for experts 4 and 5 is between these two. There is large uncertainty in the P(establishment) values estimated for most of the experts as indicated by the width of the box and whisker plots.

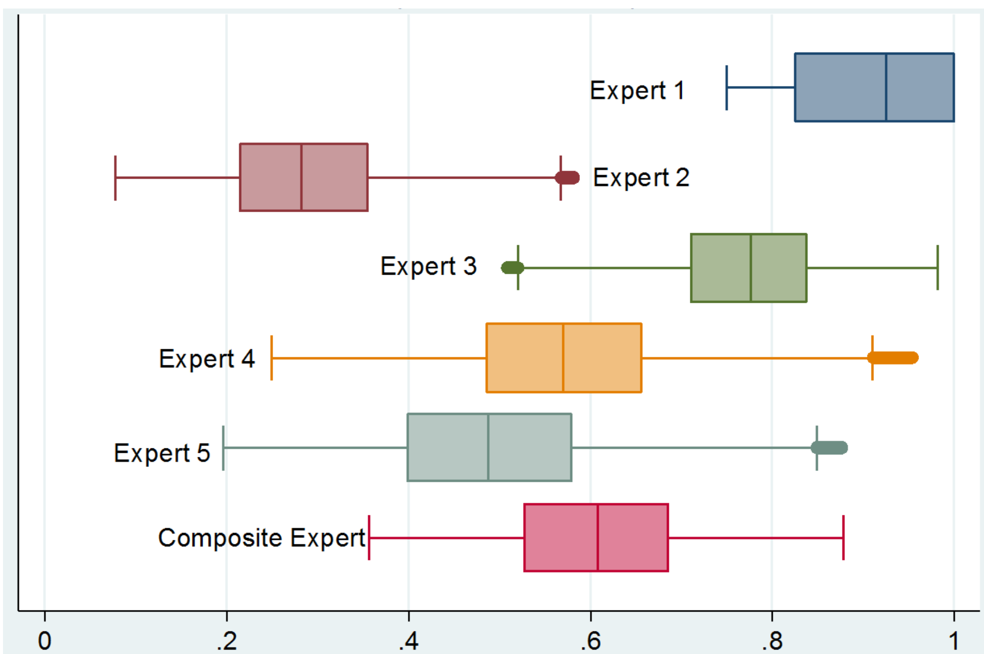

Figure 6-23 *A. lacustre* P(Establishment) 2071 Values for All Five Experts under the No New Federal Action Alternative

Table 6-9 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under the No New Federal Action Alternative

Alternative	P(Establishment)		
	Minimum	Median	Maximum
No New Federal Action Alternative	0.36	0.61	0.88

The composite expert distribution, calculated by averaging the CDFs for the five experts, most resembles that of expert 4. The uncertainty about the composite expert estimate of the P(establishment) lies between 36% and 88% with a median value of 61% (Table 6-9).

In providing their inputs, the experts cited the monitoring data collected in 2005 and 2015 identifying *A. lacustre* in the Dresden Island Pool. Subsequent monitoring in 2015 that located the species in the same location, however, did not find it upstream (Keller 2015). The experts noted that this species is very small, adults being approximately 0.2 in. (6 mm), and that the 2015 survey may not have detected this species. In light of the continued presence in the Dresden Island Pool and the heavily trafficked area between Dresden Island Lock and Lake Michigan, the experts noted that *A. lacustre* is a hitchhiking species, and vessels may transport this species through the navigation channel toward Lake Michigan. All experts believed that it was possible that *A. lacustre* may have already established in the GLB.

6.7.2 Relative Life Safety Risk

Life safety impacts are unchanged from current conditions. The GLMRIS-BR PDT rated the No New Federal Action Alternative as having a low life safety risk in comparison to the other GLMRIS-BR alternatives.

6.7.3 System Performance Robustness

System performance robustness has been evaluated as the No New Federal Action Alternative's robustness to address current and future ANS threats in the waterway:

1. This alternative has the ability to add future or modified nonstructural measures by others in response to changed conditions. New nonstructural measures could be added with existing authorities of various federal and state agencies.

2. This alternative does not include a platform for future structural measures.

3. This alternative dos not include a structural control point, and therefore the waterway would have one structural control point, the CSSC-EB.

4. This alternative targets one ANS transport mechanism, swimmers. Overfishing removes fish from the waterway; however, it does not continuously deter their upstream movement.

6.7.4 Estimated Alternative Costs

These costs are not applicable. The No New Federal Action Alternative does not include the implementation of a project and therefore has no construction, nonstructural, or OMRR&R costs.

6.7.5 Estimated Implementation Schedule

This schedule is not applicable. The No New Federal Action Alternative does not include the implementation of a project.

6.7.6 Costs of Impacts on Navigation

The No New Federal Action Alternative allows navigation to continue without new impacts.

6.8 Alternative Plan 2: Nonstructural Alternative

The Nonstructural Alternative describes nonstructural measures to be implemented by USACE and other federal agencies (Table 6-10).

6.8.1 Alternative Plan Description

Several nonstructural measures would be implemented to address the upstream dispersal of Asian carp and *A. lacustre* from the MRB, through the CAWS, and into the GLB. ANS controls would include those efforts identified within the annual ACRCC Asian Carp Action Plan that fall within the bounds of the overarching nonstructural categories: Education and Outreach, Monitoring, Integrated Pest Management, Piscicides, Manual or Mechanical Removal, and R&D. These measures would be undertaken by USACE and other federal agencies. Categories of nonstructural measures are described in Table 6-2, Categories of Nonstructural Measures for Asian Carp and *A. lacustre.*

The majority of the nonstructural measures require no engineering or construction. In order to facilitate effective monitoring and emergency response in the area of Brandon Road, however, two boat launches are proposed near the Lock in the Brandon Road and Dresden Island Pools (Figure 6-24) upstream and downstream of the lock.

Table 6-10 Measures in the Nonstructural Alternative

Location	Measure	Controlled Modes of ANS Transport
Brandon Road Lock and Approach Channel	Boat launches	Supporting measure
GLMRIS-BR IWW Study Area	Nonstructural	Swimmers

Figure 6-24 Boat Launch Locations for the Nonstructural Alternatives

The total assumed level of effort for these nonstructural activities would be similar to those currently underway as part of the MRWG annual MRP except for the following additions. Commercial fishing coordinated through the Illinois DNR (e.g., Manual or Mechanical Removal Category) would be increased within the Dresden Island, Marseilles, and Starved Rock Pools. The modification of the commercial fishing activity is described below. Annual monitoring for *A. lacustre*, continued development of eDNA markers for future ANS, and additional funds for integrated pest management coordination would be included. On a yearly basis, the details regarding the measures and level of effort will vary based on conditions in the waterway and active risk management of the system.

Public Education and Outreach

An informed and knowledgeable public is critical to address ANS and prevent their unintended transfer from the MRB to the GLB. As the public gains a greater understanding of the reasons why it is necessary and important to prevent ANS transfer, greater support from the public for ANS prevention programs can be expected. In addition, greater compliance with ANS prevention programs can be expected as well, as the public becomes more aware of personal responsibilities and how individual actions can be taken to prevent ANS transfer from one basin to another. Activities that are public education and outreach include but are not limited to the following: continued operation of the Asian carp website (www.asiancarp.us), development of information videos regarding ANS and their control, brochures or fact sheets for general public and specific audiences on ANS, educational programs for school-age children, signage to increase public awareness of the presence of ANS, and event participation with educational displays at trade shows and community festivals. The Illinois DNR, NOAA, USACE, and USFWS have a number of programs and experience in public education and outreach.

Monitoring

Monitoring for MRB ANS within the upper IWW, CAWS, and Lake Michigan is crucial for identifying a species' current distribution and abundance, habitats they prefer and where they may be aggregating, movements within the waterways, and effects on native species where they are currently established. Monitoring also ensures that there is sufficient data by which to inform potential future response actions according to the ACRCC's Upper Illinois Waterway Contingency Response Plan (MRWG 2016). Past monitoring data are used to inform development of current annual monitoring and response plans to ensure that the activities being carried out and the level of effort being expended continue to contribute to the overall goal of preventing transfer of MRB ANS into the GLB. Monitoring activities include but are not limited to the following: monitoring for ANS within the upper IWW, CAWS, and Lake Michigan using a variety of active and passive techniques to collect information for use in decision-making on future ANS management and control activities. The ACRCC member agencies have routinely collaborated in planning and executing these activities within the upper IWW, CAWS, and Lake Michigan since 2010. For a discussion of current monitoring activities, refer to Section 2.4.2, Aquatic Invasive Species Management. Future collaboration with ACRCC member agencies is needed to ensure full implementation of this measure under the Nonstructural Alternative.

Integrated Pest Management

Integrated pest management is a broad-based approach that integrates control practices on all life stages of a targeted ANS to minimize the adverse impacts on the ecosystem. These can include biological control, habitat manipulation, modification of cultural practices, and public education and outreach. The implementation of traditional ANS control techniques as well as the implementation of new technologies and methods will aid in the control of MRB ANS within the upper IWW and reduce the risk of passage to the GLB.

Activities that fall within this category include but are not limited to the following: use of multiple sampling gears and techniques to control MRB ANS populations downstream of BRLD, and the application of novel monitoring, removal, and deterrent measures that focus on the various life stages of ANS. In addition, the ACRCC Upper Illinois Contingency Response Plan (MRWG 2016) and the USACE Asian Carp Emergency Response Protocols and Standard Operating Procedures are examples of integrated pest management plans that describe specific action by members in the event a change is detected in the status of Asian carp. Refer to Section 4.9.1, Current Efforts, for additional details on these plans. Member agencies of the ACRCC have experience in the development of new gear and controls for ANS. Future collaboration with ACRCC member agencies is needed to ensure full implementation of this measure under the Nonstructural Alternative.

Piscicides

Piscicides have been applied twice within the CAWS in response to the potential presence of Asian carp. In December 2009, a fish piscicide (i.e., rotenone) was applied in lower Lockport Pool, from the CSSC-EB downstream to Lockport LD (Figure 6-25). The application occurred during annual barrier maintenance and was prompted by the late summer detection of Asian carp eDNA near the barrier system as well as the concern that CSSC-EB Permanent Barrier I (which remained active) may not have been effective in deterring juvenile fish. During the event, a single Bighead Carp was recovered.

In May 2010, a rotenone response action was completed on a section of the Little Calumet River immediately downstream of the T.J. O'Brien Lock and Control Works (Illinois DNR 2010). The treatment area extended from T.J. O'Brien Lock and Control Works downstream to the Beaubien Woods Forest Preserve boat launch (Figure 6-25). The response action was spurred by multiple positive detections of Asian carp eDNA in the waterway. No Asian carp were recovered during the response action.

Piscicide is an effective short-term and nonselective ANS control tool. Its use requires careful consideration of the habitat, effect on nontarget species, season, movement outside the treatment area, and size of the treatment area. Other factors include the location of the treatment area in relation to populated areas, commercial industries, infrastructure, utilities, and municipalities. Interference with existing water uses and risk to human health must be factored into every decision. The 2016 ACRCC Contingency Response Plan states the following in regard to piscicide use:

> *"This control action occurred at a time when Asian carp abundance and risk of a [CSSC] barrier breech was less understood. This IDNR remains the sole legal authority to apply piscicide in its waters and has previously made decisions to do so with close consultation of many local, state, and federal partners. Illinois retains the authority, ability, and responsibility to facilitate similar actions and has already determined that this tool is not appropriate for a majority of the rivers, locations, or scopes included in the plan. While not listed as tools in this Contingency Response Plan for the MRWG to consider, the IDNR reserves the right to authorize the use of piscicide in the CSSC […] when it determines the need is prudent. These technologies may be considered if convincing evidence is provided that suggests effective Asian carp control may be obtained."*

Piscicide application was retained as a nonstructural measure in this alternative; however, its use would be left to the discretion of the Illinois DNR. According to Illinois Administration Rule 890, the possession and application of piscicides is limited to an Illinois DNR Division of Fisheries Biologist. Collaboration with the Illinois DNR would be needed to implement this measure under the Nonstructural Alternative.

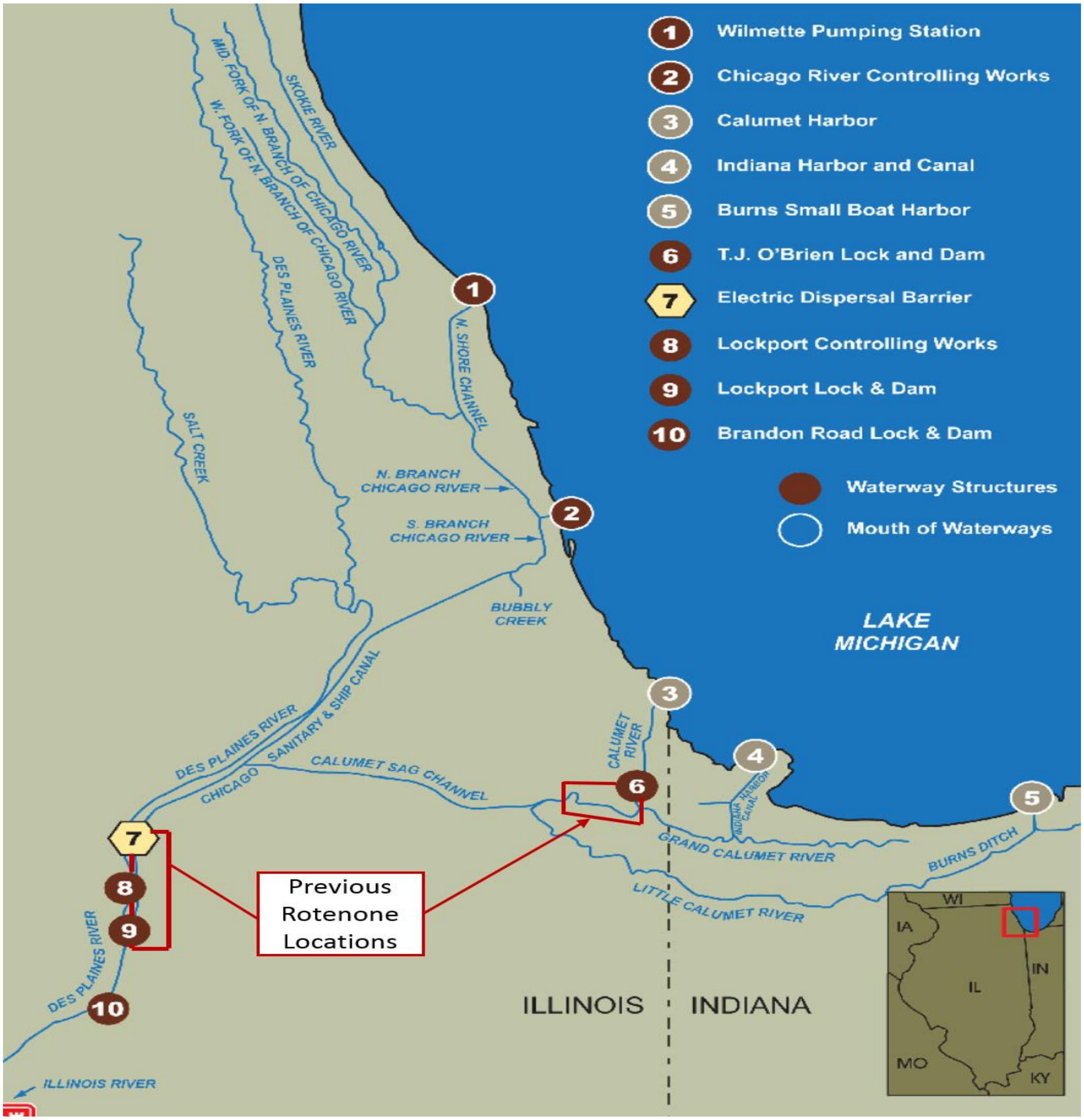

Figure 6-25 Locations of Previous Rotenone Applications within the CAWS

Manual or Mechanical Removal

Contracted commercial fishing within the upper IWW and the lower Des Plaines River, downstream of the CSSC-EB, has been occurring since 2010. Currently, five or six contracted fishing crews use various nets (e.g., gill, trammel, modified hoop nets) and seines to remove Asian carp from the Dresden Island, Marseilles, and Starved Rock Pools.

An Asian carp abundance model suggested that 70% exploitation of Asian carp across all size classes is needed to reduce populations to the point of collapse (Tsehaye et al. 2013). According to the 2016 ACRCC MRP, commercial harvest rates have not been able to reach the 70% target across all size classes. The factors influencing the inability to reach 70% exploitation in commercial operations are not specified. The Nonstructural Alternative would target doubling the current MRWG effort with the goal of increasing exploitation to the 70% target in the upper IWW. Recurring large Asian carp year classes have been observed on a 3-yr cycle in the IWW possibly due to ideal spawning conditions. The Nonstructural Alternative would aim to triple fishing effort when monitoring indicates that thresholds in abundance have been crossed to defend against these cyclical increases.

Southern Illinois University and the Illinois DNR are developing a new model, with support from other agencies, that will determine where to target overfishing and how many fish to remove. It will incorporate inter-reach movement probabilities and can predict the number of Asian carp that would reach the electric dispersal barrier under various harvest scenarios. The MRWG plans to use this model to guide contracted commercial fishing effort in the Dresden Island, Marseilles, and Starved Rock Pools in 2017. If successful, this would be used to adjust effort, refine models, and establish target harvest rates in the Dresden Island, Marseilles, and Starved Rock Pools. Gear selection would be chosen to maximize capture of all size classes of Asian carp. Commercial fishermen currently use large mesh gill and trammel nets to catch adult Asian carp and reduce by-catch of native species. The Nonstructural Alternative would target multiple life stages by adding specialized gear to target small Asian carp. The frequency and level of fishing effort would change by season to maximize harvest and capitalize on localized opportunities, such as spawning and winter aggregations of fish. Experimental gill nets with varying mesh sizes, paupier nets, and other new or emerging harvest technologies could be added to the gear currently being used to improve the capture of smaller Asian carp. Specific fishing locations and methods would be chosen with the best available information from commercial fishermen, Illinois DNR biologists, and ongoing research and monitoring activities.

The Illinois DNR requires commercial fishermen to have a commercial fishing license as well as a sport fishing license to harvest fish within waters of the state (515 ILCS5/Art. 15). In addition, commercial fishing is permitted only downstream of the Route 89 Highway Bridge (i.e., located in Peoria Pool) in the Illinois River (Illinois Administrative Rule: Part 830 Commercial Fishing and Musseling in certain waters of the state; Section 830.10[b] Waters open to commercial harvest of fish, Ill. Admin Code, title 17, §830.10[b]); fishing upstream of this location requires the presence of an Illinois DNR biologist. Therefore, collaboration with Illinois DNR would be needed to implement this measure under the Nonstructural Alternative.

Research and Development

R&D of new and emerging technologies to control MRB ANS is crucial since they may demonstrate the potential to provide additional prevention and control opportunities, exploit known life-history vulnerabilities and behavioral characteristics, and address weaknesses in current technologies that are in use on the waterway. Activities under this category would primarily focus on, but not be limited to, CSSC-EB efficacy, novel gear development, increased efficiency of contracted commercial fishing, detection of new ANS, and effects of new ANS on the ecosystem. USACE, USFWS, and USGS all have experience in the development of new gear and controls for ANS. Collaboration with ACRCC member agencies would be needed to implement this measure under the Nonstructural Alternative.

6.8.2 Probability of ANS Establishment

Figures 6-26 and 6-27 show the calculated P(establishment) for Asian carp and *A. lacustre*, respectively, under the Nonstructural Alternative based on inputs provided by each expert. Tables 6-11 and 6-12 show the calculated P(establishment) summary for Asian carp and *A. lacustre*, respectively, for the composite expert under the Nonstructural Alternative. This alternative was found to lower the P(establishment) values for Asian carp when compared to the No New Federal Action Alternative. This alternative does not include a measure specifically designed to address hitchhiking ANS, nor does it halt navigation. Consequently, the experts believed this alternative would have minimal impacts on the *A. lacustre* P(establishment) estimate when compared to the P(establishment) estimated for the No New Federal Action Alternative. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as “a fact.”

Asian Carp

The P(establishment) estimates calculated from the inputs of experts 3, 4, and 5 suggest establishment in the GLB is highly unlikely under the Nonstructural Alternative (Figure 6-26). P(establishment) for experts 3, 4, and 5 show little variation as indicated by the width of the box and whisker plots. The P(establishment) estimate is highest using inputs from expert 1. The inputs from experts 2 and 6 lead to P(establishment) estimates between these extremes but closer to the lower probability estimates.

The composite expert distribution was calculated by averaging the CDFs for the six experts. The uncertainty about the composite expert estimate of the P(establishment) lies between 15% and 26% with a median value of 20% (Table 6-11).

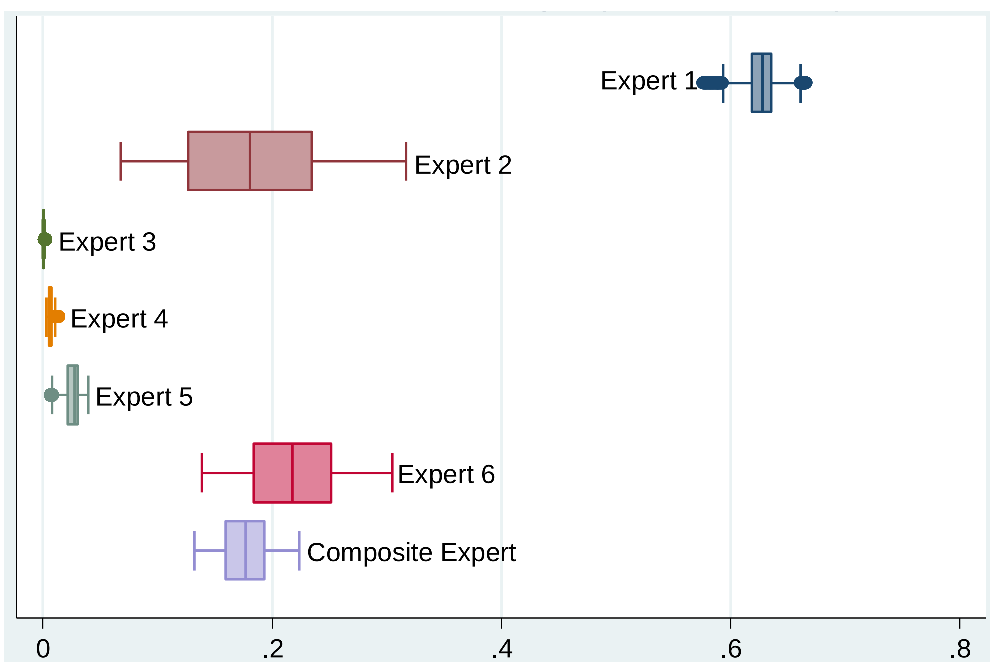

Figure 6-26 Asian Carp P(Establishment) 2071 Values for All Six Experts and the Composite Expert under the Nonstructural Alternative

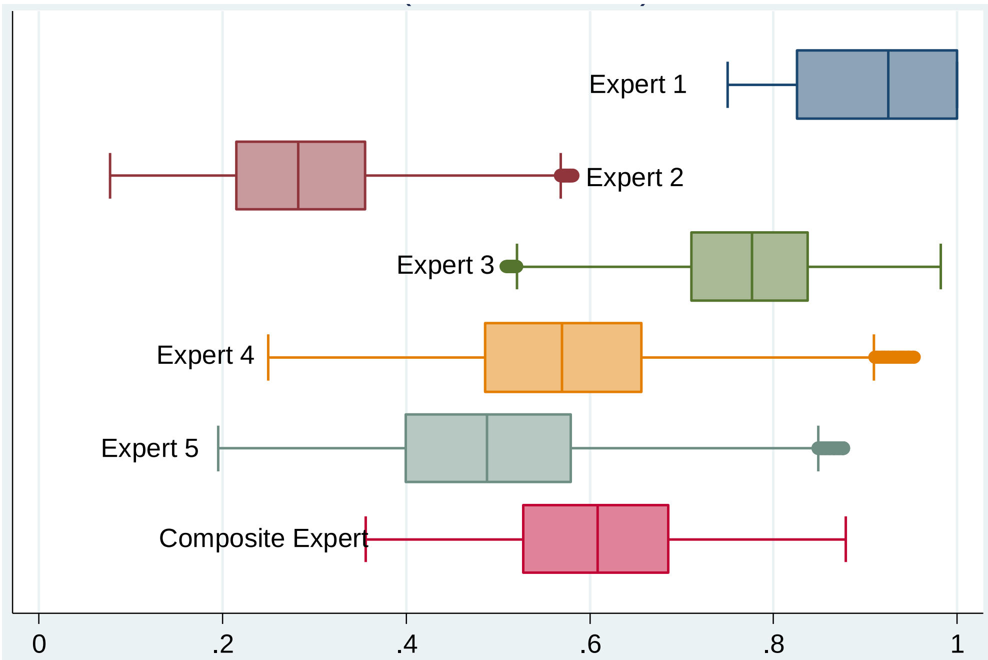

Figure 6-27 *A. lacustre* P(Establishment) 2071 Values for All Five Experts and the Composite Expert under the Nonstructural Alternative

Table 6-11 Asian Carp P(Establishment) 2071 Values for the Composite Expert under the Nonstructural Alternative

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Nonstructural Alternative	0.15	0.2	0.26

Table 6-12 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under the Nonstructural Alternative

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Nonstructural Alternative	0.36	0.61	0.88

A. lacustre

Figure 6-27 shows the diversity in the estimates of P(establishment) of *A. lacustre* by 2071 obtained from the characterizations of uncertainty in the model inputs provided by the five experts. The calculated P(establishment) obtained using inputs from expert 1 and expert 3 suggests the greatest probability of establishment, while data from expert 2 indicate a lower P(establishment). There is large uncertainty in the P(establishment) values as indicated by the width of the box and whisker plots.

The composite expert distribution, calculated by averaging the CDFs for the five experts, most resembles that of expert 4. The uncertainty about the composite expert estimate of the P(establishment) lies between 36% and 88% with a median value of 61% (Table 6-12).

6.8.3 Relative Life Safety Risk

The current activities related to nonstructural measures in the upper IWW and CAWS are the same as those included in the Nonstructural Alternative. The Nonstructural Alternative, however, increases the overfishing from current levels, thereby increasing the time fishermen are on the water. The Nonstructural Alternative was rated as having a low life safety risk in comparison to the other GLMRIS-BR alternatives.

6.8.4 System Performance Robustness

System performance robustness has been evaluated as the robustness of the Nonstructural Alternative to address current and future ANS threats in the waterway:

1. This alternative has the ability to add future or modified nonstructural measures in response to changed conditions.

2. This alternative does not include a platform for future structural measures.

3. This alternative does not include a structural control point. The waterway would continue to have only one structural control point, the CSSC-EB.

4. This alternative targets one ANS transport mechanism, swimmers. Overfishing removes fish from the waterway; however, it does not continuously deter their upstream movement.

6.8.5 Estimated Alternative Costs

The Nonstructural Alternative includes construction costs for the two boat launches, which are estimated to be $600,000. The nonstructural measure component of this alternative is estimated to be $11,400,000/yr. The yearly OMRR&R costs are estimated to be $20,000. See Table 6-13.

6.8.6 Estimated Alternative Implementation Duration

The Nonstructural Alternative could be implemented late calendar year 2020, assuming authorization is received early in fiscal year 2021 and capability funding is received for planning the activities for the Nonstructural Alternative.

Table 6-13 Estimated Cost of Nonstructural Alternative

Element	Estimated Cost
Construction[a]	$600,000
Nonstructural[b]	$11,500,000
OMRR&R[b]	$20,000

[a] Costs are provided as total cost, present value (project first costs).
[b] Costs are provided as average annual costs.

6.8.7 Impacts on Navigation (NED Costs)

The Nonstructural Alternative allows navigation to continue without new impacts. Based on the best available information, the operation of the nonstructural ANS controls are not expected to negatively impact navigation. Navigation NED costs are not expected not be incurred.

Additional information about the Nonstructural Alternative can be found in Appendix D, Economics.

6.9 Alternative Plan 3: Technology Alternative – Electric Barrier

6.9.1 Alternative Plan Description

The Technology Alternative – Electric Barrier includes the following measures: (1) nonstructural measures, (2) electric dispersal barrier, (3) engineered channel, (4) water jets, (5) flushing lock, (6) boat launches, and (7) mooring areas (Table 6-14 and Figure 6-28).

The Technology Alternative – Electric Barrier includes nonstructural measures and establishes a structural control point below the Brandon Road Lock. Nonstructural measures, in part, include overfishing to be designed to minimize the population of Asian carp and future ANS below the BRLD.

The electric barrier would be placed at the downstream end of the approach to the engineered channel. The electric barrier is this alternative's swimmer control. For the purposes of evaluating this alternative, the electric barrier is assumed to operate continuously to provide a continuously operating swimmer control. The operational parameters of the electric barrier have an impact on the alternatives' effectiveness, life safety, and navigation, which are described in the following evaluation.

The engineered channel would be designed with insulation to minimize stray current from the electric barrier and increase the likelihood of fish detection using sonar and hydroacoustic monitoring gears; to reduce the potential shielding from electric current and other ANS control effects; and to simplify clearing of fish within the channel (e.g., piscicide application, and netting). The engineered channel also would provide a platform to evaluate future ANS controls and potentially incorporate them.

Table 6-14 Measures in the Technology Alternative – Electric Barrier

Location	Measure	Controlled Modes of ANS Transport
GLMRIS-BR IWW Study Area	Nonstructural	Swimmers
Brandon Road Lock and Approach Channel	Electric barrier	Swimmers
	Engineered channel	Integral to nonstructural swimmer and floater ANS controls
	Water jets	Floaters, small and stunned swimmers
	Flushing lock	Floaters
	Boat launches	Supporting measure
Approximately 2 mi (3.2 km) downstream of BRLD	Mooring area	Supporting measure

Figure 6-28 Aerial View of BRLD with Technology Alternative – Electric Barrier

The water jets for the fish and floater entrainment and possibly vessel-induced currents are positioned immediately downstream and upstream of the electric barrier to remove entrained fish and floaters. The conceptual design includes a water jet array immediately upstream of the electric barrier. The water jets system immediately upstream of the electric barrier provides redundancy in case fish and floaters remain entrained after the first jet array.

The flushing lock addresses floating life stages of ANS in the lower pool from transferring to the upper pool by flushing them out of the lock when the lower pool miter gates are opened to allow entry of an upbound tow. Vessels approaching the lock would stage themselves on the right descending bank during lock flushing and proceed into the lock after the flush was completed.

The alternative would include boat launches upstream and downstream of the lock to reduce reaction time and increase the efficiency of the crews implementing nonstructural measures around BRLD. The boat ramps would also be used to facilitate OMRR&R and responses to safety incidents around BRLD.

After construction, the project would have to undergo an evaluation and, potentially, a USCG-regulated navigation area rulemaking process prior to full operation. The mooring area provides a reconfiguration area that is closer than the currently available fleeting area, if operators need to reconfigure their barges to meet navigation restrictions due to the presence of an electric barrier in the engineered channel.
For additional information regarding these measures, please refer to Section 6.3, Measures for Alternative Formulation. Additional study and field evaluations are needed to further refine this alternative.

The assumptions utilized for this quantitative evaluation of navigation impacts (NED costs) were developed with life safety as a primary consideration and accounted for the array of potential impacts that are expected during construction and OMRR&R. However, the estimated impacts on navigation are subject to uncertainty. As the study continues and more information is obtained about how navigation would accommodate changes at BRLD, the assumptions will be refined.

6.9.2 Probability of ANS Establishment

The Technology Alternative – Electric Barrier assumes the electric barrier at BRLD operates continuously. Figures 6-29 and 6-30 show the calculated P(establishment) for the Asian carp and *A. lacustre*, respectively, based on inputs provided by each expert. Tables 6-15 and 6-16 show the P(establishment) summary for Asian carp and *A. lacustre*, respectively, calculated for the composite expert. The experts believed this alternative would be effective against swimmers, and therefore, the P(establishment) estimates for Asian carp were reduced when compared to the No New Federal Action Alternative. This alternative does not include a measure specifically designed to address hull-fouling ANS, nor does it halt navigation. Consequently, this alternative would have minimal impacts on the *A. lacustre* P(establishment) estimate when compared to the P(establishment) estimate for the No New Federal Action Alternative. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as "a fact."

Asian Carp

The P(establishment) estimates calculated from the inputs of five of the six experts, suggest establishment in the GLB is unlikely or highly unlikely under the Technology Alternative – Electric Barrier (see Figure 6-29).

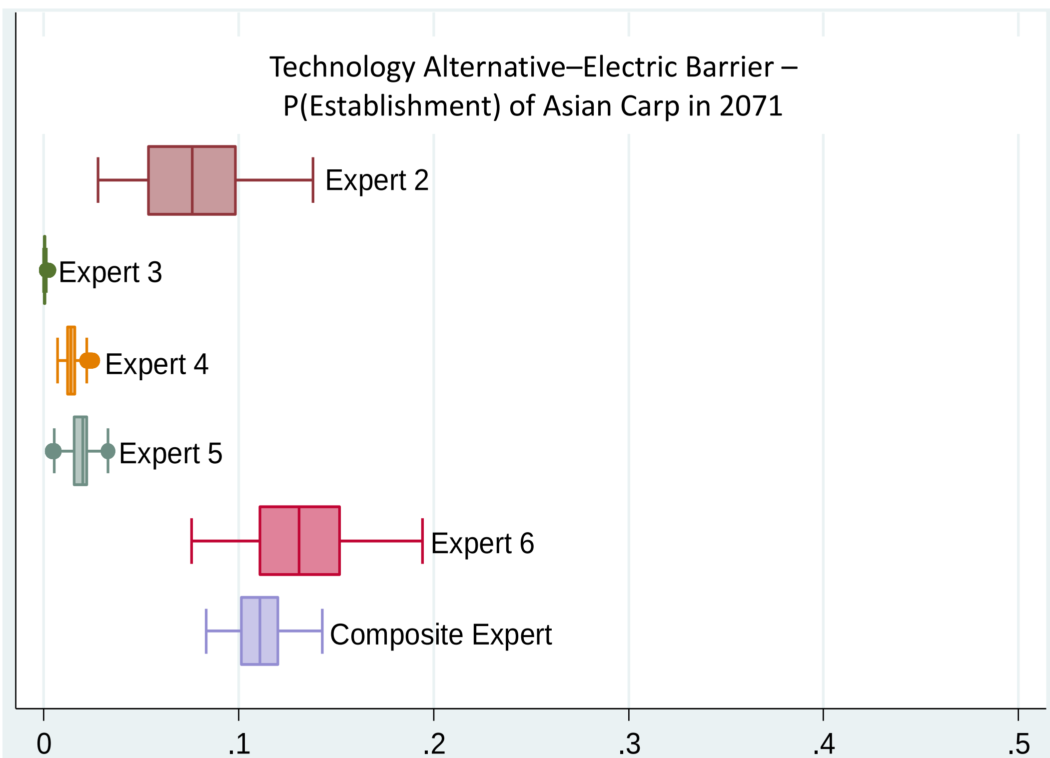

Figure 6-29 Asian Carp P(Establishment) 2071 Values for All Six Experts and the Composite Expert under Technology Alternative – Electric Barrier (operation assumption: electric barrier operates continuously)

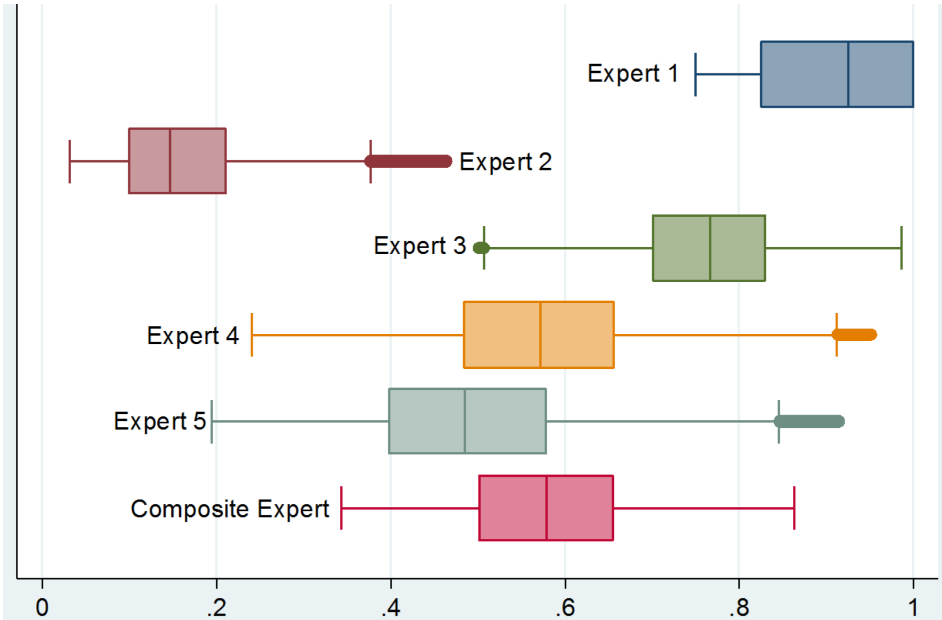

Figure 6-30 *A. lacustre* P(Establishment) 2071 Values for All Five Experts and the Composite Expert under the Technology Alternative – Electric Barrier (operation assumption: electric barrier operates continuously)

Table 6-15 Asian Carp P(Establishment) 2071 Values for the Composite Expert under the Technology Alternative – Electric Barrier

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Electric Barrier	0.08	0.11	0.14

Table 6-16 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under the Technology Alternative – Electric Barrier

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Electric Barrier	0.34	0.58	0.86

The lowest P(establishment) estimate was calculated using inputs from experts 3 and 4, and the highest P(establishment) was obtained using inputs from expert 1. The inputs of experts 2 and 6 lead to estimates between these extremes, but closer to the lower probability. P(establishment) for experts 3 and 4 shows little variation.

The composite expert distribution, calculated by averaging the CDFs for the six experts, most resembles that of expert 6. The uncertainty about the composite expert estimate of the P(establishment) lies between 8% and 14% with a median value of 11% (Table 6-15).

A. lacustre

P(establishment) was calculated using inputs from expert 1 and expert 3 suggests the greatest probability of establishment, while data from expert 2 indicate a lower P(establishment) (Figure 6-30). The median P(establishment) for experts 4 and 5 is between these two. There is large uncertainty in the P(establishment) values as indicated by the width of the box and whisker plots.

The composite expert distribution, calculated by averaging the CDFs for the six experts, most resembles that of expert 4. The uncertainty about the composite expert estimate of the P(establishment) lies between 34% and 86% with a median value of 58% (Table 6-16).

6.9.3 Relative Life Safety Risk

Nonstructural measures, engineered channel, water jets, flushing lock and boat launches were evaluated for the relative life safety risk posed during construction and OMRR&R to the other alternatives. As for the construction of the engineered channel, water jets, flushing lock and boat launches, equipment will be in the water while navigation continues in the channel and on the land surrounding the lock. This may increase the potential for life safety risks to personnel and waterway users when compared with the Nonstructural or No New Federal Action alternatives, which require minimal construction (e.g., boat launches) or no construction.

The operation of nonstructural measures, engineered channel, water jets, flushing lock and boat launches was evaluated. This alternative includes the implementation of nonstructural measures similar to the current level of effort in the upper IWW and CAWS, but also includes increased overfishing. Increased overfishing could translate to increased time fishermen are on the water or increased number of fishermen on the water. With additional personnel on the waterway and/or operating on the waterway more frequently, there is an increased likelihood of accidents (e.g., vessel collision, exposure of personnel to hazardous weather) which in turn could increase the relative life safety risk of personnel and waterway users.

The construction of two boat launches is also a nonstructural measure and provides opportunities for prompter emergency response in the Dresden and Brandon Road Pools, which would be a benefit for relative life safety of personnel and waterway users within the vicinity of BRLD. The use of the engineered channel is not assumed to impact life safety of personnel or waterway users. In regards to the operation of the water jets, during a physical model study, researchers reported the model vessel operator could feel the water jets on the tug and barges; however, the jets did not interfere with the transit of the vessel through the model channel. Overall, operation of the water jets is not expected to increase the relative life safety risk of lock personnel or waterway users.

The operation of the flushing lock is not expected to increase the relative life safety risk of lock personnel or waterway users. To evaluate, in-field measurements immediately downstream of Brandon Lock during typical lock emptying conditions were collected and measured discharges varying from 1,580 to 7,820 cfs

(44.7–221.4 cms) over 17 minutes (USGS 2017). The modeled discharge exiting the lock chamber during the operation of the flushing lock is expected to be approximately 2,600 cfs (73.6 cms). Therefore, the flow exiting the lock during a lock flush will be less than the flow exiting the lock during a standard lock empty. During flushing, it is assumed vessels will be staged along the right descending bank while the lock is flushed. Depending waterway traffic, vessels may stage themselves downstream of the lock during a lock empty. Overall, the operation of the flushing lock is assumed to have no impact on the vessels.

Operation of the BR electric dispersal barrier would produce an elevated electric field in the surrounding water, with field strength generally increasing closer to the electrodes. Additionally, based on lessons learned at the CSSC-EB, operation of the BR electric barrier could produce stray current in adjacent objects and lands. The electric field in the water and stray current on land produces the following life safety risks for personnel and waterway users:

- In a man-overboard situation, if a person falls within the stronger strength of the elevated electric field, the person may suffer ventricular fibrillation and risk death. If a person falls within the lower strength of the elevated electric field, involuntary muscular contraction could occur. With involuntary muscular contraction, a person is unable to grab or hold onto throwable personal floatation devices (e.g., ring life buoys, buoyant cushions, etc.) or other aids. In addition, people on vessels or dry land are at risk of electric shock if they reach into the water and pull the person overboard to safety.

- Stray current on land and structures also poses a safety risk. Metal surfaces may present a shock hazard to people on land surrounding the electric barrier and on vessels. The electric barrier would be built within an insulated engineered channel designed to minimize stray current escaping the area around the electrodes.

- Vessels traveling over the electric field may create a spark hazard. USCG has required vessels traveling over the CSSC-EB to be bound with wire rope to reduce the likelihood of sparking. See Section 7.8.4, Cumulative Effects on Economic, Social, and Aesthetic Values for other navigational, environmental and operational restrictions on all vessels transiting the CSSC near the CSSC-EB.

- Persons operating recreational vessels 20 ft (6.1 m) or less and personal watercrafts may be at greater risk for receiving electric shock.

If an electric barrier is implemented below the BRLD, it is anticipated USACE in coordination with USCG would conduct an evaluation to address site-specific operating considerations that cannot be addressed until after construction. In coordination with USCG, a risk assessment would evaluate how the waterway is used around BRLD. The data gathered during the testing and risk assessment would inform USACE and USCG with regard to necessary safety precautions. The USCG may create a regulated navigation area for the electric barrier. If safety precautions or changed conditions result in the cutting and reconfiguration of barges required due to this alternative, then there is an added potential for a man overboard situation. Based on these life safety considerations, the Technology Alternative – Electric Barrier was rated as having a high life safety risk in comparison to the other GLMRIS-BR alternatives.

Indirect effects associated with this alternative, including potential mode shifts from the waterway to area rails and roadways, are discussed in Chapter 7, Impacts of Alternative Plans. The indirect effects analysis discusses the potential impacts on life safety associated with those mode shifts.

6.9.4 System Performance Robustness

System performance robustness has been evaluated as the robustness of the Technology Alternative – Electric Barrier to address current and future ANS threats in the waterway:

1. This alternative has the ability to add future or modified nonstructural measures in response to changed conditions.

2. This alternative includes an engineered channel and therefore includes a platform for the testing and possible addition of future structural measures.

3. This alternative includes two structural control points within the GLMRIS-BR Illinois Waterway Study Area: the proposed one at BRLD and the current one at CSSC-EB.

4. This alternative controls ANS having two modes of transport: swimming and floating. The alternative's electric barrier targets swimming modes of transport, while the water jets and flushing lock target floating modes of transport. Therefore, within the control point at the BRLD, under the Technology Alternative – Electric Barrier, two measures would address floating transport, while one measure would address swimming transport.

6.9.5 Estimated Alternative Costs

The Technology Alternative – Electric Barrier includes construction costs estimated at $266,800,000. The nonstructural measure costs are estimated to be $11,300,000, slightly lower than those estimated for the Nonstructural Alternative because the overfishing component is assumed to be slightly lower in light of installing a control point at Brandon Road Lock. OMRR&R costs are estimated to equal $7,800,000 (see Table 6-17).

The electric barrier design is based on the CSSC-EB Permanent Barrier I; therefore, the operation and maintenance costs, including electricity costs, spare parts, and other incidentals, would be comparable to known values from the Romeoville CSSC-EB. Estimated additional costs based on Permanent Barrier I include replacing electrodes over a 25-yr span and electrical equipment upgrades every 10 yr.

Absent an existing project for comparison, OMRR&R costs for water jets were estimated as a percentage of the installation costs. Yearly cost was assumed to cover normal maintenance and repairs, along with the cost to run the pumps. Replacement of the pumps is estimated to occur every 15 yr.

Table 6-17 Estimated Costs of Technology Alternative – Electric Barrier

Element	Estimated Cost
Construction[a]	$266,800,000
Nonstructural[b]	$11,300,000
OMRR&R[b]	$7,800,000

[a] Costs are provided as total cost, present value (project first costs).
[b] Costs are provided as average annual costs.

OMRR&R costs of the flushing lock were estimated as a percentage of the installation costs, and it was assumed the mooring area would require dredging, estimated to occur after a 25-yr period. OMRR&R costs for the engineered channel are assumed to be negligible for this estimating purpose.

The estimated additional cost of labor is based on the staffing requirements of the CSSC-EB and eight full-time-equivalent (FTE) employees, including: five operators, one electrician, one mechanic, and one supervisor. The existing lock staff and electric barrier staff will cover any issues that arise from the flushing lock, water jets, or engineered channel. For more information, refer to Appendix H, Engineering.

6.9.6 Estimated Alternative Implementation Duration

The nonstructural measure component of the Technology Alternative – Electric Barrier could be implemented toward the end of calendar year 2020, assuming authorization for construction is received early in fiscal year 2021 and capability funding is received for the planning, design, and construction of the alternative. Construction of the technology components is expected to be completed in calendar year 2025 (Figure 6-31) pending an authorization in 2020 and capability funding for planning, engineering, and design.

Figure 6-30 contains a timeline for construction of the various measures associated with this alternative. The timeline also includes closures for the lock, which vary from a 40-day closure at the initiation of project construction to shorter closures for the duration of the construction. Construction of all features is expected to take approximately 3 yr. Closure times are based upon the current level of design.

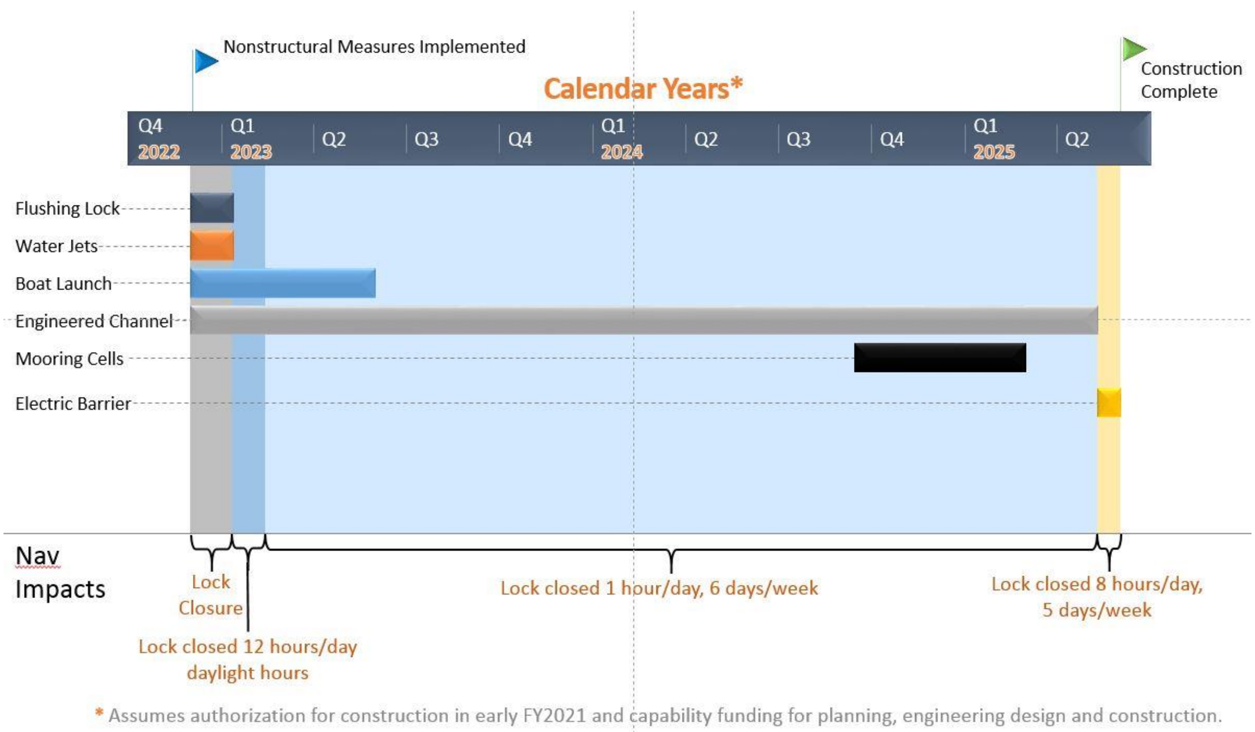

Figure 6-31 Estimated Construction Timeline for the Technology Alternative – Electric Barrier

6.9.7 Impacts on Navigation (NED Costs)

The Technology Alternative – Electric Barrier would allow for navigation to continue through the BRLD. However, the navigation economic analysis completed in support of GLMRIS-BR found that this alternative would negatively impact navigation, and result in higher transportation costs (NED costs). The average annual increase in transportation costs (NED costs) for the 50-yr period of analysis (2021–2070) were estimated at $31,400,000 (2016 prices).

Estimated Changes to Standard BR Lock Operations. For the Technology Alternative – Electric Barrier, increases in transportation costs (NED costs) are attributed to changes to standard BR Lock operations because of the following:

(1) Construction of ANS control features (Table 6-18);

(2) Operation of ANS controls (Table 6-19); and

(3) Periodic maintenance, repair, rehabilitation and replacement of ANS control features (Table 6-20).

Table 6-18 Technology Alternative – Electric Barrier: Estimated Changes to Standard BR Lock Operations During Construction[a,b]

	Construction Component			
		Engineered Channel & Water Jets		
Estimated Changes	**Flushing Lock**	**Guide Wall**	**Walls & Floor**	**Electrode & Parasitic Placement for Electric Barrier**
Estimated Closure Duration	24 hours	12 hours (during daylight)	1 hour	8 hours
Estimated Frequency	Daily	Daily	6 days/week (open Sundays)	5 days/week
Number of Calendar Days Change Would Be in Effect	40 days	30 days	800 days	22 days

[a] All changes to standard BR Lock operations were estimated based on the current level of design with the goal of minimizing impacts to navigation. During the PED phase, additional design and a value engineering (VE) study will be conducted with the goal of reducing the duration of construction impacts on navigation. Opportunities to schedule BR Lock construction (and required closures) at same times as other Illinois Waterway (IWRR) Lock schedule operation and maintenance lock (O&M) would be explored to minimize system IWW impacts on navigation.

[b] Construction methods were planned so 165-ft (50.3 m) channel width is always available. This is assumed to allow for navigation to transit without restrictions on tow configurations during construction.

Table 6-19 Technology Alternative – Electric Barrier: Assumed Changes to Standard BR Lock Operations Due to Operation of ANS Controls[a,b,c,d]

<table>
<tr><th colspan="2">Assumed Changes Due to ANS Control Measures</th></tr>
<tr><th>Flushing Lock</th><th>Continuous Electric Barrier</th></tr>
<tr><td>▪ Estimated time to flush lock is 15 minutes
▪ All upbound traffic assumed to be tied off downstream of lock chamber during flushing
▪ All upbound lockages would require flushing
▪ For downbound lockages, all consecutive lockages in the same direction would be flushed</td><td>▪ New restricted navigation area (RNA) in downstream approach channel of BR Lock
▪ Entire tow assumed to be outside RNA in order for someone to be on deck
▪ Assume no tow reconfigurations or tie-offs permitted in RNA
▪ Tows transiting RNA assumed be restricted to a maximum length of 550 ft (167.6 m)
▪ All reconfigurations or refleeting assumed to occur at one of the following: (1) new downstream mooring area or (2) a location further downstream of BR Lock</td></tr>
</table>

[a] All assumed changes to standard BR Lock operations were based on best-available engineering information at the time of the navigation economic analysis. Based on the best available information, the operation of the following ANS controls are not expected to impact navigation: nonstructural, engineered channel, water jets, complex noise, or operation of the electric dispersal barrier with no vessel traffic immediately downstream of the approach channel, in the approach channel or in the lock.

[b] Every year, there would be a 1 in 3 chance of a single 5-day closure to accommodate potential ANS emergency response procedures. For No New Action Plan, these closures fall within the emergency response procedures for the exiting EB in Romeoville, Illinois.

[c] The actual operating parameters of the electric barrier and of vessels through this area assuming an electric barrier is operating during vessel transit cannot be established until after construction, operation and testing of the system. Operating assumptions were developed with the intention of being protective of life safety.

[d] During PED, a scaled physical model of the flushing lock would be used to optimize the operating parameters to maximize flushing effectiveness while minimizing navigation impacts.

Table 6-20 Estimated Changes to Standard BR Lock Operations Due to Maintenance, Repair, Rehabilitation, and/or Replacement of ANS Controls[a,b]

Estimated Changes	Electric Barrier
Estimated Closure Duration (replacement of electrodes and parasitic assumed to occur 25 yr after construction of electric barrier)	8 hours
Estimated Frequency	5 days/week
Number of Calendar Days Change Would Be in Effect	60 days

[a] Changes to standard BR Lock operations were estimated using best-available engineering information at the time of the navigation economic analysis. The following ANS controls are not expected to require additional MRR&R that would impact navigation: nonstructural, engineered channel, water jets, complex noise, or the flushing lock.

[b] A major rehabilitation of BR Lock is assumed to occur in year 2030, with an estimated closure duration of approximately 30 days. This would occur with or without implementation of a GLMRIS-BR project, and is therefore included in both the with-project and without-project conditions.

Estimated Changes to BR Lock Average Processing Time, Average Delay Time, and Average Total Transit Time. Due to changes in standard BR Lock operations to accommodate the construction and subsequent OMRR&R of ANS control measures, changes to transit time are anticipated. Transit time is the sum of processing time and delay time. Processing time is the time related to the actual lockage process. Delay time is the time period between when a vessel arrives at the lock and when the lock is ready to begin processing that vessel.

Construction Period. The estimated changes in average processing time, average delay time, and average total transit time for the No New Federal Action Alternative, as well as the Technology Alternative – Electric Barrier (during construction), are presented in Table 6-21. The estimated average processing time, average delay time, and average total transit time during construction of the TAEB less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time during construction of the TAEB alternative.

Full Operations. The changes in average processing time, average delay time, and average total transit time the No New Federal Action Alternative, as well as the Technology Alternative – Electric Barrier (once fully operational), are presented in Table 6-22. The estimated average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Electric Barrier less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Electric Barrier.

Table 6-21 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Construction Period of Technology Alternative – Electric Barrier[a]

Alternative	Tonnage	Construction Year	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Electric Barrier (TAEB)	11,745,595	1	1.09	3.27	4.36
	11,745,595	2	1.09	1.52	2.61
	11,745,595	3	1.18	1.87	3.05
No New Federal Action (NNFA)	11,745,595	NA	1.09	1.01	2.10
Time Increases During Construction of TAEB = TAEB – NNFA		**1**	0	2.26	2.26
		2	0	0.51	0.51
		3	0.09	0.86	0.95

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics; Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

Table 6-22 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Full Operation of Technology Alternative – Electric Barrier and No New Federal Action Alternative[a]

Alternative	Tonnage	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Electric Barrier (TAEB)	11,745,595	1.22	3.79	5.01
No New Federal Action (NNFA)	11,745,595	1.09	1.01	2.10
Time Increases During Full Operations of TAEB = TAEB – NNFA		**0.13**	**2.78**	**2.91**

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics; Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

6.10 Alternative Plan 4: Technology Alternative – Complex Noise

6.10.1 Alternative Plan Description

The Technology Alternative – Complex Noise includes the following measures: (1) nonstructural measures, (2) complex noise, (3) water jets, (4) engineered channel, (5) flushing lock, and (6) boat launches (Table 6-23 and Figure 6-32).

Table 6-23 Measures in the Technology Alternative – Complex Noise

Location	Measure	Controlled Modes of ANS Transport
GLMRIS-BR IWW Study Area	Nonstructural	Swimmers
Brandon Road Lock and Approach Channel	Complex noise	Swimmers
	Engineered channel	Integral to nonstructural swimmer and floater ANS controls
	Water jets	Floaters, small and stunned swimmers
	Flushing lock	Floaters
	Boat launches	Supporting measure

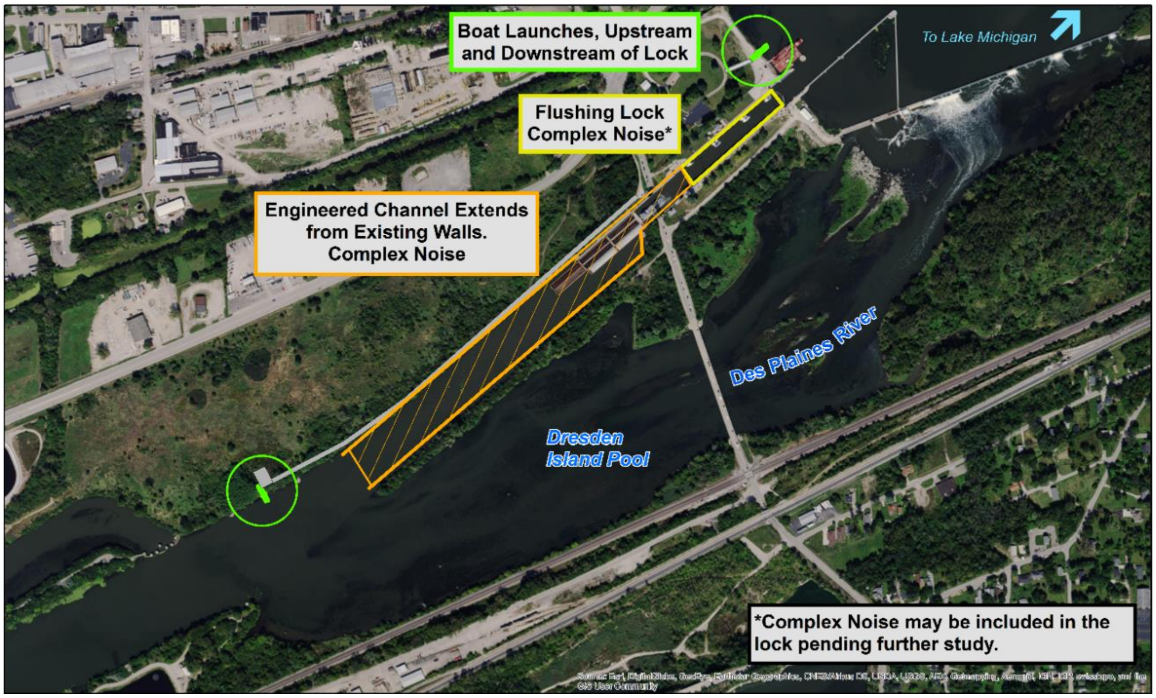

Figure 6-32 Aerial View of BRLD with Technology Alternative – Complex Noise

This alternative includes nonstructural measures and establishes a structural control point at the BRLD. These technologies reduce P(establishment) for Asian carp in the GLB. Nonstructural measures, in part, are included to keep the population of Asian carp at current or reduced levels and to identify future ANS.

Complex noise, which is delivered to the waterway through underwater speakers, deters fish movement. Speakers for the complex noise measure would be installed below the water's surface within the engineered channel (Figure 6-4). The smooth surface of the engineered channel provides an engineered environment that reduces the shielding of sound waves and increases the likelihood that target frequencies and decibel levels will be achieved. Pending further study, the speakers would also be placed in the BRL.

In addition to creating an engineered environment for the sound pressure field, the engineered channel increases the likelihood of fish detection using sonar and hydroacoustic monitoring gears; reduces the potential shielding from ANS control effects; and simplifies clearing of fish within the channel (e.g., piscicide application and netting). The engineered channel would also provide a platform to evaluate future ANS controls and potentially incorporate them.

The placement of the water jets for the fish and floater entrainment and possibly vessel-induced currents would be within the channel. Additional field study is needed to assess the best location for water jets in an alternative with complex noise as the only fish deterrent.

The flushing lock (Figure 6-9) addresses floating life stages of ANS in the lower pool from transferring to the upper pool by flushing them out of the lock when the lower pool miter gates are opened to allow entry of an upbound tow. Vessels approaching the lock would stage themselves on the right descending bank during lock flushing and proceed into the lock after the flush was completed. For additional information regarding the flushing lock, please see Section 6.3.2, Structural Measures.

This alternative includes boat launches upstream and downstream of the lock to reduce reaction time and increase the efficiency of the crews implementing nonstructural measures around the BRLD. The boat ramps would also be used to facilitate OMRR&R and response to safety incidents around the BRLD.

For additional information regarding these measures, please refer to Section 6.3, Measures for Alternative Formulation. Additional study and field evaluations are needed to further refine this alternative. After construction, the project would undergo an evaluation to assess safe operating parameters and potentially a USCG-regulated navigation area rulemaking process prior to full operation.

6.10.2 Probability of ANS Establishment

Figures 6-33 and 6-34 show the calculated P(establishment) for the Asian carp and *A. lacustre*, respectively, for the Technology Alternative – Complex Noise based on inputs provided by each expert. Tables 6-24 and 6-25 include the calculated P(establishment) for the Asian carp and *A. lacustre*, respectively, summary for the composite expert. The experts believed that complex noise was a less effective swimmer control compared to an electric barrier. Therefore, the P(establishment) estimates for this alternative are higher than the P(establishment) estimates for the Technology Alternative – Electric Barrier. This alternative does not include a measure specifically designed to address hitchhiking ANS, nor does it halt navigation. Consequently, the experts believed this alternative would have minimal impacts on the *A. lacustre* P(establishment) estimate when compared to the P(establishment) estimate for the No New Federal Action Alternative. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as "a fact."

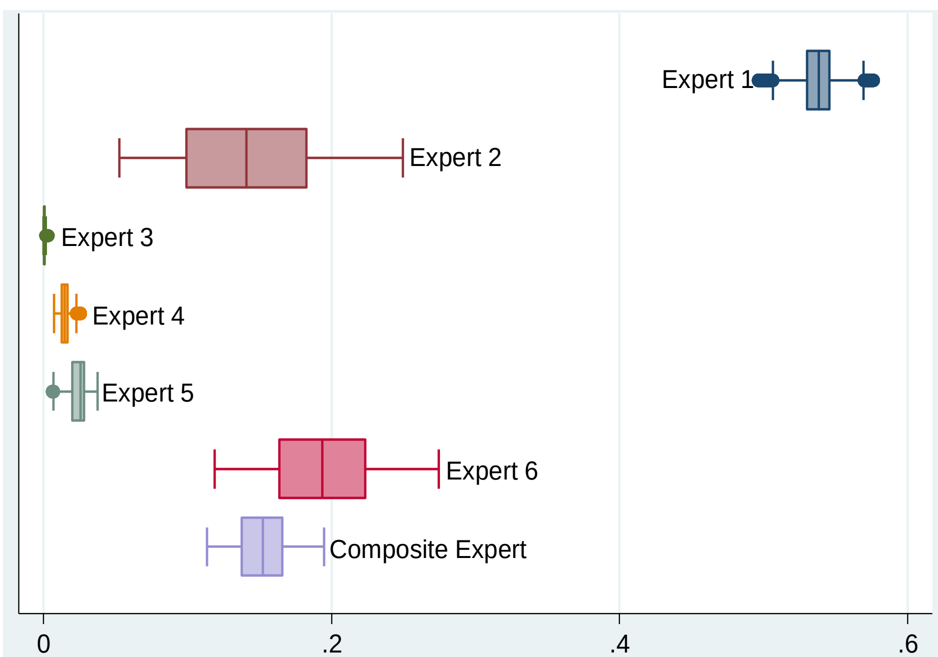

Figure 6-33 Asian Carp P(Establishment) 2071 Values for All Six Experts and the Composite Expert under Technology Alternative – Complex Noise

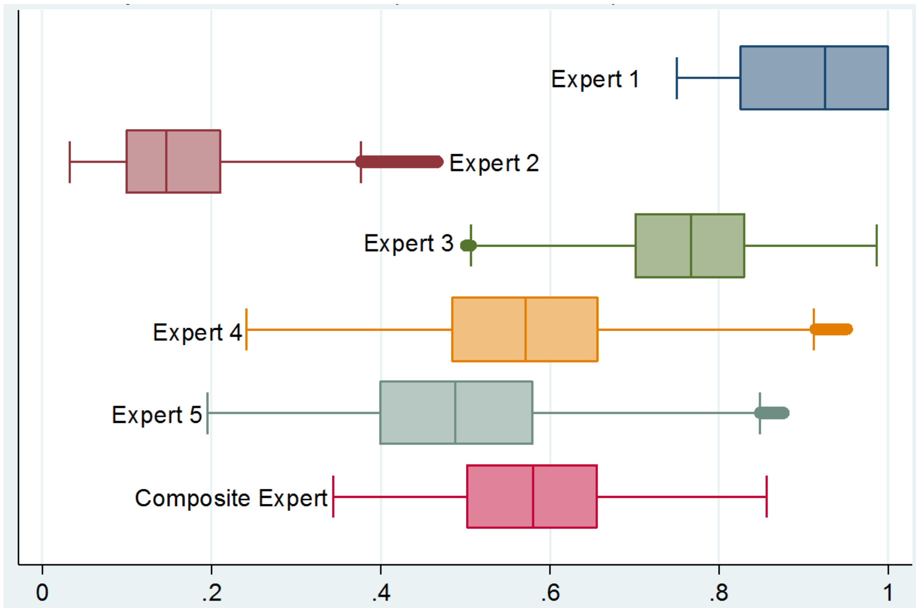

Figure 6-34 *A. lacustre* P(Establishment) 2071 Values for All Five Experts and the Composite Expert under Technology Alternative – Complex Noise

Table 6-24 Asian Carp P(Establishment) 2071 Values for the Composite Expert under Technology Alternative – Complex Noise

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Complex Noise	0.11	0.15	0.19

Table 6-25 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under Technology Alternative – Complex Noise

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Complex Noise	0.34	0.58	0.86

Asian Carp

The P(establishment) estimates calculated from the inputs of five of the six experts suggest establishment is unlikely or highly unlikely under the Technology Alternative – Complex Noise (Figure 6-33). The P(establishment) estimate is lowest using inputs from experts 3, 4, and 5, and highest using inputs from expert 1. Inputs from experts 2 and 6 lead to estimates between these extremes, but closer to the lower probability estimates. P(establishment) for experts 3, 4, and 5 show minimal variation.

The composite expert distribution, calculated by averaging the CDFs for the six experts, most resembles that of expert 6. The uncertainty about the composite expert estimate of the P(establishment) lies between 11% and 19% with a median value of 15% (Table 6-24).

A. lacustre

The P(establishment) estimate calculated using inputs from expert 1 and expert 3 suggest the greatest probability of *A. lacustre* establishment, while data from expert 2 indicate a lower P(establishment) (Figure 6-34). The median P(establishment) for experts 4 and 5 is between these two. There is large uncertainty in the P(establishment) values calculated for most of the experts as indicated by the width of the box and whisker plots.

The composite expert distribution, calculated by averaging the CDFs for the five experts, most resembles that of expert 4. The uncertainty about the composite expert estimate of the P(establishment) lies between 34% and 86% with a median value of 58% (Table 6-25).

6.10.3 Relative Life Safety Risk

Refer to Section 6.9.3, Relative Life Safety Risk, Technology Alternative – Electric Barrier, for an explanation of relative life safety risks related to the nonstructural measures, engineered channel, water jets, flushing lock and boat launches.

This alternative includes underwater speakers installed within the engineered channel and possibly the lock, and would be installed by divers. The current construction assumption is the channel is closed to navigation when the divers are in the water. Although navigation would not be permitted while divers are in the water, there could still be an increased life safety risk potential for the divers and other personnel carrying out the construction activities associated with placement of the complex noise feature. Increased life safety risks to the divers could potentially be associated with diving in a poor visibility environment and working with large equipment underwater. Construction personnel providing support to the divers could potentially be at increased risk for falling in the water. Overall, an increase in the potential for life safety risks to divers and construction personnel is expected for the TACN when compared with the Nonstructural and No New Federal Action alternatives, which do not require construction of a permanent feature in the waterway, with the exception of a boat ramp for the Nonstructural Alternative.

The underwater speakers would play complex noise as a fish deterrent. The sound played on the speakers may pose a life safety risk to navigators and lock operators. Complex noise would be designed to achieve the target sound profile throughout the water column while minimizing the sound emitted above the water's surface. Two circumstances that may have an impact on human health and safety are (1) sound emitted from the water into the air and (2) a man overboard within the sound field. Depending on its decibel level, frequency, and final placement of the speakers, sound transfer between the water-air barrier may affect communications between navigators and lock and control point personnel. In designing such a system accounting for potential life safety risks, the strategy would focus on addressing possible reverberation (vibrations caused by the speaker array) and echoing sound (from solid surfaces such as the lock gates).

Regarding a man overboard scenario within the sound field, the characteristics of the sound (decibel level frequency) deterrent are uncertain and require additional development. Consequently, the potential impact of the sound on the hearing of a person overboard is unknown. Considerations of whether the sound would have an impact on a person's hearing include the characteristics of the sound being played by the speaker, how close the person comes to the speaker, and how long the person is exposed to the sound.

Based on these considerations, the Technology Alternative – Complex Noise was rated as having an intermediate life safety risk in comparison to the other GLMRIS-BR alternatives. Indirect effects associated with this alternative, including potential mode shifts from the waterway to area rails and roadways, are discussed in Chapter 7, Impacts of Alternative Plans. The analysis discusses the potential impacts on life safety associated with those mode shifts.

6.10.4 System Performance Robustness

System performance robustness has been evaluated as the robustness of an alternative to address current and future ANS threats in the waterway:

1. This alternative has the ability to add future or modified nonstructural measures in response to changed conditions.

2. This alternative includes an engineered channel and therefore includes a platform for the testing and possible addition of future structural measures.

3. This alternative includes two structural control points within the GLMRIS-BR Illinois Waterway Study Area: the proposed one at BRLD and the current one at CSSC-EB.

4. This alternative controls ANS having two modes of transport: swimming and floating. The alternative's electric barrier targets swimming modes of transport, while the water jets and flushing lock target floating modes of transport. Therefore, within the control point at the BRLD, under the Technology Alternative – Electric Barrier, two measures would address floating transport, while one measure would address swimming transport.

6.10.5 Estimated Alternative Costs

The Technology Alternative – Complex Noise includes construction costs estimated to equal \$113,900,000. The nonstructural measure costs are estimated to be \$11,300,000 per year, slightly lower than those estimated for the Nonstructural Alternative because the overfishing component is assumed to be lower in light of installing a control point at the Brandon Road Lock. OMRR&R costs are estimated to equal \$1,400,000. Estimated alternative costs are shown in Table 6-26.

OMRR&R costs for the complex noise system were estimated as a percentage of the installation costs. Based on other similar installations, the speakers used are standard and do not require unusual maintenance.

Absent an existing project for comparison, OMRR&R costs for water jets and complex noise were estimated as a percentage of the installation costs. For the water jets, replacement is estimated to occur every 15 yr. For the speakers, the percentage of installation costs was assumed to cover the replacement costs.

OMRR&R costs of the flushing lock were estimated as a percentage of the installation costs, and OMRR&R costs for the engineered channel are assumed to be negligible for this estimating purpose.

In this alternative, the additional cost of labor is based on three FTE employees assumed to supplement the existing lock operation staff to operate and address any issues with the complex noise system for a 24-hr, 7 days/week operation. The existing lock staff and electric barrier staff will cover any issues that arise from the flushing lock, water jets, or engineered channel.

Table 6-26 Estimated Costs of Technology Alternative – Complex Noise

Element	Estimated Cost
Construction[a]	$113,900,000
Nonstructural[b]	$11,300,000
OMRR&R[b]	$1,400,000

[a] Costs are provided as total cost, present value (project first costs).
[b] Costs are provided as average annual costs.

6.10.6 Estimated Alternative Implementation Duration

The nonstructural component of the Technology Alternative – Complex Noise could be implemented toward the end of calendar year 2020, assuming authorization for construction is received early in fiscal year 2021 and capability funding is received for planning, design, and construction of the alternative. Construction of the technology components is expected to be completed by calendar year 2025 (Figure 6-35) pending a 2020 authorization and capability funding for planning, engineering, and design.

Figure 6-35 contains a timeline for construction of the various measures associated with this alternative. The figure also includes closures of the lock, which vary from a 40-day closure at the initiation of project construction to shorter closures for the duration of the construction. Construction of all features is expected to take approximately 3 yr. Closure times are based upon the current level of design.

Figure 6-35 Estimated Construction Timeline for the Technology Alternative – Complex Noise

6.10.7 Impacts on Navigation (NED Costs)

The Technology Alternative – Complex Noise would allow for navigation to continue through the BRLD. However, the navigation economic analysis completed in support of GLMRIS-BR found that this alternative would negatively impact navigation, and result in higher transportation costs (NED costs). The average annual increase in transportation costs (NED costs) for the 50-yr period of analysis (2021–2070) were estimated at $26,000,000 (2016 prices).

For the Technology Alternative – Complex Noise, increases in transportation costs (NED costs) are attributed to changes to standard BR Lock operations because of the following:

(1) construction of ANS control features (Table 6-27); and
(2) operation of ANS controls (Table 6-28).

The ANS control features included in Technology Alternative – Complex Noise are not expected to require additional maintenance, repair, rehabilitation, or replacement (MRR&R) activities that would negatively impact navigation. A major rehabilitation of BR Lock is assumed to occur in year 2030, with an estimated closure duration of approximately 30 days. This would occur with or without implementation of a GLMRIS-BR project, and is therefore included in both the with-project and without-project conditions.

Table 6-27 Technology Alternative – Complex Noise: Estimated Changes to Standard BR Lock Operations During Construction[a,b]

Estimated Changes	Construction Component			
	Flushing Lock	Engineered Channel & Water Jets: Guide Wall	Engineered Channel & Water Jets: Walls & Floor	Speaker Placement for Complex Noise
Estimated Closure Duration	24 hours	12 hours (during daylight)	8 hours	8 hours
Estimated Frequency	Daily	Daily	5 days/week	5 days/week
Number of Calendar Days Change Would be in Effect	40 days	30 days	45 days	22 days

[a] All changes to standard BR Lock operations were estimated based on the current level of design with the goal of minimizing impacts to navigation. During the PED phase, additional design and a value engineering (VE) study would be conducted with the goal of reducing the duration of construction impacts on navigation. Opportunities to schedule BR Lock construction (and required closures) at same times as other Illinois Waterway (IWRR) Lock schedule operation and maintenance lock (O&M) would be explored to minimize system IWW impacts to navigation.

[b] Construction methods were planned so 165-ft (50.3 m) channel width is always available. This is assumed to allow for navigation to transit without restrictions on tow configurations during construction.

Table 6-28 Technology Alternative – Complex Noise: Assumed Changes to Standard BR Lock Operations Due to Operation of ANS Controls[a,b]

Assumed Changes Due to ANS Control Measure
Flushing Lock
▪ Estimated time to flush lock is 15 minutes. ▪ All upbound traffic assumed to be tied off downstream of lock chamber during flushing. ▪ All upbound lockages would require flushing. ▪ For downbound lockages, all consecutive lockages in the same direction would be flushed.

[a] All assumed changes to standard BR Lock operations were based on best-available engineering information at the time of the navigation economic analysis. Based on the best available information, the operation of the following ANS controls are not expected to impact navigation: nonstructural, engineered channel, water jets, complex noise, or operation of the electric dispersal barrier with no vessel traffic immediately downstream of the approach channel, in the approach channel or in the lock.

[b] Every year, there would be a 1 in 3 chance of a single 5-day closure to accommodate potential ANS emergency response procedures. For No New Federal Action Alternative, these closures fall within the emergency response procedures for the exiting EB in Romeoville, Illinois.

[c] During PED, a scaled physical model of the flushing lock would be used to optimize the operating parameters to maximize flushing effectiveness while minimizing navigation impacts.

Estimated Changes to BR Lock Average Processing Time, Average Delay Time, and Average Total Transit Time. Due to changes in standard BR Lock operations to accommodate the construction and subsequent operation of ANS control measures, changes to transit time is anticipated. Transit time is the sum of processing time and delay time. Processing time is the time related to the actual lockage process. Delay time is the time period between when a vessel arrives at the lock and when the lock is ready to begin processing that vessel.

Construction Period. The estimated changes in average processing time, average delay time, and average total transit time the No New Federal Action Alternative, as well as the Technology Alternative – Complex Noise (during construction), are presented in Table 6-29. The estimated average processing time, average delay time, and average total transit time during construction of the TACN less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time during construction of the TACN alternative.

Full Operations. The changes in average processing time, average delay time, and average total transit time the No New Federal Action Alternative, as well as the Technology Alternative – Complex Noise (once fully operational), are presented in Table 6-30. The estimated average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Complex Noise less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Complex Noise.

Table 6-29 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Construction Period of Technology Alternative – Complex Noise[a]

Alternative	Tonnage	Construction Year	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Complex Noise (TACN)	11,745,595	1	1.09	3.27	4.36
	11,745,595	2	1.09	1.52	2.61
	11,745,595	3	1.2	1.88	3.08
No New Federal Action (NNFA)	11,745,595	NA	1.09	1.01	2.1
Time Increases During Construction of TACN = TACN – NNFA		**1**	**0**	**2.26**	**2.26**
		2	**0**	**0.51**	**0.51**
		3	**0.11**	**0.87**	**0.98**

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics, Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

Table 6-30 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Full Operation of Technology Alternative – Complex Noise and No New Federal Action Alternative[a]

Alternative	Tonnage	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Complex Noise (TACN)	11,745,595	1.27	3.27	4.54
No New Federal Action (NNFA)	11,745,595	1.09	1.01	2.10
Time Increases During Full Operations of TACN = TACN – NNFA		0.18	2.26	2.44

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics, Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

Additional information about the navigation economic analysis for Technology Alternative – Complex Noise can be found in Appendix D, Economics.

6.11 Alternative Plan 5: Technology Alternative – Complex Noise with Electric Barrier

6.11.1 Alternative Plan Description

The Technology Alternative – Complex Noise with Electric Barrier includes the following measures: (1) nonstructural measures, (2) electric dispersal barrier, (3) complex noise, (4) engineered channel, (5) water jets, (6) flushing lock, (7) boat launches, and (8) mooring areas (Table 6-31 and Figure 6-36).

Table 6-31 Measures in Technology Alternative – Complex Noise with Electric Barrier

Location	Measure	Controlled Modes of ANS Transport
GLMRIS-BR IWW Study Area	Nonstructural	Swimmers
Brandon Road Lock and Approach Channel	Electric barrier	Swimmers
	Complex noise	Swimmers
	Engineered channel	Integral to nonstructural swimmer and floater ANS controls
	Water jets	Floaters, small and stunned swimmers
	Flushing lock	Floaters
	Boat launches	Supporting measure
Approximately 2 mi (3.2 km) downstream of BRLD	Mooring area	Supporting measure

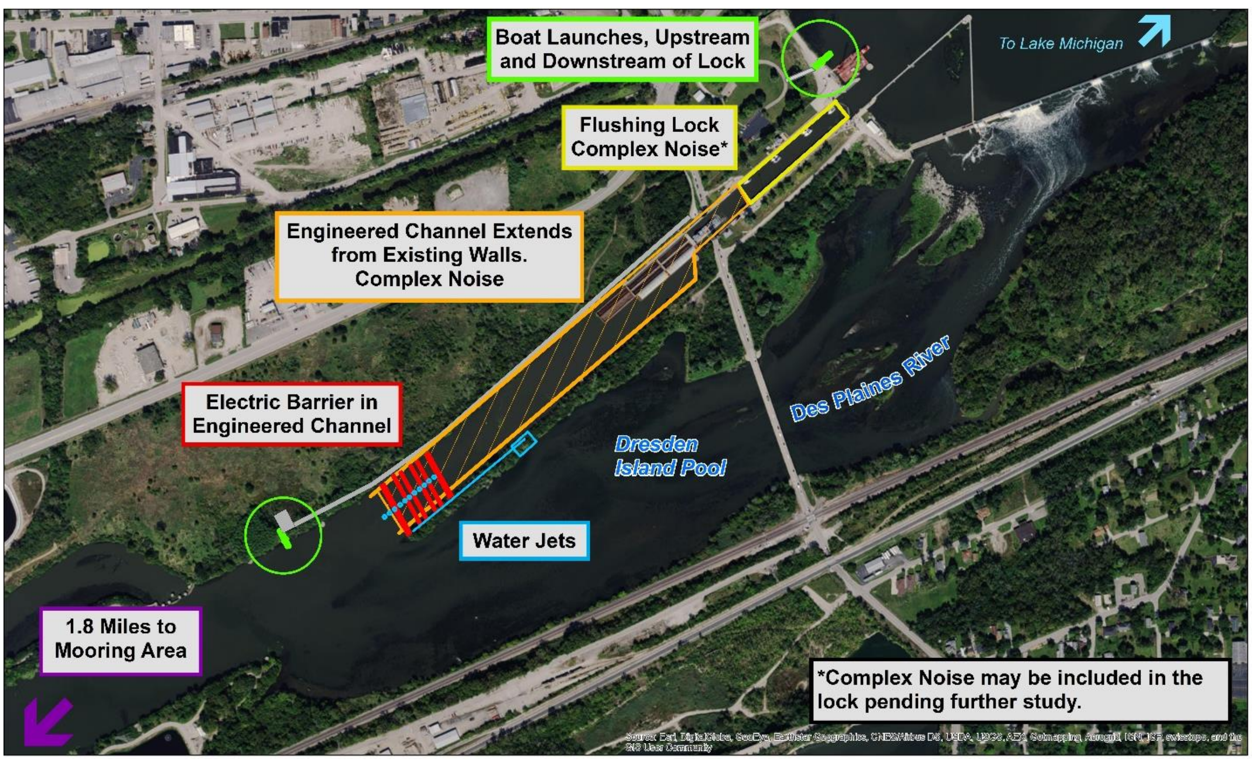

Figure 6-36 Aerial View of BRLD with Technology Alternative – Complex Noise with Electric Barrier

This alternative includes nonstructural measures and establishes a structural control point at BRLD. These technologies reduce P(establishment) of Asian carp in the GLB. Nonstructural measures, in part, are included to keep the population of Asian carp at current or reduced levels and to identify future ANS.

The electric barrier deters upstream fish movement and is placed within an engineered channel designed with insulation to minimize stray current. The electric barrier would be placed within the downstream end of the engineered channel. Complex noise, which is delivered to the waterway through underwater speakers, deters fish movement and is this alternative's second swimmer control. Speakers for the complex noise measure would be installed below the water's surface within the engineered channel (Figure 6-4). Pending further study, the speakers may also be placed within the BR Lock chamber.

In light of the uncertainty related to possible safety impacts of operating an electric barrier in the approach channel, it was assumed complex noise would be operated when vessels were in the approach channel and lock. After the vessels exits the lock or approach channel, it was assumed the electric barrier would be turned on. Complex noise would be operated during the time the electric barrier is off. The operational parameters of the electric barrier impact the alternative's effectiveness, relative life safety impacts, and impacts on navigation (NED costs), which are described in the following evaluation.

The engineered channel would be designed to minimize stray electrical current, and the smooth surface of the engineered channel provides an engineered environment. This environment reduces the shielding of sound waves and increases the likelihood that target frequencies and decibel levels will be achieved. The engineered channel also increases the likelihood of fish detection using sonar and hydroacoustic monitoring gears; reduces the potential shielding from electric current and other ANS control effects; and simplifies clearing of fish within the channel (e.g., piscicide application, and netting). The engineered channel would also provide a platform to evaluate future ANS controls and potentially incorporate them.

The water jets for the fish and floater entrainment and possibly vessel-induced currents are positioned immediately downstream and upstream of the electric barrier to remove entrained fish and floaters. The water jets system immediately upstream of the electric barrier provides redundancy in case fish and floaters remain entrained after the first jet array.

The flushing lock addresses floating life stages of ANS in the lower pool from transferring to the upper pool by flushing them out of the lock when the lower pool miter gates are opened to allow entry of an upbound tow. Vessels approaching the lock would stage themselves on the right descending bank during lock flushing and proceed into the lock after the flush was completed.

This alternative includes a boat launch upstream and downstream of the lock to reduce reaction time and increase the efficiency of the crews implementing nonstructural measures around BRLD. The boat ramps would also be used to facilitate OMRR&R and respond to safety incidents around BRLD.

After construction, the project would have to undergo an evaluation to assess safe operating parameters and, potentially, a USCG-regulated navigation area rulemaking process prior to full operation. The mooring area provides a barge reconfiguration area that is closer than the currently available fleeting area, if operators need to reconfigure their barges to meet navigation restrictions due to the presence of an electric barrier in the engineered channel.

For more information regarding the measures, please refer to Section 6-3, Measures for Alternative Formulation. Additional study and field evaluations are needed to further refine this alternative.

The assumptions utilized for this quantitative evaluation of navigation impacts (NED costs) were developed with life safety as a primary consideration and accounted for the array of potential impacts that are expected during construction, and OMRR&R. However, the estimated impacts to navigation are subject to uncertainty. As the study continues and more information is obtained about how navigation would accommodate changes at BRLD, the assumptions will be refined.

6.11.2 Probability of ANS Establishment

Figures 6-37 and 6-38 show the estimated P(establishment) for Asian carp and *A. lacustre*, respectively, under the Technology Alternative – Complex Noise with Electric Barrier based on inputs provided by each expert. Tables 6-32 and 6-33 include the P(establishment) summary estimated by the composite expert for Asian carp and *A. lacustre*, respectively. In this alternative, the electric barrier would operate intermittently and complex noise would operate when the electric barrier was off. The experts believed complex noise was a less effective swimmer control compared to an electric barrier. Therefore, the P(establishment) estimates for this alternative are higher than the P(establishment) values for the

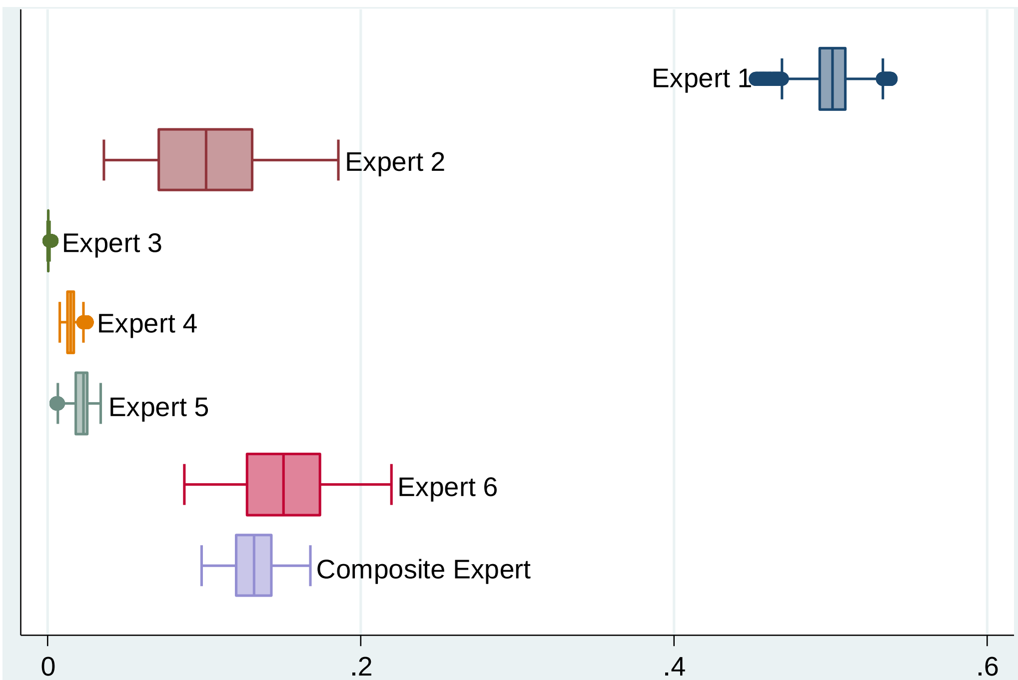

Figure 6-37 Asian Carp P(Establishment) 2071 Values for All Six Experts and the Composite Expert under Technology – Complex Noise with Electric Barrier

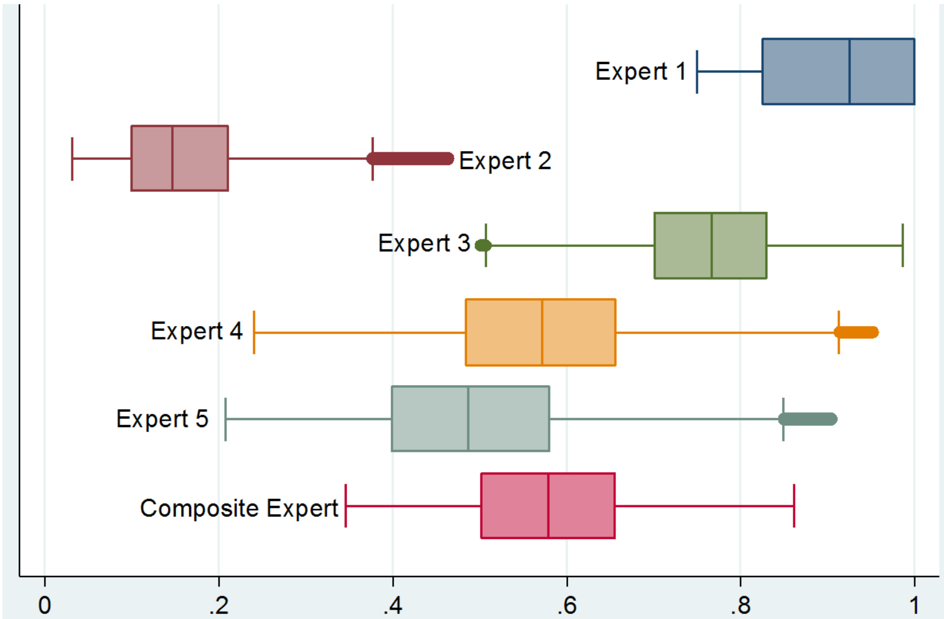

Figure 6-38 *A. lacustre* P(Establishment) 2071 Values for All Five Experts and the Composite Expert under Technology Alternative – Complex Noise with Electric Barrier

Table 6-32 Asian Carp P(Establishment) 2071 Values for the Composite Expert under the Technology Alternative – Complex Noise with Electric Barrier

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Complex Noise with Electric Barrier	0.10	0.13	0.17

Table 6-33 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under the Technology Alternative – Complex Noise with Electric Barrier

Alternative	P(Establishment)		
	Minimum	Median	Maximum
Technology Alternative – Complex Noise with Electric Barrier	0.34	0.58	0.86

Technology Alternative – Electric Barrier, where the electric barrier is intended to operate continuously, but lower than the Technology Alternative – Complex Noise, where complex noise is the sole swimmer control. This alternative does not include a measure specifically designed to address hitchhiking ANS, nor does it halt navigation. Consequently, the experts believed this alternative would have minimal impacts on the *A. lacustre* P(establishment) estimates when compared to the P(establishment) estimate for the No New Federal Action Alternative. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as "a fact."

Asian Carp

P(establishment) calculated from the inputs of five of the six experts suggest establishment is unlikely under the Technology Alternative – Complex Noise with Electric Barrier (Figure 6-37). The P(establishment) estimate is lowest using inputs from experts 3, 4, and 5, and highest using inputs from expert 1. Inputs of experts 2 and 6 lead to estimates between these extremes. P(establishment) for experts 3, 4, and 5 shows little variation.

The composite expert distribution, calculated by averaging the CDFs for the six experts, most resembles that of expert 6. The uncertainty about the composite expert estimate of the P(establishment) lies between 10% and 17% with a median value of 13% (Table 6-32).

A. lacustre

P(establishment), calculated using inputs from expert 1 and expert 3, suggests the greatest probability of establishment, while data from expert 2 indicate a lower P(establishment) (Figure 6-38). The median P(establishment) for experts 4 and 5 is between these experts. There is large uncertainty in the P(establishment) values estimated for most of the experts as indicated by the width of the box and whisker plots.

The composite expert distribution, calculated by averaging the CDFs for the five experts, most resembles that of expert 4. The uncertainty about the composite expert estimate of the P(establishment) lies between 34% and 86% with a median of 58 (Table 6-33).

6.11.3 Relative Life Safety Risks

Refer to Section 6.9.3, Relative Life Safety Risk, for the Technology Alternative – Electric Barrier for an explanation of the potential life safety impacts related to the water jets, flushing lock, and operation of the electric dispersal barrier. Refer to Section 6.10.3, Relative Life Safety Risk, for the Technology Alternative – Complex Noise for an explanation of potential life safety impacts related to complex noise. Based on these considerations, the Technology Alternative – Complex Noise with Electric Barrier is rated as having a high life safety risk compared with the other alternatives. Indirect effects associated with this alternative, including potential mode shifts from the waterway to area rails and roadways, are discussed in Chapter 7, Impacts of Alternative Plans. The analysis discusses the potential impacts on life safety associated with those mode shifts.

6.11.4 System Performance Robustness

System performance robustness has been evaluated as an alternative's robustness to address current and future ANS threats in the waterway:

1. This alternative includes an engineered channel and therefore includes a platform for future nonstructural measures.

2. This alternative includes an engineered channel and therefore includes a platform for future structural measures.

3. This alternative includes two structural control points within the GLMRIS-BR Illinois Waterway Study Area: the proposed one at BRLD and the current one at CSSC-EB.

4. This alternative controls the swimming and floating modes of transport. The electric barrier and complex noise targets swimming modes of transport, while the water jets and flushing lock target floating modes of transport. Therefore, within the control point at BRLD, under the Technology Alternative – Complex Noise with Electric Barrier, two measures would address floating transport and one measure would address swimming transport.

6.11.5 Estimated Alternative Costs

The Technology Alternative – Complex Noise with Electric Barrier includes construction costs estimated at $275,300,000. The nonstructural measure costs are estimated to be $11,300,000, slightly lower than those estimated for the Nonstructural Alternative because the overfishing component is assumed to be slightly lower in light of installing a control point at Brandon Road Lock. OMRR&R costs are estimated to equal $8,200,000. Estimated costs for this alternative are shown in Table 6-34.

The BR Electric Barrier measure design is based on the CSSC-EB Permanent Barrier I; therefore, the operation and maintenance costs – including electrical bill, spare parts, and other incidentals – would be comparable to known values from the Romeoville CSSC-EB. Estimated additional costs based on Permanent Barrier I include replacing electrodes over a 25-yr span and electrical equipment upgrades every 10 yr. At this point in the study and design, all costs are assumed to be the same for an electric dispersal barrier operating continuously or intermittently.

Absent an existing project for comparison, operation and maintenance costs of water jets were estimated as a percentage of the installation costs. Yearly cost was assumed to cover normal maintenance and repairs, along with the cost to run the pumps. Based on pumps running 1 hr for each lockage and an average of nine lockages a day, replacements are estimated to occur every 15 yr.

Table 6-34 Estimated Costs of Technology Alternative – Complex Noise with Electric Barrier

Element	Estimated Cost
Construction[a]	$275,300,000
Nonstructural[b]	$11,300,000
OMRR&R[b]	$8,200,000

[a] Costs are provided as total cost, present value (project first costs)
[b] Costs are provided as average annual costs.

Staffing requirements for this alternative are the same as those for the Technology Alternative – Electric Barrier. The estimated additional cost of labor is based on the staffing requirements of the CSSC-EB and eight FTE employees, including five operators, one electrician, one mechanic, and one supervisor. These employees will also cover any operational needs for the complex noise system, along with the flushing lock, water jets, and engineered channel. See Appendix H, Engineering, for more information.

6.11.6 Estimated Alternative Implementation Duration

The nonstructural component of the Technology Alternative – Complex Noise with Electric Barrier could be implemented toward the end of calendar year 2020, assuming authorization for construction is received early in fiscal year 2021 and capability funding is received for planning, design, and construction of the alternative. Construction of the technology components is expected to be completed by calendar year 2025 (Figure 6-39). Figure 6-39 contains a timeline for construction of the various measures associated with this alternative. Assumes authorization for construction in FY2021 and capability funding for planning, engineering design, and construction. The figure also includes closures for the lock, which vary from a 40-day closure at the initiation of project construction to shorter closures for the duration of the construction. Construction of all features is expected to take approximately 3 yr. Closure times are based upon the current level of design.

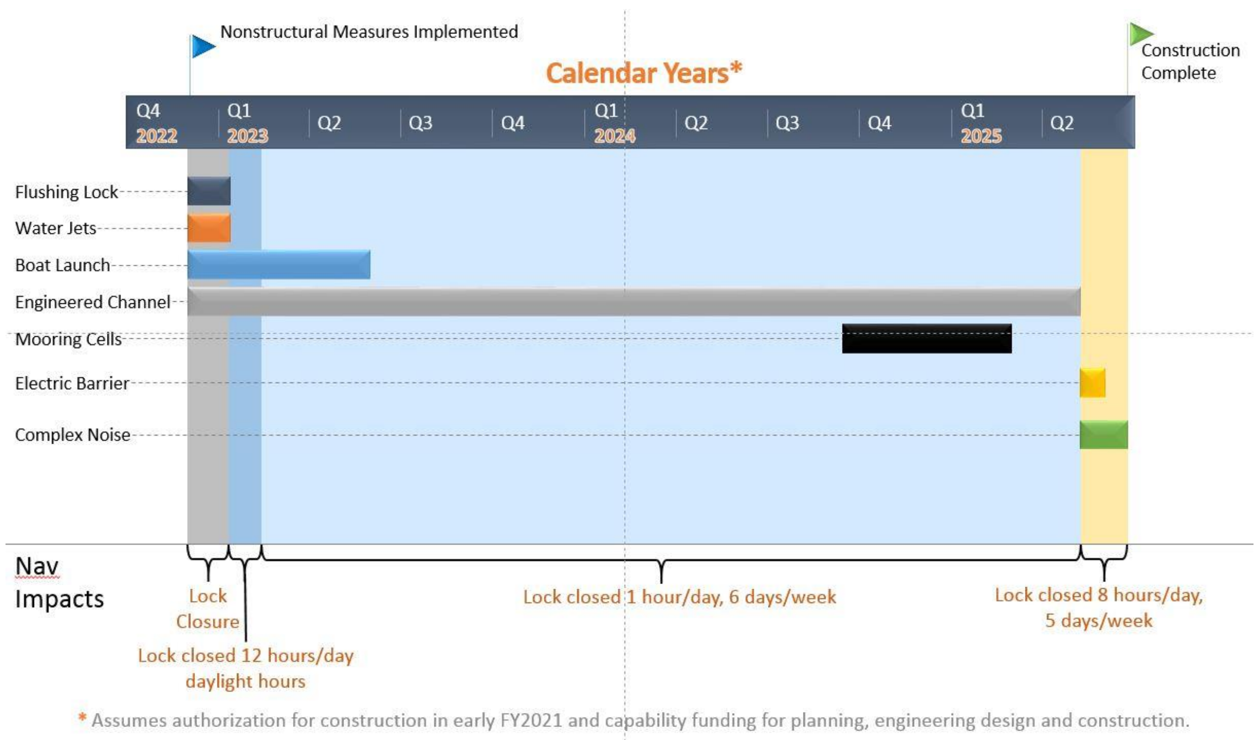

Figure 6-39 Estimated Construction Timeline for the Technology Alternative – Complex Noise with Electric Barrier

6.11.7 Navigation Impacts (NED Costs)

The Technology Alternative – Complex Noise with Electric Barrier would allow for navigation to continue through the BRLD. However, the navigation economic analysis completed in support of GLMRIS-BR found that this alternative would negatively impact navigation, and result in higher transportation costs (NED costs). For the navigation economic analysis, the Technology Alternative – Complex Noise with Electric Barrier was analyzed based on the assumed operating parameters of intermittent operation, which would be less restrictive to navigation than a continuously operated electric barrier. The electric dispersal barrier is assumed to be turned off as vessels approach the downstream approach channel, are within the approach channel, and are within the lock. By shutting off the electric barrier in the presence of vessels, the restrictions assumed under the continuous barrier are avoided.

The average annual increases in transportation costs (NED costs) for the 50-yr period of analysis (2021–2070) were estimated for Technology Alternative – Complex Noise with Electric Barrier: $26,200,000. This NED cost is presented in 2016 prices.

Estimated Changes to Standard BR Lock Operations. For the Technology Alternative – Complex Noise with Electric Barrier, increases in transportation costs (NED costs) are attributed to changes to standard BR Lock operations because of the following:

(1) construction of ANS control features (Table 6-35);

(2) operation of ANS controls (Table 6-36); and

(3) periodic maintenance, repair, rehabilitation, and replacement of ANS control features (Table 6-37).

Table 6-35 Technology Alternative – Complex Noise with Electric Barrier: Estimated Changes to Standard BR Lock Operations During Construction[a]

Estimated Changes	Construction Component				
	Flushing Lock	Engineered Channel & Water Jets: Guide Wall	Engineered Channel & Water Jets: Walls & Floor	Speaker Placement for Complex Noise	Electrode & Parasitic Placement for Electric Barrier
Estimated Closure Duration	24 hours	12 hours (during daylight)	8 hours	8 hours	8 hours
Estimated Frequency	Daily	Daily	5 days/week	5 days/week	5 days/week
Number of Calendar Days Change Would Be in Effect	40 days	30 days	45 days	45 days	22 days

[a] All changes to standard BR Lock operations were estimated based on the current level of design with the goal of minimizing impacts to navigation. During the PED phase, additional design and a value engineering (VE) study will be conducted with the goal of reducing the duration of construction impacts on navigation. Opportunities to schedule BR Lock construction (and required closures) at same times as other Illinois Waterway (IWRR) Lock schedule operation and maintenance lock (O&M) would be explored to minimize system IWW impacts on navigation.

[b] Construction methods were planned so a 165-foot (50.3 km) channel width is always available. This is assumed to allow for navigation to transit without restrictions on tow configurations during construction.

Table 6-36 Technology Alternative – Complex Noise with Electric Barrier: Assumed Changes to Standard BR Lock Operations Due to Operation of ANS Controls[a,b]

Assumed Changes Due to ANS Control Measures
Flushing Lock
▪ Estimated time to flush lock is 15 minutes. ▪ All upbound traffic assumed to be tied off downstream of lock chamber during flushing. ▪ All upbound lockages would require flushing. ▪ For downbound lockages, all consecutive lockages in the same direction would be flushed

[a] All assumed changes to standard BR Lock operations were based on best-available engineering information at the time of the navigation economic analysis. Based on the best available information, the operation of the following ANS controls are not expected to impact navigation: nonstructural, engineered channel, water jets, or complex noise.

[b] Every year, there would be a 1 in 3 chance of a single 5-day closure to accommodate potential ANS emergency response procedures. For No New Federal Action Plan, these closures fall within the emergency response procedures for the existing CSSC-EB in Romeoville, Illinois.

[c] During PED, a scaled physical model of the flushing lock would be used to optimize the operating parameters to maximize flushing effectiveness while minimizing navigation impacts.

Table 6-37 Technology Alternative – Complex Noise with Electric Barrier: Estimated Changes to Standard BR Lock Operations Due to Maintenance, Repair, Rehabilitation, and/or Replacement of ANS Controls[a,b]

Estimated Changes	Electric Barrier
Estimated Closure Duration (Replacement of Electrodes and Parasitic Assumed to Occur 25 Years After Construction of Electric Barrier)	8 hours
Estimated Frequency	5 days/week
Number of Calendar Days Change Would be in Effect	60 days

[a] Changes to standard BR Lock operations were estimated using best-available engineering information at the time of the navigation economic analysis. The following ANS controls are not expected to require additional MRR&R that would impact navigation: nonstructural, engineered channel, water jets, complex noise, or the flushing lock.

[b] A major rehabilitation of BR Lock is assumed to occur in year 2030, with an estimated closure duration of approximately 30 days. This would occur with or without implementation of a GLMRIS-BR project, and is therefore included in both the with-project and without-project conditions.

Estimated Changes to BR Lock Average Processing Time, Average Delay Time, and Average Total Transit Time. Due to changes in standard BR Lock operations to accommodate the construction and subsequent OMRR&R of ANS control measures, changes to transit time is anticipated. Transit time is the sum of processing time and delay time. Processing time is the time related to the actual lockage process. Delay time is the time period between when a vessel arrives at the lock and when the lock is ready to begin processing that vessel.

Construction Period. The estimated changes in average processing time, average delay time, and average total transit time the No New Federal Action Alternative, as well as the Technology Alternative – Complex Noise with Electric Barrier during construction, are presented in Table 6-38.

The estimated average processing time, average delay time, and average total transit time during construction of the Technology Alternative – Complex Noise with Electric Barrier less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time during construction of Technology Alternative – Complex Noise with Electric Barrier.

Full Operations. The changes in average processing time, average delay time, and average total transit time the No New Federal Action Alternative, as well as the Technology Alternative – Complex Noise with Electric Barrier, are presented in Table 6-39.

The estimated average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Complex Noise with Electric Barrier less those estimated for the No New Federal Action Alternative yield the estimated increases in average processing time, average delay time, and average total transit time for the fully operating Technology Alternative – Complex Noise with Electric Barrier.

Table 6-38 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Construction Period of Technology Alternative – Complex Noise with Electric Barrier[a]

Alternative	Tonnage	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Complex Noise with Electric Barrier (TACNEB)	11,745,595	1.09	3.27	4.36
	11,745,595	1.09	1.52	2.61
	11,745,595	1.20	1.88	3.08
No New Federal Action (NNFA)	11,745,595	1.09	1.01	2.10
Time Increases During Construction of TACNEB = TACNEB – NNFA		0	2.26	2.26
		0	0.51	0.51
		0.11	0.87	0.98

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics; Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

Table 6-39 Estimated Average Processing Time, Average Delay Time, and Average Total Transit Time During Full Operation of Technology Alternative – Complex Noise with Electric Barrier and No New Federal Action Alternative[a]

Alternative	Tonnage	Processing Time (Hours)	Delay (Hours)	Total Transit Time (Hours)
Technology Alternative – Complex Noise with Electric Barrier (TACNEB)	11,745,595	1.27	3.27	4.54
No New Federal Action (NNFA)	11,745,595	1.09	1.01	2.10
Time Increases During Full Operations of TACNEB = TACNEB - NNFA		0.18	2.26	2.44

[a] The modeling process, underlying assumptions, and various other details of the capacity analysis can be found in Appendix D, Economics; Attachment 1, Capacity Analysis. The times are expressed in terms of the average time at the 2015 Lock Performance Monitoring System (LPMS) tonnage level.

6.12 Alternative Plan 6: Lock Closure Alternative

6.12.1 Alternative Plan Description

The Lock Closure Alternative includes the following measures: (1) nonstructural measures, (2) lock closure (physical barrier) and (3) boat launches (Table 6-40 and Figure 6-40).

Table 6-40 Measures for the Lock Closure Alternative

Location	Measure	Controlled Modes of ANS Transport
Brandon Road Lock and Approach Channel	Lock closure	Floaters, swimmers, hull foulers
	Boat launches	Supporting measure
GLMRIS-BR Illinois Waterway Study Area	Nonstructural	Swimmers

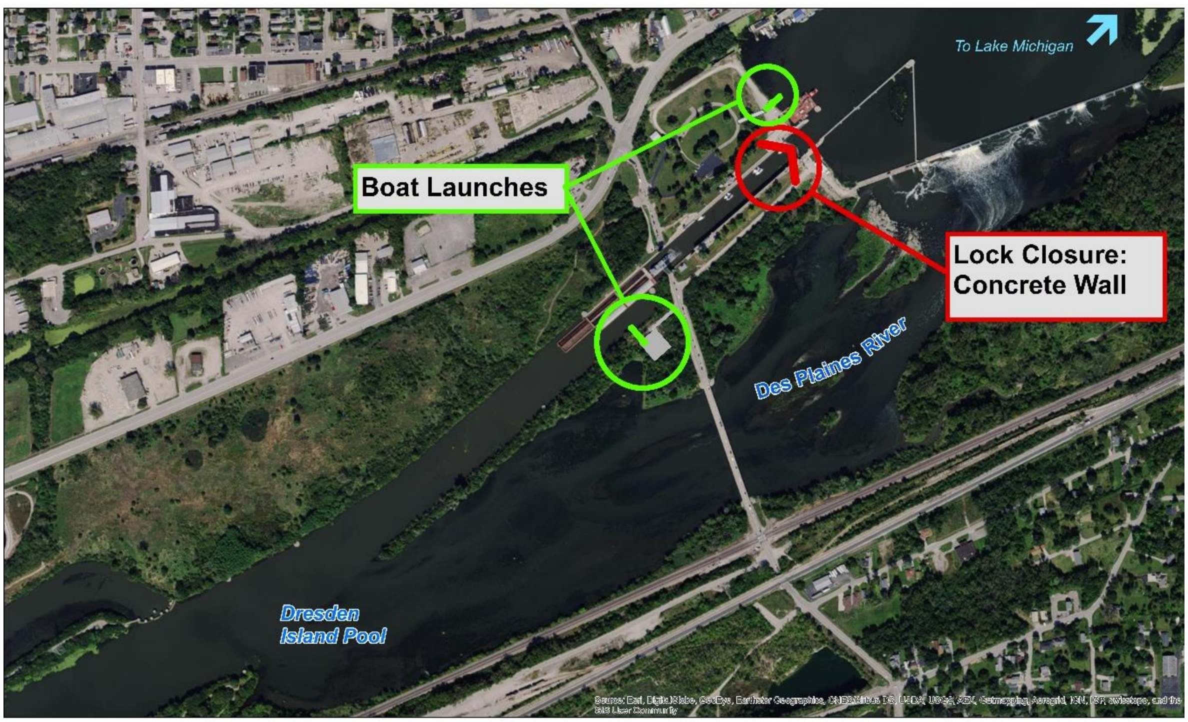

Figure 6-40 Aerial View of BRLD with Potential Layout of Lock Closure Alternative

This alternative includes nonstructural measures and establishes a structural control point at BRLD. These technologies reduce the P(establishment) of Asian carp and *A. lacustre* in the GLB. The goal of the nonstructural measures is to keep the population of Asian carp at current or reduced levels. Refer to Section 6.3.1, Nonstructural Measures, for details on the measures that would be implemented. Based on input received during the expert elicitation, the effectiveness of the management system at preventing the establishment of Asian carp in the GLB is indirectly related to the population size below BRLD. The lock would be closed once the project was authorized. After which, a concrete wall on the upstream end of the lock would be poured.

For more information regarding the measures, please refer to Section 6.3, Measures for Alternative Formulation. Additional study and field evaluations are needed to further refine this alternative.

6.12.2 Probability of ANS Establishment

Figures 6-41 and 6-42 show the estimated P(establishment) for Asian carp and *A. lacustre*, respectively, under the Lock Closure Alternative based on inputs provided by each expert. Tables 6-41 and 6-42 include the P(establishment) summary calculated for the composite expert for Asian carp and *A. lacustre*, respectively. The experts believed there is some positive probability Asian carp could become established before the lock could be closed. After closure, if there has been no establishment, the probability of establishment through the CAWS drops to zero. This alternative halts navigation. However based on historic sampling data, the experts believed there was some probability that *A. lacustre* may have already established in the GLB before lock closure occurs. Therefore, this alternative results in a relatively small reduction in the *A. lacustre* P(establishment) estimate when compared to the P(establishment) estimate for the No New Federal Action Alternative. It is important to note that an expert elicitation does not create new knowledge, and it is not appropriate to treat an elicited value, range of values, or distribution of values as “a fact.”

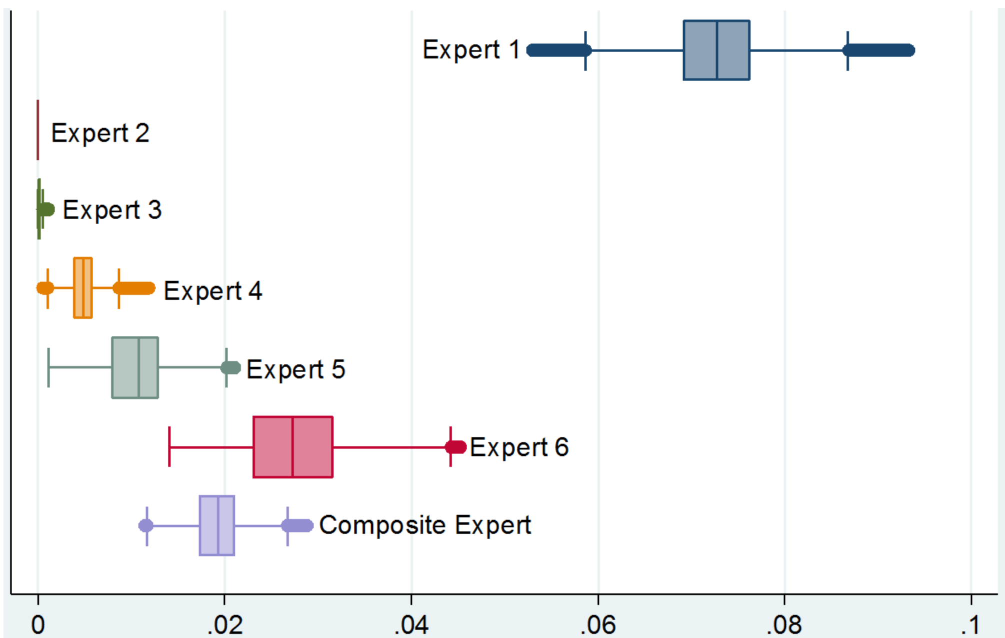

Figure 6-41 Asian Carp P(Establishment) 2071 Values for All Five Experts and the Composite Expert under the Lock Closure Alternative

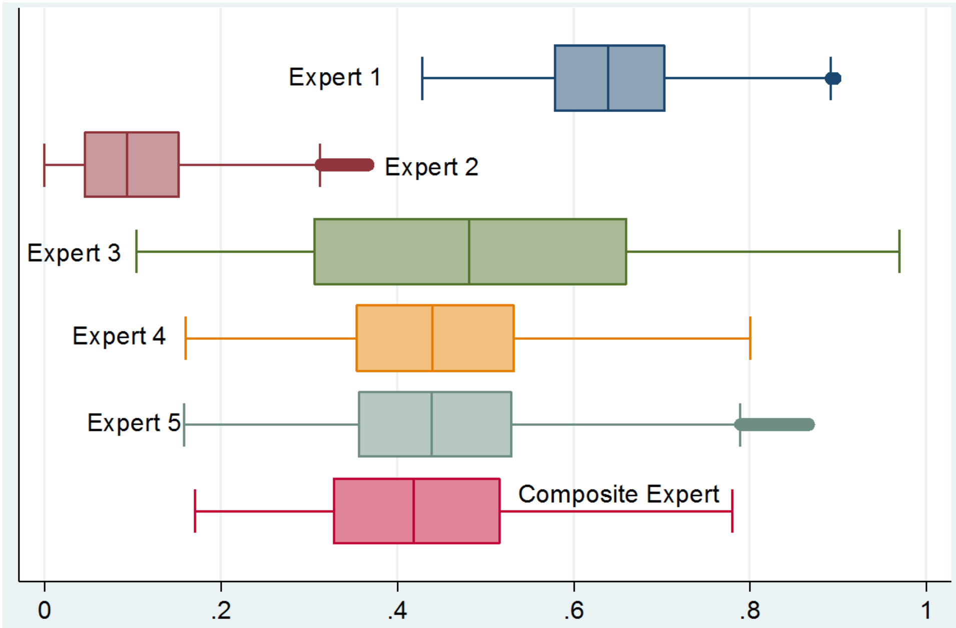

Figure 6-42 *A. lacustre* P(Establishment) 2071 Values for All Five Experts and the Composite Expert under the Lock Closure Alternative

Table 6-41 Asian Carp P(Establishment) 2071 Values for the Composite Expert under the Lock Closure Alternative

Alternative	P(Establishment) Minimum	P(Establishment) Median	P(Establishment) Maximum
Lock Closure Alternative	0.01	0.02	0.03

Table 6-42 *A. lacustre* P(Establishment) 2071 Values for the Composite Expert under the Lock Closure Alternative

Alternative	P(Establishment) Minimum	P(Establishment) Median	P(Establishment) Maximum
Lock Closure Alternative	0.17	0.42	0.78

Asian Carp

The P(establishment) estimates calculated from the inputs of five of the six experts suggest establishment is unlikely or highly unlikely under the Lock Closure Alternative (Figure 6-41). The P(establishment) estimate is lowest using inputs from experts 2, 3, 4, and 5, and highest using inputs from expert 1. Inputs from expert 6 leads to estimates between these extremes, but closer to the lower probability estimates. P(establishment) for experts 3, 4, and 5 show minimal variation.

The uncertainty about the composite expert estimate, calculated by averaging the CDFs for the six experts, of P(establishment) lies between 1% and 3% with a median value of 2% (Table 6-41).

A. lacustre

The P(establishment) estimate calculated using inputs from expert 1 suggests the greatest probability of establishment, while data from expert 2 indicate a lower P(establishment) (Figure 6-42). The median P(establishment) for experts 3, 4, and 5 is between these two extremes. There is large uncertainty in the P(establishment) values estimated for most of the experts as indicated by the width of the box and whisker plots.

The composite expert distribution, calculated by averaging the CDFs for the five experts, most resembles that of experts 4 and 5. The uncertainty about the composite expert estimate of the P(establishment) lies between 17% and 78% with a median value of 42% (Table 6-42).

6.12.3 Relative Life Safety Risk

For the Lock Closure Alternative, no additional navigation travels through the BR Lock and there are no measures that would have an impact on USACE staff present in the USACE buildings adjacent to the lock or other waterway users or uses. As such, the Lock Closure Alternative is rated as having a low life safety risk in comparison to the other GLMRIS-BR alternatives. Indirect effects associated with this alternative, including potential mode shifts from the waterway to area rails and roadways, are discussed in Chapter 7, Impacts of Alternative Plans. The analysis discusses the potential impacts on life safety associated with those mode shifts.

6.12.4 System Performance Robustness

System performance robustness has been evaluated as an alternative’s robustness to address current and future ANS threats in the waterway:

1. This alternative has the ability to add future or modified nonstructural measures in response to changed conditions.

2. This alternative does not include a platform for future structural measures.

3. This alternative includes two structural control points within the GLMRIS-BR Illinois Waterway Study Area: the proposed one at BRLD and the current one at CSSC-EB.

4. This alternative controls the swimming, floating, and hitchhiking modes of transport. Lock Closure in combination with the CSSC-EB provides two structural control points in the system.

6.12.5 Estimated Alternative Costs

The Lock Closure Alternative includes construction costs estimated to equal $5,900,000. The nonstructural measure component of this alternative is estimated to cost $9,200,000 per year and is the lowest nonstructural component cost when compared with the other alternatives because of lock closure’s effectiveness. Nonstructural continues to be an important component of this alternative as well because a large population below BRLD is a concern for increased likelihood of transfer from non-aquatic pathways. The yearly OMRR&R costs are estimated at $20,000 to maintain the boat launches (see Table 6-43).

Table 6-43 Estimated Costs of the Lock Closure Alternative

Element	Estimated Cost
Construction[a]	$5,900,000
Nonstructural[b]	$9,200,000
OMRR&R[b]	$20,000

[a] Costs are provided as total cost, present value (project first costs).
[b] Costs are provided as average annual costs.

6.12.6 Estimated Alternative Implementation Duration

The nonstructural component of the Lock Closure Alternative would be implemented toward the end of calendar year 2020, assuming authorization for construction is received early in fiscal year 2021 and capability funding is received for planning, design, and construction of the alternative. The lock would be closed, upon authorization, at the end of calendar year 2020. Construction of the concrete lock closure features and boat launches would be completed by the end of calendar year 2023. See Figure 6-43 for the estimated construction timeline.

Figure 6-43 Estimated Construction Timeline for the Lock Closure Alternative

6.12.7 Impacts on Navigation (NED Costs)

The Lock Closure Alternative would not allow for navigation to continue through the BRLD. This alternative would negatively impact navigation, and result in higher transportation costs (NED costs). Based on the navigation economic analysis completed in support of GLMRIS-BR, the average annual increase in transportation costs (NED costs) for the 50-yr period of analysis (2021–2070) were estimated at $318,700,000 (2016 prices).

For the Lock Closure Alternative, increases in transportation costs (NED costs) are attributed to the permanent closure of Brandon Road Lock and Dam.

Additional information about the Lock Closure Alternative can be found in Appendix D, Economics.

Chapter 7 Impacts of Alternative Plans*

This chapter discusses the effects on the existing environment that are expected from implementation of each proposed alternative. The assessments of environmental effects are organized by evaluating the No New Federal Action Alternative and the following action alternatives (Table 7-1):

- Nonstructural Alternative
- Technology Alternative – Electric Barrier
- Technology Alternative – Complex Noise
- Technology Alternative – Complex Noise with Electric Barrier
- Lock Closure

The No New Federal Action Alternative is expected to be the baseline condition; therefore, any impacts as a result of implementation of an action alternative would be above and beyond those discussed for the No New Federal Action Alternative. The potential affected environment is described in detail in Chapter 4, Affected Environment (Existing Conditions).

The indirect and cumulative analyses were prepared in accordance with the requirements of NEPA and guidance from the CEQ, *Considering Cumulative Effects under the National Environmental Policy Act*. The CEQ defines direct, indirect, and cumulative impacts as:

- **Direct impacts** are caused by the action and occur at the same time and place (40 CFR §1508.8[a]).

- **Indirect impacts** "are caused by an action and are later in time or further removed in distance but are still reasonably foreseeable." (40 CFR §1508.8[b]). They may include growth-inducing effects related to changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems. Indirect impacts associated with GLMRIS-BR alternatives are those that affect the natural or built environment beyond the immediate "footprint" of the alternatives. An example of an indirect impact is the potential reduction species reestablishment within a historic river system due to the loss of connectivity between that historic river system and river systems with source populations.

Table 7-1 Reference for Discussion of Alternatives throughout Chapter 7

Alternative	Category (Action or No Action)	Acronym
No New Federal Action	No Action	NNFA
Nonstructural Alternative	Action Alternative	NSA
Technology Alternative – Electric Barrier	Action Alternative	TAEB
Technology Alternative – Complex Noise	Action Alternative	TACN
Technology Alternative – Complex Noise with Electric Barrier	Action Alternative	TACNEB
Lock Closure	Action Alternative	LCA

- **Cumulative impacts** "results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." (40 CFR §1508.7). They can result from individually minor but collectively significant actions taking place over a period of time. For example, degradation of a stream's water quality by several developments that taken individually would have minimal effects, but collectively would cause a measurable negative impact is considered a cumulative effect. The cumulative effects of an action may be undetectable when viewed in the individual context of direct and even indirect impacts, but nonetheless can add to other disturbances and eventually lead to a measurable environmental change.

The assessment of direct, indirect, and cumulative effects looked at potential impacts on the GLMRIS-BR System-Wide Study Area (Figure 1-3); however, a majority of the potential impacts identified were concentrated in the GLMRIS-BR Site-Specific Study Area (Figure 1-5). Therefore, the following discussions of the potential impacts focus on the GLMRIS-BR Site-Specific Study Area. Discussions on the GLMRIS-BR Illinois Waterway Study Area (Figure 1-4) and GLMRIS-BR System-Wide Study Area are only included if potential impacts were identified that would extend to the wider bounds of the study area. The affected environment and reasonably foreseeable actions were identified in Chapter 4, Affected Environment (Existing Conditions). The project design year (assumed to be 2021) was used to analyze indirect and cumulative impacts.

The 17 points defined in Section 122 of the Rivers, Harbors & Flood Control Act of 1970 (P.L. 91-611) include noise, displacement of people, aesthetic values, community cohesion, desirable community growth, tax revenues, property values, public facilities, public services, desirable regional growth, employment, business and industrial activity, man-made resources, displacement of farms, natural resources, air, and water. These 17 points are addressed throughout this chapter under the specific environmental resource.

Direct impacts of the alternative plans at the GLMRIS-BR Site-Specific Study Area are discussed. Thus, only impacts on the resources within the immediate vicinity of the BRLD are discussed. Indirect impacts and cumulative impacts are discussed at the larger scale (i.e., GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area); hence, impacts on the resources of the MRB and GLB are discussed. In terms of short-term and long-term impacts, short-term impacts are those that are expected to occur during construction of an alternative and are not expected to last throughout the planning period of analysis. Long-term impacts are those that are expected to occur once construction is complete, and are expected to have some degree of impact throughout the planning period of analysis.

7.1 Physical Resources

7.1.1 Climate

No New Federal Action Alternative

Normal operation and maintenance activities at the BRLD are expected to continue through the planning period of analysis. Maintenance activities could include dredging, which may be necessary to maintain the regulated 9-ft (2.7-m) channel depth for navigation. In addition, repairs or updates to the components of the lock (e.g., lock chamber, lock gates, and motors) and/or the downstream approach channel walls may be necessary during the planning period of analysis. Monitoring activities conducted under the annual MRWG MRP are also expected to continue through the planning period of analysis, albeit at a reduced level of effort in light of uncertainties associated with the availability of future appropriations and allocation decisions. All of the aforementioned activities require the use of vehicles and vessels and the consumption of energy (e.g., electricity, fossil fuels) to some degree, which could have a negative impact on the regional climate. However, the energy consumed, on a regional scale, is not expected to be significant; therefore, no short- or long-term direct or indirect impacts on climate are expected with the NNFA.

Action Alternatives

The NSA is not expected to have any short- or long-term direct or indirect impacts on climate. As part of the NSA/nonstructural measures, contracted commercial fishing effort is increased (potentially doubled or tripled depending upon the year and active risk management) within the upper IWW. However, the increased contracted commercial fishing does not necessarily translate to additional vessels being on the water. The increased contracted commercial fishing could mean that the same number of crews under the NNFA are on the water, but more frequently. The contracted commercial fishing effort also requires contractors to pick up the harvested fish to be properly disposed of. Due to the increased commercial fishing effort and potentially increased catches, this could result in increased trips by contractors from the pick-up location to the disposal site. Also under the NSA, monitoring for *A. lacustre*, which currently does not occur, would be conducted. This effort is expected to require minimal additional vessels (e.g., 1–2) and towing vehicles. The NSA also includes the construction of two boat launches within the vicinity of the BRLD. Only minimal excavation is anticipated to shape the land at these sites, and dump trucks would be necessary to transport the gravel used for construction of the launches. While the aforementioned activities under the NSA potentially require the increased use of electricity and/or fossil fuels, the energy consumed on a climatic scale is not expected to be significant.

The TAEB is not expected to have any long-term direct or indirect impacts on climate. Additional electricity and fossil fuels would be needed during the construction of the alternative measures, which are expected to have a negative short-term localized impact. Once the components of the alternative are constructed, additional electricity and fossil fuels would be needed to run the electric barrier, water jets, and associated operation buildings. The flushing lock component is not expected to need any additional electricity and/or fossil fuels above those required under the NNFA. In addition, the TAEB includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, while construction and operation of the TAEB are expected to require increased use of electricity and/or fossil fuels, the energy consumed on a regional scale is not expected to be significant. (Note that the electricity impact is attributed to the generator, so that increased electricity consumption associated with this action and any climate change related to that does not count as a direct impact from the alternative.)

The TACN is not expected to have any indirect impacts on climate. Additional electricity and fossil fuels would be needed during the construction of the alternative measures, which are expected to have a negative short-term localized impact. As described under the TAEB, additional electricity and fossil fuels would be needed during construction and operation of the various components of the alternative. Additional electricity and fossil fuels would also be needed during the long-term operation of the water jets and complex noise components. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, while construction and operation of the TACN are expected to require increased use of electricity and/or fossil fuels, the energy consumed on a regional scale is not expected to be significant.

The TACNEB is a combination of the TAEB and TACN, whose impacts were discussed above. In addition, the TACNEB includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, while construction and operation of the TACNEB are expected to require increased use of electricity and/or fossil fuels, the energy consumed on a regional scale is not expected to be significant.

The LCA has the potential to have short-term direct impacts and long-term indirect impacts on regional climate. Additional electricity and fossil fuels would be needed during construction of the LCA, which is expected to have a negative short-term localized impact. The LCA is not expected to have a long-term direct impact on regional climate since it does not require the continued operation of the BR Lock. However, there could be potential adverse long-term indirect impacts from implementation of the LCA on the regional climate, as there is the potential for a modal shift to less efficient modes of transportation within the region. For example, one standard dry cargo barge can move as much cargo as 16 rail cars or 70 tractor trailers (Kruse et al. 2012). In addition, barges can move 1 ton of cargo 576 mi (927.0 km) for the same amount of fuel as it takes a rail car to carry the same amount of cargo 413 mi (664.7 km), and a tractor trailer to transport it 155 mi (249.4 km) (Kruse et al. 2012). Due to a potential shift from barge transport (i.e., due to some barge companies potentially closing) to rail car and tractor trailer transportation, it would be anticipated that greenhouse gas (GHG) pollutant mass would increase some; the amounts, however, would not be regionally significant (i.e., a very small percentage of what is currently emitted in the region). The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

In general, the technology alternatives (i.e., TAEB, TACN, and TACNEB) that have the highest energy uses overall are expected to have the highest GHG emissions. It is anticipated that an electric barrier, including the other features of an alternative with an electric barrier, would have the highest electricity usage. Although the electricity generator would be the one to account for the GHG generation, alternatives with an electric barrier could be viewed as having the highest GHG emissions of the technology alternatives. Similarly, the LCA, while not using energy itself, would cause a mode shift to higher fuel usage transportation alternatives, which would result in generally higher GHG emissions. The magnitude of GHG emissions was not calculated, but it can be inferred from fuel usage and criteria pollutant emissions.

7.1.2 Geologic Setting

No New Federal Action Alternative

No short-term or long-term direct or indirect impacts on the geologic setting are expected with the NNFA. It is important to note that the GLMRIS-BR Site-Specific Study Area has already been impacted from the construction of the BRLD in the late 1920s, early 1930s. The NNFA is expected to only include nonstructural measures throughout the planning period of analysis. Nonstructural measures do not include any construction activities, which could potentially affect area geology, unique geologic features, or geological processes.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on the geologic setting of the GLMRIS-BR Site-Specific Study Area. The majority of the measures are nonstructural and do not require any construction activities that could potentially affect the area's geologic setting. The construction of two boat launches is included in the NSA, which would require minimal excavation to shape the land at these sites. Gravel would then be placed to achieve the correct slope for the launches. Overall, no impacts on unique geologic features or processes are anticipated with this action.

The TAEB is expected to have only minor, localized direct impacts, and no long-term or indirect impacts on the geologic setting of the GLMRIS-BR Site-Specific Study Area. The construction of the engineered channel would require controlled blasting of the limestone bedrock in the downstream approach channel of the BRLD. Precast concrete walls are being placed along the bottom of the downstream approach channel and channel side slopes, and in order to maintain a 9-ft (2.7-m) draft within the channel for navigation purposes, the current channel walls and channel bottom would need to be excavated. The blasting within the approach channel is expected to remove approximately 5 ft (1.5 m) of bedrock from the downstream approach channel walls, 3 ft (0.9 m) of bedrock from the majority of the channel bottom, and 5 ft (1.5 m) of bedrock from the channel bottom where the electric barrier would be located. Controlled blasting to deepen and widen the downstream approach channel at the BR Lock could include potential impacts such as fractures to the surrounding bedrock. Impacts on the surrounding bedrock could potentially be minimized by a properly designed controlled blasting plan. The flushing lock component would require new port holes, which would be constructed by line drilling and diamond wire saw cutting the opening, or by line drilling and impact removal. Components of the electric barrier and water jets would be anchored into the constructed engineered channel and would not require any excavation and/or controlled blasting for their placement. Buildings would also need to be constructed upland to house the operating equipment necessary for the water jets and electric barrier. The TAEB also includes the construction of a new mooring location approximately 1.8 mi (2.9 km) downstream of the BRLD. The proposed mooring location would include four moorings that are large circular structures made of sheet pilings, and would be typical of mooring cells found elsewhere along major waterways. The proposed mooring cells would be approximately 400 ft (121.9 m) apart for tow docking and staging adjacent to the IWW (Des Plaines River reach) between IWW river miles 276 and 285. The new mooring location would require dredging and the construction of the aforementioned four mooring cells. Finally, the TAEB includes the nonstructural measures that were discussed under the NSA.

The TACN is expected to have only minor, localized direct impacts, and no long-term or indirect impacts on the geologic setting of the GLMRIS-BR Site-Specific Study Area. This alternative plan would include all of the measures in the TAEB, except for the electric barrier and new mooring location. The potential impacts on the geologic setting for these measures were discussed above under the TAEB. In addition, the TACN would include complex noise, but similar to water jets, the components of this feature would be anchored into the constructed engineered channel and would not require any excavation and/or controlled blasting for their placement. The complex noise measure would also require a building to be constructed upland that would house operating equipment. Finally, the TACN includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is a combination of the TAEB and TACN, whose impacts were discussed above. In addition, the TACN includes the nonstructural measures whose potential impacts were discussed under the NSA. Overall, the TACNEB requires controlled blasting and the construction of various measures, which are expected to have only minor, localized direct impacts, and no long-term or indirect impacts on the geologic setting of the GLMRIS-BR Site-Specific Study Area.

The LCA is not expected to have any short-term or long-term direct or indirect effects on the geologic setting of the GLMRIS-BR Site-Specific Study Area. This alternative does not include any controlled blasting or excavation activities that could impact bedrock within the vicinity of the BRLD. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.3 Soils

No New Federal Action Alternative

The GLMRIS-BR Site-Specific Study Area is considered degraded since it was initially impacted by the construction of the BRLD in the late 1920s, early 1930s. The NNFA maintains the status quo of BRLD operations and routine maintenance activities, which are not expected to have any short-term or long-term direct or indirect effects on the composition of soils within the area, which were previously disturbed.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on the soil composition of the GLMRIS-BR Site-Specific Study Area. The majority of the measures are nonstructural and require no construction activities in upland areas that could potentially affect area soils. Construction of the two boat launches under the NSA would require minor excavation. Gravel would be placed in order to achieve the appropriate slop for the launches. Where the gravel is placed, underlying soils could potentially be compacted, which, in turn, could impact the capability of these soils for infiltration of precipitation. Short-term direct impacts on soils would result from the minor excavation for the boat launches, which would likely remove the top layer of soil at these sites. In addition, a long-term direct impact on soils where the gravel is placed could be expected; however, the impact is expected to be small and localized to the areas around and under the boat launches.

The TAEB is not expected to have any short-term or long-term direct or indirect impacts on soil composition within the area. As discussed in Section 7.1.2, Geologic Setting, construction activities would primarily disturb bedrock. This alternative would also include approximately three to four operational support facilities to house the operating equipment necessary for the various technologies, as well as, for example, associated access roads and parking for implementation. These building are expected to be located on the right descending bank of the BRLD and cover approximately 1 to 3 ac (0.4–1.2 ha). Additional impervious surface (i.e., beyond the approximately 1–3 ac [0.4–1.2 ha]) could be placed, depending on the results of a pending site investigation; the site may contain materials which require a temporary or permanent cover. A site investigation to characterize soils has not yet been conducted; however, review of historical aerials indicates that soils within the property may already be impacted due to past uses. Therefore, construction of the operation support buildings is not expected to impact soil composition at the site. Construction of the operational support facilities and associated other features (e.g., access roads and parking) is anticipated to cause compaction of the soils within the area as well as potentially cover soils (i.e., between 1 and 45 ac [0.4 and 18.2 ha]). Compaction of soils and/or covering of soils would reduce infiltration and increase runoff. Also included in the TAEB are nonstructural measures whose potential impacts were discussed under the NSA.

The TACN is not expected to have any short-term or long-term direct or indirect impacts on soil composition within the area. This alternative plan would include all of the measures in the TAEB, except for the electric barrier and new mooring location. The potential impacts on soils for these measures were discussed above under the TAEB. In addition, the TACN would include complex noise, but similar to water jets, the components of this feature would be anchored into the constructed engineered channel and would not impact soils within the area. The complex noise measure would also require a building to be constructed upland that would house operating equipment. The location of the building and potential impacts on soils were discussed under the TAEB. In addition, the TACN includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, the TACN is not expected to have any impacts on soil composition.

The TACNEB is a combination of the TAEB and TACN, the impacts of which were discussed above. In addition, the TACNEB includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, the measures associated with the TACNEB are not expected to have any short-term or long-term direct or indirect effects on soils within the GLMRIS-BR Site-Specific Study Area.

The LCA is not expected to have any short-term or long-term direct or indirect effects on soils within the GLMRIS-BR Site-Specific Study Area, since it would not include ground-disturbing activities. Construction associated with closure of the lock would include pouring a concrete wall on the upstream end of the lock. All of the soils within these areas, if even present, have already been impacted by construction of the BRLD and are not expected to be impacted further from implementation of the LCA. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.4 Hydrology and Hydraulics

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on hydrology and hydraulics. This alternative plan assumes continued operation of the BR Lock and the continuation of some nonstructural measures. Since the hydraulics of the upper IWW have already been impacted by construction of the BRLD and other control structures in the late 1920s, early 1930s, activities under the NNFA are not expected to impact hydrology or hydraulics within the GLMRIS-BR Site-Specific Study Area.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on current hydrologic and hydraulic functionality of the GLMRIS-BR Site-Specific Study Area. Construction of the boat launches, under the NSA, are not expected to have an impact on flood stages. If selected, additional details would be developed, and a hydraulic evaluation would be performed to ensure the boat launches comply with all applicable floodway construction requirements.

The TAEB is not expected to have any short-term or long-term direct or indirect impacts on hydrology or hydraulics within the GLMRIS-BR Site-Specific Study Area. Components of the electric barrier (e.g., electrodes, parasitics, and other subsurface elements) are not expected to impede flow or alter the water level of the waterway, nor is operation of the electric barrier expected to affect in-channel flow conditions. Similarly, components of the water jets are not expected to impede flow or alter the water elevation of the waterway. Water levels in the pool downstream of the BRLD (i.e., Dresden Island Pool) are not expected to be impacted by the water jets, since water drawn from the Dresden Island Pool to operate the water jets would then be discharged back into this same pool. The engineered channel is not expected to impede flow, since the channel would be blasted out to ensure that the current width and depth of the channel are maintained. The flushing lock component is not expected to impact water levels in the Dresden Island Pool. Both the Brandon Road Pool (located upstream of the BRLD) and the Dresden Island Pool (located downstream of the BRLD) are regulated pools which must maintain a 9-ft (2.7-m) navigational channel; therefore, the volume of water used to flush the lock could be limited by the volume available in the Brandon Road Pool (see Section 6.2.2, Structural Measures Flushing Lock, for discussion of operating considerations). In addition, stages in the Brandon Road and Dresden Island Pools are influenced by flow but are also heavily dependent on the operation of head gates and tainter gates at each dam. Operation of the flushing lock is not expected to significantly affect the flow rates or the ability to operate these gates; therefore, water levels are not expected to be affected. Water elevation of the waterway is likely to be affected by the flushing lock; however, the water level along the river has already been affected by operation of the lock, which has been occurring since 1933. The TAEB also includes construction of a new mooring location approximately 1.8 mi (2.9 km) downstream of the BR Lock in Dresden Island Pool. The new mooring location would require the construction of four new mooring cells. The mooring cells are not expected to have an impact on flood stages. If selected, additional details would be developed, and a hydraulic evaluation would be performed to ensure that the mooring location complies with all applicable floodway construction requirements. Lastly, the TAEB would also include nonstructural measures whose potential impacts were discussed under the NSA. Overall, no appreciable change from current water surface conditions, in-channel flow conditions, or pool stages would be expected.

The TACN is not expected to have any short-term or long-term direct or indirect impacts on hydrology or hydraulics within the GLMRIS-BR Site-Specific Study Area. This alternative plan would include all of the measures in the TAEB, except for the electric barrier and new mooring location. The potential impacts on hydrology and hydraulics for these measures were discussed above under the TAEB. In addition, the TACN would include complex noise; but similar to water jets, the components of this feature would be anchored into the constructed engineered channel and are not expected to impede flow or alter the water level of the waterway, nor is operation of the complex noise expected to affect in-channel flow conditions. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is a combination of the TAEB and TACN, the impacts of which were discussed above. In addition, the TACNEB includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, the measures associated with the TACNEB are not expected to have any short-term or long-term direct or indirect effects on hydrology or hydraulics within the GLMRIS-BR Site-Specific Study Area.

The LCA is not expected to have any appreciable effect on the hydrology or hydraulics within the GLMRIS-BR Site-Specific Study Area. Currently, during wet periods, conveyance of water through operation of the BR Lock is relatively small in volume when compared to the volume released by the head and tainter gates of the BR Dam. Under the LCA, conveyance of water through the BR Dam would still occur. Although relatively small, the loss of conveyance through lock empties could potentially be compensated for by minor gate change operations at the BR Dam. Overall, this would result in a more uniform flow within the GLMRIS-BR Site-Specific Study Area rather than a pulsing flow from lock empties. In addition, pool levels within the Dresden Island Pool (i.e., downstream of the BRLD) are not expected to be impacted by closure of the BR Lock. Pool elevation within the Dresden Island Pool is primarily regulated by the Dresden Lock and Dam. Flow within the downstream approach channel of the BR Lock would be affected by closure of the lock, which would become a stagnant backwater area; however, this is a man-made channel, and flows within this channel have already been impacted by the BR Lock. Nonstructural measures are also included in the LCA, the potential impacts of which were discussed under the NSA.

7.1.5 Limnology

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct impacts on limnology.[5] Based on the potential risk of establishment of Asian carp in the Great Lakes, the NNFA may have long-term indirect impacts on the Great Lakes' biological features. The potential consequences of these species if they were to become established are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. Overall, monitoring data from previously invaded systems have documented significant changes in resident fish species following Asian carp establishment. The results of the NOAA-GLERG modeling for Lake Erie indicate that these species have the potential to significantly alter the food web depending on Silver and Bighead Carp biomass, which could range from 10 to 34% of fish biomass in Lake Erie. These studies also suggest that Asian carp have the potential to become a dominant species in portions of the GLB with suitable habitat conditions. However, uncertainty exists as to the

[5] Limnology is the study of inland waters—lakes (both freshwater and saline), reservoirs, rivers, streams, wetlands, and groundwater—as ecological systems interacting with their drainage basins and the atmosphere. The limnological discipline integrates the functional relationships of growth, adaptation, nutrient cycles, and biological productivity with species composition, and describes and evaluates how physical, chemical, and biological environments regulate these relationships (ASLO 2015).

magnitude and extent of impacts if Bighead and Silver Carp were to become established in the GLB. There is general concern that if *A. lacustre* were to become established in the GLB, they could smother native mussel species and compete directly with them for food. It is important to note that *A. lacustre* is a hull-fouling species and currently the only alternative that would effectively address this species is the LCA. Other activities under the NNFA, such as monitoring, are expected to continue through the planning period of analysis, albeit at a reduced level of effort in light of uncertainties associated with the availability of future appropriations and allocation decisions during the planning period of analysis. Overall, these monitoring activities are not expected to have any direct impacts on the biological, chemical, or physical features of the Great Lakes. There are no lakes within the immediate vicinity of the GLMRIS-BR Site-Specific Study Area for which this would be applicable.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct impacts on limnology. None of the additional monitoring activities or other features (e.g., boat launches) proposed under the NSA would occur within the Great Lakes or within any lakes near the GLMRIS-BR Site-Specific Study Area.

The remaining action alternatives (e.g., TAEB, TACN, TACNEB, and LCA) include nonstructural measures whose potential impacts were discussed under the NSA. In addition, none of the other measures which comprise these alternatives would occur within the Great Lakes or within any lake near the GLMRIS-BR Site-Specific Study Area. Therefore, no short-term or long-term direct impacts on limnology are expected.

To the extent that each action alternative reduces the risk of establishment of Asian carp in the Great Lakes, the alternatives would have a beneficial, long-term indirect impact on the Great Lakes' biological features. For a discussion on the potential long-term indirect adverse impact on the Great Lakes' biological features based on the potential risk of establishment of Asian carp in the Great Lakes, refer to the NNFA.

7.1.6 Sediment Quality

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on sediment quality. Under the NNFA, nonstructural measures would continue within the GLMRIS-BR Site-Specific Study Area, as well as the Illinois Waterway Study Area, but at a reduced level. This alternative plan also assumes the continued operation of the BR Lock and the continuation of some nonstructural measures. Near the BRLD, there is little sediment in the man-made downstream approach channel, and the stony substrate is expected to remain. The aforementioned activities are not expected to involve construction activities that would impact sediment.

Action Alternatives

The NSA is not expected to have any long-term direct or indirect impacts on sediment quality of the GLMRIS-BR Site-Specific Study Area. The NSA includes nonstructural measures that would require construction of two boat launches. Construction of the boat launches could disturb nearshore sediment. Potential impacts on the sediment in the proposed boat ramp areas would be evaluated following the Inland Testing Manual (EPA and USACE 1998), as required for compliance with Sections 401 and 404 of the CWA.

The action alternatives TAEB, TACN, and TACNEB are not expected to have sediment quality impacts per se, although construction activities may cause sediment disturbances that would necessitate removal. Sediment in the mooring area or along the approach channel walls or other construction zones would be evaluated following the Inland Testing Manual (USEPA and USACE 1998), as required for compliance with Sections 401 and 404 of the CWA. It is assumed a priori that any sediment dredged from the canal would be placed at an upland disposal facility consistent with the level of anthropogenic compounds found during characterization. The action alternatives also include nonstructural measures, the potential impacts of which were discussed under the NSA.

The LCA includes nonstructural measures whose potential impacts were discussed under the NSA. The LCA also includes pouring a concrete wall on the upstream end of the lock to permanently close the lock and stop the passage of water (and vessels) through the chamber. The construction of the concrete wall would occur within the existing man-made concrete lock chamber, so that sediment within the GLMRIS-BR Site-Specific Study Area would not be impacted. Temporary construction impacts could be prevented by working within the dry; that is, within a dewatered lock chamber. Overall, permanent closure of the lock is not expected to impact the sediment environment in either the short or long term.

7.1.7 Water Quality

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on water quality. Activities associated with the NNFA for the most part do not involve the addition of chemicals, the use of processes that alter water quality, or any construction activities that would impact the water quality in the Site-Specific Study Area. The NNFA could potentially include the application of piscicide within portions of the Illinois Waterway Study Area, which occurred in 2009 and 2010 (Section 6.2.1, Nonstructural Measures). The piscicide, rotenone, is a natural substance that is registered by the EPA. Rotenone is relatively short-lived and has a half-life between 1.5 and 20 days in warm and cold water, respectively. In addition, rotenone can be deactivated with the subsequent application of potassium permanganate ($KMnO_4$). Overall, rotenone is not expected to have any short-term or long-term effects on water quality, since the piscicide acts directly on fish by inhibiting respiration at the cellular level, making it impossible for fish to use the oxygen absorbed in the blood and needed in the generation of energy during cellular respiration. It is important to note that use of rotenone has been determined to not be appropriate for the majority of the rivers and or locations (i.e., man-made channels with sufficient aquatic habitat to support diverse aquatic species assemblage) within the GLMRIS-BR Illinois Waterway Study Area, because of the quality of the habitat and aquatic species occurring there.

Action Alternatives

The NSA is not expected to have any long-term direct or indirect impacts on water quality. The nonstructural measures associated with the NSA for the most part do not involve the addition of chemicals or the use of processes that alter water quality that would impact the water quality in the Site-Specific Study Area. The NSA could also include the application of piscicide, which was discussed under the NNFA. The construction of two boat launches, as part of the NSA, could potentially have short-term, minor and localized direct impacts on water quality. The grading of slopes and placement of gravel for the boat launches could increase turbidity locally; however, the use of best management practices, such as erosion controls as required under the CWA, would prevent large-scale impacts. Construction of the boat launches and floating docks would require compliance with Sections 404 and 401 of the CWA.

The TAEB would involve construction in the BRLD downstream approach channel, lock chamber, and adjacent areas (upland and potentially in water near the approach channel or lock) to add energy imparting equipment (e.g., electric barrier and water jets) to the approach channel and lock. The addition of energy (i.e., electricity) to the water is not expected to cause a change to water quality; the energy added would not cause physical changes such as temperature impacts, nor cause other chemical changes. The use of water jets would add mixing to the downstream approach channel, which may increase dissolved oxygen levels if the approach channel is stagnant. The water jets would not be used continuously, so any improvement from oxygen transfer induced by the mixing caused with their use would be temporary. It is anticipated that this would be at best a small and localized improvement in water quality; this small benefit is not expected to translate into water quality improvements further downstream of the BRLD approach channel. Construction activities associated with the TAEB could potentially cause temporary localized impacts on water quality. To minimize impacts, construction activities would be conducted in compliance with Sections 404 and 401 of the CWA. The construction activities would include best management practices for minimizing localized impacts on water quality, such as erosion control, good practices during construction, and other standard practices already in use on navigational maintenance projects. Overall, these construction activities are expected to only have short-term direct impacts on water quality that would be considered localized and minor. The TAEB also includes the construction of a new mooring location, which would require dredging and construction of four new mooring cells, but would not include in-water placement of any dredged materials. During construction of the new mooring location, there would likely be increased turbidity; however, this would be a short-term direct impact lasting only the duration of the construction. The TAEB also includes nonstructural measures, the potential impacts of which were discussed under the NSA.

The TACN is expected to potentially have short-term direct impacts on water quality similar to those discussed for the TAEB. Although the TACN does not include the electric barrier or the new mooring location, it does include energy-imparting equipment, as well as the necessary construction for placement of technologies (i.e., water jets and complex noise). For a discussion of the potential impacts on water quality associated with operation and construction of the TACN, refer to the TAEB. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is a combination of the TAEB and TACN, and potential impacts on water quality were discussed above under these respective alternatives. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA includes nonstructural measures, the potential water quality impacts of which were discussed under the NSA. This alternative also includes pouring a concrete wall on the upstream end of the lock to permanently close the lock and stop the passage of water (and vessels) through the BR Lock chamber. The construction of the concrete wall would occur within the existing man-made concrete lock chamber, so that water within the GLMRIS-BR Site-Specific Study Area is not expected to be impacted. Temporary construction impacts would be prevented by working in the dry, within the dewatered lock chamber. The closure of the lock would represent a minor change in the flow patterns of the river. Most of the water passes over the existing dam, and this would not change. The lock operation is not associated with water quality impacts, and stopping the lock operation is not expected to be associated with water quality impacts. This local impact could be addressed using a sidestream aeration process, similar to the process used upstream on the CAWS, or the entire approach channel could be abandoned and filled to eliminate the potential for stagnant water. The impacts from a stagnant approach channel would be localized and are not expected to cause downstream or upstream water quality impacts. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.8 Air Quality

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on air quality. Current activities that could continue at a lower effort into the future are considered de minimis in terms of air emissions.

Action Alternatives

The NSA is not expected to have any long-term direct or indirect impacts on air quality. All equipment operation, activities, or processes performed by the USACE or partner agencies would comply with all federal, state, and local air emission and performance laws and standards, including worker health and safety laws and standards. The operation of nonroad internal combustion engines related to construction of the boat launches would only have a short-term and localized effect on air quality. Construction equipment used would meet all current environmental emission standards with clean burning diesel engines fired with low-sulfur fuel. Small marine vessel motor emissions are generally considered de minimis. Implementation of this alternative is not expected to have a significant impact on air quality.

The TAEB is not expected to have any long-term direct or indirect impacts on air quality. All equipment operation, activities, or processes performed by USACE or partner agencies would comply with all federal, state, and local air emission and performance laws and standards, including worker health and safety laws and standards. The operation of nonroad internal combustion engines related to construction would only have a short-term and localized effect on air quality. Construction equipment used would meet all current environmental emission standards with clean burning engines fired with low-sulfur fuel. Small marine vessel motor emissions are generally considered de minimis. (Electricity for the continuous operation of the electric barrier would be obtained from a commercial source, and emissions associated with the commercial generation of such electricity are difficult to quantify with regard to indirect impacts on air quality. Commercial power generators need to comply with applicable laws associated with air quality.) The addition of energy (i.e., electricity) to the water is not expected to create a change in air quality. The TAEB also includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, implementation of this alternative is not expected to have a significant impact on air quality.

The TACN is not expected to have any long-term direct or indirect impacts on air quality. All equipment operation, activities, or processes performed by the USACE or partner agencies would comply with all federal, state, and local air emission and performance laws and standards, including worker health and safety laws and standards. The operation of nonroad internal combustion engines related to construction would only have a short-term and localized effect on air quality. Construction equipment used would meet all current environmental emission standards with clean burning diesel engines fired with low-sulfur fuel. Small marine vessel motor emissions are generally considered de minimis. (Electricity for the operation of the complex noise would be obtained from a commercial source, and emissions associated with the commercial generation of such electricity are difficult to quantify with regard to indirect impacts on air quality. Commercial power generators need to comply with applicable laws associated with air quality.) The addition of energy (i.e., sound) to the water is not expected to create a change in air quality. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA. Overall, implementation of this alternative is not expected to have a significant impact on air quality.

The TACNEB is a combination of the TAEB and TACN, whose potential impacts on air quality are discussed under these respective alternatives. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA includes pouring a concrete wall on the upstream end of the lock, which would require the use of construction vehicles. All equipment operation, activities, or processes performed by the USACE or partner agencies would comply with all federal, state, and local air emission and performance laws and standards, including worker health and safety laws and standards. Construction equipment used would meet all current environmental emission standards with clean burning diesel engines fired with low-sulfur fuel. Small marine vessel motor emissions are generally considered de minimis. Implementation of this alternative is not expected to have a significant impact on air quality. During construction of the concrete wall, the operation of nonroad internal combustion engines would be expected to have only short-term localized impacts on the GLMRIS-BR Site-Specific Study Area. Beyond construction, closure of the lock could shift thousands of tons of commodities to land-based modes of transportation, which would indirectly affect air quality in the region. A General Conformity Determination (Appendix F, General Conformity for Clean Air Compliance) was prepared August 2016 to document determination of conformity for closure of the BR Lock, which would impact Cook, DuPage, and Will Counties in Illinois, and Lake and Porter Counties in Indiana. While closure of the BR Lock would potentially impact air quality by shifting barge traffic onto land, mobile source emissions estimated using EPA MOVES (Motor Vehicle Emission Simulator) models were found to be de minimis for criteria air pollutants. Based on these findings, closure of the BR Lock demonstrates conformity. This determination is subject to review by state and local authorities, and by the public. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.9 Noise

No New Federal Action Alternative

Under the NNFA, normal operation and maintenance activities at the BRLD are expected to continue through the planning period of analysis. Potential maintenance activities could include dredging, which may be necessary to maintain the regulated 9-ft (2.7-m) channel depth for navigation. In addition, repairs or updates to the components of the lock (e.g., lock chamber, lock gates, and motors) and/or the downstream approach channel walls may be necessary during the planning period of analysis. Monitoring activities conducted under the annual MRWG MRP are also expected to continue through the planning period of analysis, albeit at a reduced level of effort. All of the aforementioned activities require the use of noise-imparting equipment (e.g., vessels, vehicles, and operation and maintenance equipment); however, the continuance of these activities would create no appreciable increase in noise levels. Noise levels within the GLMRIS-BR Site-Specific Study Area are indicative of an industrialized/urban area.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on noise levels within the GLMRIS-BR Site-Specific Study Area. While the NSA does include additional nonstructural measures beyond the NNFA, these activities are not expected to appreciably increase noise levels. The construction of the boat launches would require the use of construction equipment to shape the land at these sites as well as for the placement of the gravel used to create the slope of the launches. However, the operation of this equipment would be short term and is not expected to increase noise levels in the industrialized/urban area.

The TAEB is not expected to have any long-term direct or indirect impacts on noise levels within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts could potentially occur during construction of the components of the alternative. Heavy machinery used during construction would impart noise above the NNFA; however, this would only be short term (lasting the length of the construction period) and localized (limited to the GLMRIS-BR Site-Specific Study Area). In addition, construction would include controlled blasting for the engineered channel, which would have localized direct impacts on noise levels while occurring. Potential impacts on local noise levels may potentially be minimized by a properly designed controlled blasting plan. No long-term direct impacts on noise levels are anticipated with the operation of the water jets or electric barrier. The water jets themselves are not expected to have an associated noise; however, the pumps required for the water jets will have requirements for the motors not to exceed the hazardous noise level of 85 decibels (dB). The electric barrier also has no associated noise based on observations from the CSSC-EB. The only potential source of increased ambient noise would be the operation of diesel-powered backup generators if utility power to the electric barrier were lost. If this occurred, it would be expected to only be a temporary increase in the ambient noise levels, lasting only as long as it takes to restore utility power to the electric barrier. Overall, the decibel level of the water jets and electric barrier is thought to be of low intensity and is not expected to appreciably increase ambient noise levels within the highly industrialized/urbanized area. This alternative also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACN is not expected to have any long-term direct or indirect impacts on noise levels within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts related to construction are similar to those discussed under the TAEB. Long-term direct impacts on noise levels due to operation of the water jets are discussed above under the TAEB. Instead of the electric barrier, the TACN includes the operation of complex noise. It is unknown at this time what decibel level the complex noise measure will feature, or what decibel level could potentially be heard above the water surface. However, complex noise would be designed to achieve the target sound profile throughout the water column while minimizing the sound emitted above the water's surface. Depending on its decibel level and frequency, sound escaping the water into the air may impact marine radio and cell phones communication between navigators and lock and control point personnel. When designing such a system, the strategy would focus on addressing possible reverberation, reechoed sound, from solid surfaces such as the lock gates to address sound escaping the water. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is not expected to have any long-term direct or indirect impacts on noise levels within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN. Potential short-term direct impacts as a result of construction and operation of the various technologies are discussed under the TAEB and TACN, respectively. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA could potentially have short-term and long-term direct impacts on noise levels within the GLMRIS-BR Site-Specific Study Area. Closure of the BR Lock would require construction equipment, and operation of that equipment would likely have a short-term impact on noise levels. Long-term impacts on noise levels could potentially include both a reduction of some noise sources and an increase in others. Closure of the lock may result in a reduction of vessels operating within the vicinity of the Study Area. In addition, noises associated with lock operations would cease with closure of the BR Lock (however, there would still be noises associated with the continued operation of the BR Dam). While there could potentially be a reduction in noise levels within the GLMRIS-BR Site-Specific Study Area, there may be an increase in other noise levels within the GLMRIS-BR Illinois Waterway Study Area. If some vessel operations do not continue to operate due to the closure of the lock, then those goods that were transported by those vessels would need to be carried by an alternative form of transportation (e.g. rail or tractor trailer). This could result in increased noise levels where these goods are transferred from the waterway to land (e.g., intermodal facility), and within the GLMRIS-BR Illinois Waterway Study Area as additional trucks and trains would likely be needed to transport the additional goods. For example, 1 standard dry cargo barge can move as much cargo as 16 rail cars or 70 tractor trailers (Kruse et al. 2012). The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.10 Land Use

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on land use within the GLMRIS-BR Site-Specific Study Area. There is no construction that could potentially impact land use associated with the nonstructural measures that are expected to continue, albeit at a reduced level. Response actions could occur within the GLMRIS-BR Illinois Waterway Study Area, which may require use of adjacent land for staging of the action; however, these events are relatively short in duration (e.g., average 5–10 days) and would ultimately not alter the designated land use.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on surrounding land uses. The NSA does include the construction of two boat launches; however, these boat launches would be constructed on USACE property and would not alter the designated land use that is open lands (Figure 4-11).

The TAEB is expected to have short-term and long-term direct impacts on land use within the GLMRIS-BR Site-Specific Study Area; however, these impacts are expected to be minor and localized. Tract 3 (Figure 7-1), adjacent to the right descending bank of the downstream approach channel, which is currently categorized as open land (Figure 4-11 and Figure 7-1), would be used for staging during construction of the in-channel features. Spoil piles from construction of the engineered channel would also be staged on this property. Overall, short-term direct impacts are not expected to alter the designated land use of the property. Long-term direct impacts on land use could potentially occur post construction. The property adjacent to the right descending bank of the downstream approach channel would contain operational facilities needed to run the in-channel technologies (e.g., electric barrier and water jets). This could potentially alter the land use from open lands to developed lands where the buildings are located. For the TAEB, it was estimated that approximately three to four operational support facilities would be needed, as well as, for example, associated access roads and parking for implementation. Therefore, approximately 1 to 3 ac (0.4–1.2 ha) of property for the operational support facilities would be cleared of vegetation. Additional impervious surface (i.e., beyond the approximately 1–3 ac [0.4–1.2 ha]) could be placed depending on the results of a pending site investigation; the site may contain materials which require a temporary or permanent cover. Overall, the amount of impervious surface could range from 1 to 45 ac (0.4–18.2 ha); therefore, the range of the impact due to loss of infiltration and increased runoff would vary. Regardless, it is not anticipated that a significant impact would occur, but rather a localized impact on runoff infiltration is expected.

The operation of the electric barrier continuously is not expected to have long-term direct impacts on surrounding land use as a result of stray current. American Petroleum Institute (API) Recommended Practice (2003) states that "the term stray current applies to any electrical current flowing in paths other than those deliberately provided for it." At the CSSC-EB, stray current was found on an adjacent pipeline (600 ft [182.9 m]), railroad (80 ft [24.4 m]), and bridge (120 ft [36.6 m]), and on the utility network directly connected to two of the barriers. The CSSC-EB pulse was measured at a distance as far as 1,700 ft (518.2 m) to the north, 3,400 ft (1,036.3 m) to the south, 500 ft (152.4 m) to the east, and 900 ft (274.3 m) to the west. The pulse traveled farther distances via the utility connected to two of the CSSC-EB's, a pipeline passing through the influence of the fish barriers, and the railroad.

At the BRLD, the influence of stray current was investigated for the tow haulage motors, BR lock gates, and the nearby BR lift bridge. Variable frequency drive (VFD) motors are used both upstream and downstream of the BR Lock to pull barges out of the lock. The source voltage and frequency of the VFDs

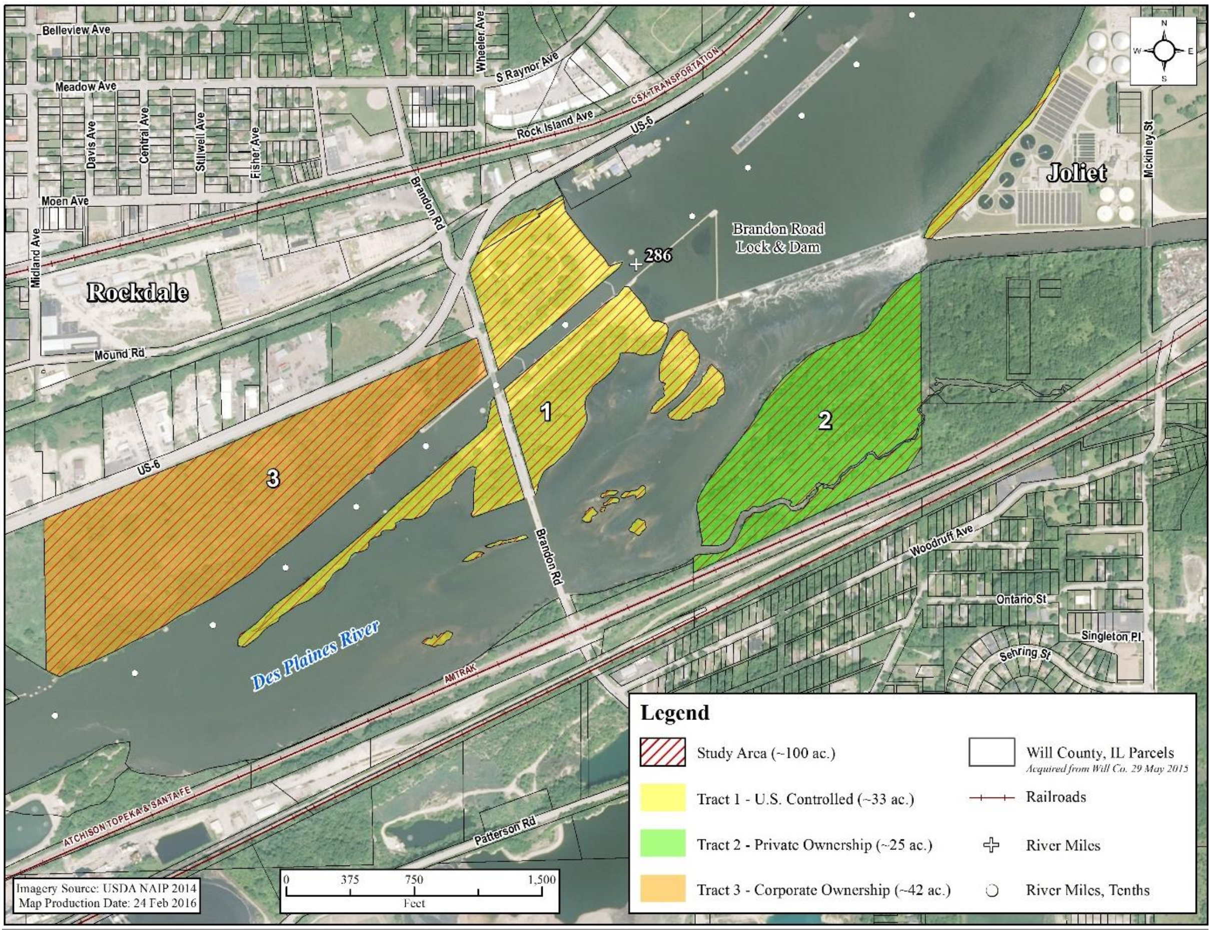

Figure 7-1 Aerial of Potential Location of Operational Support Facilities

is 480 volts (V), 60 Hertz (Hz). The system driver operates through a continuously changing frequency (VFD). The VFDs convert 480 V alternating current (AC), 60 Hz to DC, then back to variable frequency power to drive the winches (i.e., tow haulage units). The DC frequency can include 50 Hz, which is the same as the presently proposed frequency of the barrier at the BRLD. Though the motors at 1,400 ft (426.7 m) from the proposed barriers are likely to be within the influence of the barrier pulses, the motors are not expected to be influenced by the barriers. This is because the pulse amplitude will be greatly diminished at this distance, and the motors are not activated by detecting a frequency.

Regarding the lock gates, the 2-speed winding miter gate drive motors operate at 60 Hz, which is also similar to the proposed frequency of the barrier at the BRLD. However, the lock gates are approximately 2000 ft (609.6 m) from the proposed location of the electric barrier at the BRLD. In addition, similar to the motors, they are not activated by sensors that detect a frequency. Therefore, they are not expected to be interfered with by the proposed electric barrier. Finally, the BR lift bridge is approximately 1,800 ft (548.6 m) from the proposed location of the electric barrier at the BRLD. Similar to the motors and lock gates, the lift bridge does not require an electrical signal to operate. There are plans to operate the lift bridge gates via a signaling system in the future; however, the signal range is proposed to be between 900 megahertz (MHz) and 2.4 gigahertz (GHz), which is considerably farther away from the proposed frequency of the electric barrier at the BRLD. By comparison, the USACE has seen interference at the adjacent 430-Hz railroad signal in Romeoville, Illinois, that corresponds to the 12–13th harmonic of the present operating frequency of 34 Hz. An operating frequency of 900 MHz is about 2 million times greater than the frequency of the rail crossing signal influenced by the CSSC-EB. Therefore, it is not expected that the proposed barrier will interfere with the BR lift bridge signals. The proposed barrier should be energized via a power feed separate from the bridge and lock to reduce the likelihood of influencing adjacent facilities, such as the bridge and lock, via stray current through utility neutral or static lines. Overall, interference is not expected on the lock gates, drive motors, of the BR lift bridge (Appendix H, Engineering). However, testing and research, including coordination with controls manufacturers, will be necessary if stray current influences items such as computers. Should this occur, an uninterruptable power supply (UPS) may be used to mitigate this influence.

The TAEB also includes nonstructural measures whose potential impacts were discussed under the NSA. Construction of the new mooring location is not expected to have any short-term or long-term direct impacts on land use. Construction activities would occur within the waterway, and the use of the waterway would not be impacted by the development of the mooring location.

The TACN is expected to have short-term and long-term direct impacts on land use within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts related to construction are similar to those discussed under the TAEB. Long-term direct impacts would also be similar to the TAEB alternative, since operational facilities for the in-channel features (e.g., complex noise and water jets) would be needed on the Tract 3 (Figure 7-1) property adjacent to the right descending bank of the downstream approach channel. This could potentially alter the land use from open lands to developed lands where the buildings are located. For the TACN, it was estimated that approximately three to four operational support facilities would be needed, as well as, for example, associated access roads and parking for implementation. Therefore, approximately 1 to 3 ac (0.4–1.2 ha) of property for the operational support facilities would be cleared of vegetation. Additional impervious surface (i.e., beyond the approximately 1–3 ac [0.4-1.2 ha]) could be placed, depending on the results of a pending site investigation; the site may contain materials which require a temporary or permanent cover. Overall, the amount of impervious surface could range from 1 to 45 ac (0.4–18.2 ha); therefore, the range of the impact due to loss of infiltration and increased runoff would vary. Regardless, it is not anticipated that a significant impact would occur, rather a localized impact on runoff infiltration. It is not anticipated that the operation of the complex noise would have long-term direct impacts on land use. The engineered channel is expected to act as a buffer and contain the sound. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is expected to have short-term and long-term direct impacts on land use within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN. Potential short-term and long-term direct impacts on land use due to construction and operation of the various technologies are discussed under the TAEB and TACN, respectively. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA is not expected to have any long-term direct or indirect impacts on surrounding land uses within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts on land use could occur during construction; however, the current land use where staging would occur is considered developed. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.1.11 Displacement of Farms

No New Federal Action Alternative and Action Alternatives

There are no farms in the study area that would be impacted or displaced by the NNFA or action alternatives. The NNFA and NSA do not include construction activities that would require the displacement of farmland. Construction associated with the action alternatives also would not displace any farmland since the surrounding area is primarily developed or open land (Figure 4.11).

7.1.12 Natural Areas

No New Federal Action Alternative and Action Alternatives

There are no natural areas within the immediate vicinity of the BRLD that would be impacted by the NNFA or action alternatives. The surrounding area within the immediate vicinity of the BRLD is primarily developed or open land (Figure 4.11).

7.2 Biological Resources

7.2.1 Plant Communities

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. Plant communities within the vicinity of the BRLD and adjacent floodplain were altered with the urbanization and industrialization of the area, as well as hydrological modification (i.e., construction of the IWW 9-ft [2.7-m] System) of the waterways in late 1920s, early 1930s. Under the NNFA, response actions could occur within the GLMRIS-BR Illinois Waterway Study Area, which may require the use of adjacent land for staging of the event. Typically, these events last an average of 5 to 10 days, and staging areas occur on open gravel lots or open lots with turf grass. Therefore, nonstructural measures under the NNFA would not be expected to affect plant communities.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. The majority of the nonstructural measures do not require construction. The construction of the two boat launches (Section 6.2.2, Structural Measures, Boat Launches) will occur on USACE-owned property that is covered with either turf grass or gravel/soil. Construction of the launches would require minimal excavation to shape the land at these sites. No high-quality plant communities occur within the vicinity of the GLMRIS-BR Site-Specific Study Area; therefore, no impacts on these communities under the NSA are anticipated.

The TAEB is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. As described in Section 7.1.10, Land Use, Tract 3 (Figure 7-1), which is adjacent to the right descending bank of the downstream approach channel, is expected to serve as the staging area during construction, and the location of the operational support facilities for the in-channel features. It was estimated that approximately three to four operational support facilities would be needed, as well as, for example, associated access roads and parking. Therefore, approximately 1 to 3 ac (0.4–1.2 ha) of property for the operational support facilities would be cleared of vegetation. Additional impervious surface (i.e., beyond the approximately 1–3 ac [0.4-1.2 ha]) could be placed, depending on the results of a pending site investigation; the site may contain materials which require a temporary or permanent cover. A site investigation of the property for plant communities has not occurred yet. However, historical aerials of the property were reviewed and indicate that the site may have been impacted from past uses and users. Therefore, it is assumed that there are no high-quality plant communities on the property. However, if the TAEB is implemented, a vegetation survey of the site would need to occur to confirm this assumption. If high-quality plant communities were to be found on the property, attempts would be made to avoid these areas. The property is considered open land and contains a mixture of grasses and trees; however, these present plant communities are not of high quality. In addition, review of historical aerials of the property indicate that the property may have been impacted from past uses and users. The TAEB also includes the construction of a new mooring location downstream of the BRLD. The construction of the mooring location is expected to occur primarily from the water; therefore, no impacts on plant communities are anticipated. This alternative also includes nonstructural measures whose potential impacts on plant communities were discussed under the NSA.

The TACN is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. While this alternative does not include an electric barrier or a new mooring location, potential impacts on plant communities due to construction and/or operation activities would be similar to those discussed under the TAEB. This alternative also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN; therefore, refer to these alternatives for a discussion of the potential impacts on plant communities within the area. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA is not expected to have any short-term or long-term direct or indirect impacts on plant communities within the GLMRIS-BR Site-Specific Study Area. This alternative would require construction to close the lock; however, staging would occur within the water and/or near the lock, which is composed of concrete and turf grass. Therefore, no impacts on plant communities are anticipated. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.2.2 Wildlife Resources

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. The surrounding area within the vicinity of BRLD is considered urban and/or open land, which primarily supports only tolerant wildlife (Section 4.4.3, Wildlife Resources). The NNFA also potentially includes the application of rotenone, a fish piscicide registered by the EPA. Rotenone is classified as highly toxic to mammals on an acute oral exposure basis. While it is highly toxic to mammals, the likelihood of exposure to mammals from registered uses is considered low, since the compound is applied directly to water. Therefore, the likelihood of rotenone residues on terrestrial animal forage items is considered low. In addition, even if birds or mammals were to consume fish killed by rotenone, there would be insufficient quantities of rotenone in the carcasses to represent a risk of acute mortality in terrestrial wildlife. It is important to note that the use of rotenone has been determined to not be appropriate for the majority of the rivers and or locations (i.e., man-made channels with sufficient aquatic habitat to support diverse aquatic species assemblage) within the GLMRIS-BR Illinois Waterway Study Area, because of the quality of the habitat and aquatic species occurring there. Overall, no impacts on wildlife resources, including federally listed and state-listed bird species (Section 4.4.3, Wildlife Resources, Avian Communities) which may utilize the flyway, are anticipated.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. This alternative does include the construction of two boat launches; however, these boat launches are being constructed on open/urban land that would likely only be used by tolerant wildlife species. The NSA could also potentially include the application of rotenone, whose potential impacts on wildlife resources were discussed under the NNFA.

The TAEB is expected to have short-term and long-term direct impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. During construction of the in-channel components as well as the operational support facilities, there could be minor disturbances to wildlife inhabiting Tract 3 (Figure 7-1), which is adjacent to the right descending bank of the downstream approach channel. However, the wildlife that inhabit this urban/open land area are expected to be tolerant species. During construction, controlled blasting would be needed to widen and deepen the downstream approach channel of the BR Lock for placement of the engineered channel. Controlled blasting is expected to disturb wildlife that may be present within the vicinity of the BR Lock downstream approach channel. Disturbance to wildlife may be minimized by a properly designed controlled blasting plan. During the continuous operation of the electric barrier, semi-aquatic wildlife species (e.g., turtles, frogs, water snakes, aquatic salamanders, beaver, muskrat, and otter) could be impacted if they attempt to traverse the electric field. The degree to which these species could be injured or killed by the electric field is uncertain; this depends upon the size of the animal and whether the electric barrier is operating when the animal is in the channel. The operation of the water jets is not expected to have a significant impact on wildlife species. A screen with an opening size of 2 to 3 in. (5.1–7.6 cm) would be in place on grinder pump intakes to minimize injury to nontargeted aquatic organisms. While larger organisms would be prevented from entering the pumps, smaller organisms could still conceivably make it through the screen openings. Overall, the potential impact on wildlife resources from the operation of the TAEB is expected to be minimal. The TAEB also includes the construction of a mooring area. Construction activities (e.g., dredging and construction of four mooring cells) could potentially disturb wildlife within the vicinity of this new mooring location; however, this is an urban area, and wildlife that could potentially be disturbed are considered tolerant species. Last, the TAEB includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACN is expected to have short-term and long-term direct impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. Potential short-term construction impacts are similar to the TAEB and are discussed under that alternative. During the operation of the complex noise, semi-aquatic wildlife species (e.g., turtles, frogs, water snakes, aquatic salamanders, beaver, muskrat, and otter) could be impacted if they attempt to traverse the area where decibel levels may be greater than ambient sound levels. It is currently unknown what the operating parameters of the complex noise feature will be and if it would fall within the hearing range of wildlife species that may be within the vicinity of the BRLD. If operating parameters of the complex noise feature are eventually found to fall within the hearing range of wildlife species within the vicinity of the BRLD, these species could experience discomfort, which would likely cause them to leave or avoid the area. Water jets are also included as part of the TACN, and the potential impacts on wildlife species were discussed under the TAEB. In addition, the potential impacts associated with nonstructural measures were discussed under the NSA.

The TACNEB is expected to have short-term and long-term direct impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN; therefore, refer to these alternatives for a discussion of the potential impacts on wildlife resources within the vicinity of the BRLD. Note that, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the

TAEB's electric barrier may be greater than the TACNEB's electric barrier. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA.

The LCA is not expected to have any short-term or long-term direct or indirect impacts on wildlife resources within the GLMRIS-BR Site-Specific Study Area. This alternative would involve construction to close the lock; however, the construction would be short in duration and would occur within the lock chamber where no wildlife communities exist. In regard to potential long-term direct impacts, it is unknown whether semi-aquatic wildlife species utilize the lock for transit between the Dresden Island Pool and the Brandon Road Pool. It is believed that this would be highly unlikely as transit would most often occur with a vessel, and the noise created by the vessel would likely deter wildlife species. In addition, wildlife species would have the capability to circumvent the lock closure by exiting the Dresden Island Pool and moving upon land. Overall, no long-term direct or indirect impacts on wildlife resources due to lock closure are anticipated. The LCA also includes nonstructural measures whose potential impacts were discussed under the NSA.

7.2.3 Aquatic Resources

No New Federal Action Alternative

The NNFA could have potential short-term direct impacts, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Under the NNFA, response actions could occur within the GLMRIS-BR Illinois Waterway Study Area, which may include conventional gears (e.g., netting and electrofishing) and/or the application of piscicide. These actions could have significant short-term direct impacts on aquatic resources where they occur. For example, in 2010, a response action using conventional gear and rotenone occurred in the Little Calumet River downstream of T.J. O'Brien LD. Sampling occurred along 2.6 mi (4.2 km) of river, with 67,224 fish collected from the rotenone application. In addition, 1,579 fish were collected during electrofishing and trammel/gill net sampling (MRWG 2011). While electrofishing and trammel/gill netting do not necessarily kill fish that are sampled (nontarget fish are returned to the waterway), injury or death due to stress or injury could occur.

The use of rotenone directly kills all fish species. Rotenone is registered by the EPA and works directly on fish by inhibiting cellular respiration, making it impossible for fish to use the oxygen absorbed in the blood and needed to generate energy during respiration. Numerous laboratory and field tests have been conducted on rotenone, and, while it is derived from leguminous plants and is relatively nontoxic to plants and mammals, it is considered highly toxic to fish and invertebrates. In general, toxicity to invertebrates and fish depends on the species. One of the most comprehensive field studies on rotenone toxicity to macroinvertebrates was conducted in conjunction with a rotenone treatment of Strawberry Reservoir in 1990. Depending on the sampling location, Mangum and Madrigal (1999) found that 9 to 33% of invertebrate taxa were resistant to the rotenone treatment. Mayflies and caddisflies were the species impacted the greatest and were slow to recover. Vinson and Vinson (2007) suggest that mayflies, caddisflies, and stoneflies (small invertebrates that use gills to acquire aqueous oxygen) may be more sensitive to rotenone than larger invertebrates that acquire aqueous oxygen cutaneously, use respiratory pigments, or that can breathe atmospheric air. Mangum and Madrigal (1999) also found that benthic invertebrates such as chironomids were also greatly affected by the treatment, but recovered quickly as downstream invertebrate drift repopulated areas. Vinson and Vinson (2007) stated that the ability of taxa to recolonize treated areas is likely a function of their overall population sizes within the basin, upstream and local habitat conditions, and the dispersal abilities of individual taxon. Therefore, these response actions could have short-term direct impacts on the aquatic communities where they occur. Aquatic communities are expected to recover, but the time it takes for these communities to recover could vary.

The application of rotenone also has the potential for short-term indirect impacts on aquatic communities within the areas where response actions could potentially occur. For example, if the macroinvertebrate community is impacted by a rotenone event, this in turn could have indirect impacts on species that depend on macroinvertebrates for food. Essentially the food source for some species could be depressed until it is able to recover, which subsequently would impact higher trophic levels. Outside of the treatment area, the effect rotenone will have on aquatic resources depends on the extent to which the chemical moves beyond the treatment area. In the past (i.e., during the 2009 and 2010 rotenone events in the CAWS), $KMnO_4$ was used to deactivate the rotenone once it reached a certain point within the treatment zone. It is anticipated that $KMnO_4$ would be utilized in any future rotenone applications within the GLMRIS-BR Illinois Waterway Study Area. The use of rotenone for a response action in the BRLD vicinity requires controlled application by trained and certified staff of the State of Illinois and compliance with all applicable federal and state environmental and human health/safety regulations. In addition, immediate collection and disposal of fish carcasses following a rotenone application must be implemented to preclude degradation of local water and air quality due to decomposition. It is important to note that the use of rotenone has been determined to not be appropriate for the majority of the rivers and or locations (i.e., man-made channels with sufficient aquatic habitat to support diverse aquatic species assemblage) within the GLMRIS-BR Illinois Waterway Study Area, because of the quality of the habitat and aquatic species occurring there.

The NNFA also includes the continuation of contracted commercial fishing efforts; however, the level at which these efforts are currently carried out may be reduced during the planning period of analysis. Contracted commercial fishing has occurred since 2011, and data on this effort are available from 2011 through 2015. Contracted commercial fishing targets Bighead and Silver Carp for removal within the Dresden Island, Marseilles, and Starved Rock Pools; however, by-catch (species not targeted for removal) does occur. From 2011 to 2015, a total of 437,623 fish were captured (MRWG 2016). Bighead and Silver Carp accounted for 76.58% of the total fish captured. Other nonnative species (e.g., Common Carp, Grass Carp, Hybrid Striped Bass, Common Carp, Goldfish Hybrid, Goldfish, and White Perch) accounted for 4.22% of the total fish captured. Native species accounted for 19.21% of the total fish captured and included the following species: Smallmouth Buffalo (11.81%), Bigmouth Buffalo (4.64%), Freshwater Drum (1.12%), Flathead Catfish (0.36%), Channel Catfish (0.39%), Black Buffalo (0.30%), Paddlefish (0.05%), River Carpsucker (0.20%), Quillback (0.08%), Largemouth Bass (0.03%), Sauger (0.02%), Shortnose Gar (0.03%), White Bass (0.02%), Longnose Gar (0.05%), Walleye (0.01%), Skipjack Herring (0.01%), Blue Catfish (0.01%), Gizzard Shad (0.01%), Yellow Bass (0.01%), White Crappie (<0.01%), Bluegill (<0.01%), Black Crappie (<0.01%), Shorthead Redhorse (<0.01%), Golden Redhorse (0.01%), River Redhorse (<0.01%), Rock Bass (<0.01%), Muskellunge (<0.01%), Northern Pike (<0.01%), Mooneye (<0.01%), Goldeye (<0.01%), unidentified buffalo species (<0.01%), Bowfin (<0.01%), and Silver Redhorse (<0.01%) (MRWG 2016). While by-catch species are returned to the waterway, it is unknown how many fish sustain injuries or do not recover from being captured. Overall, contracted commercial fishing is expected to have long-term direct impacts on aquatic communities within the GLMRIS-BR Illinois Waterway Study Area; however, the extent of the impact is unknown.

Lastly, the NNFA could have a potential indirect impact on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The indirect impact on aquatic resources could occur if ANS, specifically Bighead Carp, Silver Carp, and *A. lacustre*, were to become established in lake and river systems where they currently do not exist (e.g., upper Des Plaines River, Chicago River, and the Great Lakes and connecting tributaries). The potential consequences of these species if they were to become established are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. Overall, monitoring data from previously invaded systems have documented significant changes in resident fish species following Asian carp establishment. The results of the NOAA-GLERL modeling for Lake Erie indicate that these species have the potential to significantly alter the food web depending on Silver and Bighead Carp biomass, which could range from

10 to 34% of the fish biomass in Lake Erie. These studies also suggest that Asian carp have the potential to become a dominant species in portions of the GLB with suitable habitat conditions. However, uncertainty exists as to the magnitude and extent of impacts if Bighead and Silver Carp were to become established in the GLB. There is general concern that if *A. lacustre* were to become established in the GLB, they could smother native mussel species and compete directly with them for food. It is important to note that *A. lacustre* is a hull-fouling species, and, currently the only alternative that would effectively address this species is Lock Closure.

Action Alternatives

The NSA could have potential short-term direct impacts, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. The NSA includes nonstructural measures that would be carried out at a level likely greater than that under the NNFA; however, potential impacts on aquatic resources that were discussed under the NNFA are applicable to the NSA. The NSA also includes increased contracted commercial fishing within the Dresden Island, Marseilles, and Starved Rock Pools, as well as monitoring for *A. lacustre* within the GLMRIS-BR Illinois Waterway Study Area. Potential long-term direct impacts associated with contracted commercial fishing were discussed under the NNFA; however, these impacts could be greater under the NSA, since higher by-catch is likely due to additional fishing crews and/or additional fishing days.

The NSA also includes the construction of two boat launches, which could have potential short-term direct impacts on aquatic communities within the vicinity of the launches. However, the launches are within the vicinity of the BRLD and only tolerant aquatic species are likely to be affected. Effects could include disturbance during placement of gravel for the launches, covering of aquatic macroinvertebrates, and covering of nekton. To minimize some of these potential impacts, gravel could be placed during the nonbreeding season for aquatic species within the vicinity of the BRLD. While placement of the gravel has the potential to cover aquatic macroinvertebrates, this would be a small area, and the species being impacted are considered tolerant and undesirable (see Section 4.4.4, Aquatic Resources, Plankton and Benthic Invertebrate Communities).

Lastly, similar to the NNFA, the NSA could have a potential indirect impact on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The potential consequences of ANS species, specifically Bighead Carp, Silver Carp, and *A. lacustre*, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. Overall, monitoring data from previously invaded systems have documented significant changes in resident fish species following Asian carp establishment. The results of the NOAA-GLERL modeling for Lake Erie indicate that these species have the potential to significantly alter the food web depending on Silver and Bighead Carp biomass, which could range from 10 to 34% of fish biomass in Lake Erie. These studies also suggest that Asian carp have the potential to become a dominant species in portions of the GLB with suitable habitat conditions. However, uncertainty exists as to the magnitude and extent of impacts if Bighead and Silver Carp were to become established in the GLB. There is a general concern that if *A. lacustre* were to become established in the GLB, they could smother native mussel species and compete directly with them for food. It is important to note that *A. lacustre* is a hull-fouling species, and, currently, the only alternative that would effectively address this species is Lock Closure. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed above are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TAEB could have potential short-term direct impacts, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Short-term direct impacts could potentially occur during construction of the in-channel features. During construction, noises from equipment on land and in the water could potentially disturb aquatic communities within the immediate vicinity of the BRLD and/or prevent their movements through the area. In addition, nekton, tadpoles, and aquatic macroinvertebrates within the area could be covered by construction of the engineered channel. Construction of the engineered channel would also require controlled blasting to widen and deepen the downstream approach channel of the BR Lock for placement of the engineered channel. Controlled blasting is expected to disturb aquatic resources that may be present within the vicinity of the BR Lock downstream approach channel. Disturbance to aquatic resources may be minimized by a properly designed controlled blasting plan. However, the impact is not expected to be significant, since the downstream approach channel is devoid of habitat and very few aquatic species likely occur here. In addition, any aquatic species present would likely be tolerant species.

Construction activities associated with the TAEB could also have short-term localized impacts on aquatic resources due to potential water quality impacts (e.g., increased turbidity). During continuous operation of the TAEB, long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area could occur. The electric barrier is a nonselective deterrent to fish; therefore, continuous operation of the electric barrier would directly impact both nonnative and native species movement between Dresden Island Pool and Brandon Road Pool. The operation of the electric barrier continuously would also directly impact amphibians that may attempt to traverse the electric field. Similar to fish, these species would be stunned and could potentially be injured depending on the size of the animal and the operating parameters of the electric barrier.

Under the TAEB, there may also be long-term indirect impacts on aquatic communities within the upper Des Plaines River. Connectivity within the upper Des Plaines River is in the process of being restored, with the majority of the mainstem dams either removed or scheduled to be removed. This watershed has been identified as a priority for ecosystem restoration within the state of Illinois by the Illinois DNR. Once removed, the only remaining impediment to connectivity within the mainstem Des Plaines River would be the BRLD. Recent studies by the USFWS have shown fish species utilizing the BR Lock. During July 2014, mean densities of 38.6 fish/1,000 cubic meters (m^3) were observed within the BR Lock chamber (USFWS 2016). In 2016, the USFWS conducted capture surveys within the BR Lock chamber and observed the following species: Common Carp, Northern Pike, Smallmouth Buffalo, Emerald Shiner, and Gizzard Shad (USFWS 2016). In addition to utilizing the lock chamber, it is also believed that fish species disperse through the BR Lock chamber to waterways upstream of the BRLD. In recent years, species have been observed in the upper Des Plaines River (e.g., Rosyface Shiner, Longnose Gar) that have never been recorded, which have led biologists to speculate that these species may have originated from the lower Des Plaines River and its tributaries (e.g., Kankakee River). Although connectivity within the Des Plaines River was originally impacted by construction of the BRLD in the late 1920s, early 1930s, the BR Lock does provide a permeable point for fish to still migrate from below the BRLD to upstream of the BRLD. Another potential long-term indirect impact on aquatic resources within the Des Plaines River downstream of BRLD would be the stacking of fish below the BR electric barrier. This could subsequently result in fish stacking up near the NRG Energy Joliet facility water intake, approximately 904.1 ft (275.6 m) downstream of the BR approach channel entrance, which could potentially increase fish impingement at the intake.

Operation of the electric barrier, as part of the TAEB, would no longer provide this permeable point for aquatic species. Therefore, operation of the electric barrier would have long-term direct impacts on connectivity of the Des Plaines River and long-term indirect impacts on native species migration and reestablishment between the lower Des Plaines River and the upper Des Plaines River. This would also indirectly impact mussel species reestablishment in the upper Des Plaines River given the strong interdependence of specific native mussel species with specific riverine fish species to successfully complete development during their larval life stages, achieve maturity, and properly disperse within their historic range. For example, the federally endangered sheepnose mussel was extirpated from the Des Plaines River, but stable populations are found in the Kankakee River. Larvae of the sheepnose mussel are believed to attach to Sauger for transformation and ultimately dispersal. Therefore, operation of the electric barrier would subsequently prevent mussel larvae transfer on the host fish from the lower Des Plaines River to the upper Des Plaines River, and indirectly impact the potential reestablishment of certain mussel species in the upper Des Plaines River watershed. The USACE will continue to coordinate with the relevant federal and state agencies to further define the degree of impact on the aquatic communities within the upper Des Plaines River, and whether mitigation measures should be implemented to address these impacts. Some potential mitigation measures are outlined in Section 7.7, Mitigation, and in Appendix A, Draft Fish and Wildlife Coordination Act Report (FWCAR).

Water jets are also a measure of the TAEB. Screens with opening sizes of 2 to 3 in. (5.1–7.6 cm) would be placed on pump intakes for the water jets to minimize injury to nontarget aquatic species. While larger organisms would be prevented from entering the pumps, smaller organisms could still conceivably make it through the screen openings. Overall, the impact on nontarget species is expected to be minimal from operation of the water jets due to the presence of the screens. The flushing lock component of the alternative is not expected to have any direct impacts on aquatic species within the GLMRIS-BR Site-Specific Study Area. This feature is expected to target only floating life stages and species that are incapable of movement on their own and/or have not reached a mobile life stage yet. In addition, the flushing lock is not expected to impact water levels in the Dresden Island Pool as a result of its operation, hence native species aquatic habitat is not expected to be impacted (see Section 7.1.4, Hydrology and Hydraulics).

Construction of a new mooring location downstream of the BRLD is also proposed as part of the TAEB. Potential short-term direct impacts are similar to those discussed above for the construction of the in-channel features. Nonstructural measures are also part of the TAEB, whose potential impacts on aquatic resources were discussed under the NSA.

Finally, similar to the NSA, the TAEB could have a potential indirect impact on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The potential consequences of ANS species, specifically Bighead Carp, Silver Carp, and *A. lacustre*, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and a summary of the information is discussed under the NSA. Although implementation of the TAEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exist. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the TAEB. However, the TAEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACN could have potential short-term direct impacts, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Short-term direct impacts could potentially occur during construction of the in-channel features. While the TACN does not include an electric barrier or a new mooring area, construction activities would be similar to the TAEB; therefore, refer to the TAEB for a discussion of the potential short-term direct impacts on aquatic resources.

During operation of the TACN, long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area could occur. The potential long-term direct impacts on aquatic resources as a result of operation of the water jets and flushing lock are discussed under the

TAEB. With regard to the operation of complex noise, it is uncertain whether there would be long-term direct impacts on native species, connectivity of the Des Plaines River, and long-term indirect impacts on native species migration and reestablishment in the upper Des Plaines River. The USGS recently completed noise trials on adult fish to assess their response to the recording of an outboard boat motor (i.e., a complex noise). Responses were classified into the following three categories: no/low (maximum number of consecutive responses of less than or equal to 1), medium (maximum number of consecutive responses of less than or equal to 10), and high (maximum number of consecutive responses of greater than 10). Channel Catfish, Lake Sturgeon, Paddlefish, American Eel, and Fathead Minnow were considered to have a no/low response level to the complex sound. Grass Carp, Gizzard Shad, and Common Carp had mixed responses to complex sound and were considered to have a medium response level. Silver Carp and Bighead Carp were considered to have a high response level to the complex noise. Response levels are believed to be linked to the hearing sensitivity of the fish species. Grass Carp, Common Carp, Silver Carp, Bighead Carp, Channel Catfish, and Fathead Minnow have structures (i.e., Weberian apparatus) that may increase their hearing sensitivity. Gizzard Shad are also believed to have greater hearing sensitivity, although they lack these additional apparatus. Lake Sturgeon, Paddlefish, and American Eel do not have these additional apparatus and are believed to have lower hearing sensitivity. Additional species to be tested in the future by the USGS include Bigmouth Buffalo and native freshwater mussels. Trials on juvenile fish species, as well as on habituation of fish species to complex noise, have not been conducted at this time (Murchy 2017). Similar to the TAEB, the operation of the TACN could also potentially cause fish to stack up below the complex noise feature. This could subsequently result in fish stacking up near the NRG Energy Joliet facility water intake, approximately 904.1 ft (275.6 m) downstream of the BR approach channel entrance, which could potentially increase fish impingement at the intake. The likelihood of this occurring is unknown; however, this could be a potential long-term indirect impact due to operation of the TACN. Overall, it is uncertain whether complex noise would have any long-term direct or indirect impacts on aquatic resources within the GLMRIS-BR Site-Specific Study Area and the GLMRIS-BR Illinois Waterway Study Area. Nonstructural measures are also part of the TACN, whose potential impacts on aquatic resources were discussed under the NSA.

Finally, similar to the TAEB, the TACN could have a potential indirect impact on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The potential consequences of ANS species, specifically Bighead Carp, Silver Carp, and *A. lacustre*, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and a summary of the information is discussed under the NSA. Although implementation of the TACN would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the TACN. However, the TACN attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACNEB is expected to have short-term direct, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. This alternative is a combination of the TAEB and TACN; therefore, refer to these alternatives for a discussion of the potential impacts on aquatic resources. Note that, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB's electric barrier may be greater than the TACNEB's electric barrier. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA. In addition, while implementation of the TACNEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in

Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the TACNEB. However, the TACNEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA is expected to have short-term direct, and long-term direct and indirect impacts on aquatic resources within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although the LCA does not include any of the technologies listed under the TAEB and TACN, the short-term direct impacts related to construction and the long-term direct and indirect impacts related to severing the connectivity of the Des Plaines River and potentially causing fish to stack up near the NRG Energy Joliet facility water intake are similar. Refer to the TAEB and TACN for a discussion of these potential short-term and long-term direct and indirect impacts. The LCA also includes nonstructural measures whose impacts were discussed under the NSA. Lastly, although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.2.4 Threatened and Endangered Species

No New Federal Action Alternative

The NNFA could have potential short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Under the NNFA, response actions could occur within the GLMRIS-BR Illinois Waterway Study Area, which may include conventional gear (e.g., netting and electrofishing) and/or the application of piscicide. These actions could have short-term direct impacts on federally listed mussel species and state-listed mussel and fish species within the GLMRIS-BR Illinois Waterway Study Area. However, these direct impacts would only occur if these actions, specifically application of rotenone, were to occur where these species exist. The legal authority to apply piscicide within Illinois water resides with the Illinois DNR. Before application of piscicide, consultation with local, state, and federal partners would need to occur. In addition, this tool has been determined to not be appropriate for the majority of the rivers and or locations within the GLMRIS-BR Illinois Waterway Study Area, because of the quality of the habitat and aquatic species occurring there. Therefore, it would be highly unlikely that these response actions would have direct impacts on threatened and endangered species. For a discussion of the potential direct impacts as a result of response actions, refer to the NNFA in Section 7.2.3, Aquatic Resources.

The NNFA also includes the continuation of contracted commercial fishing efforts; however, the level at which these efforts are currently carried out may be reduced during the planning period of analysis. The potential short-term direct impacts of contracted commercial fishing were discussed for the NNFA in Section 7.2.3, Aquatic Resources. It is highly unlikely that there would be any direct impacts on threatened and endangered species from contracted commercial fishing; however, the possibility does exist.

The NNFA could also have a potential indirect impact on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The indirect impact on threatened and endangered species could occur if ANS, specifically Bighead Carp, Silver Carp, and *A. lacustre*, were to become established in lake and river systems where they currently do not exist (e.g., upper Des Plaines River, Chicago River, and the Great Lakes and connecting tributaries). The potential consequences of these species, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. In general, pressures from Bighead Carp and Silver Carp on native fish species have the potential to disrupt native species' life cycles; however, uncertainty exists as to the extent of impacts if Bighead and Silver Carp were to become established in the GLB. With regard to *A. lacustre*, there is general concern that if they were to become established in the GLB, they could smother native mussel species and compete directly with them for food. It is important to note that *A. lacustre* is a hull-fouling species, and currently the only alternative that would effectively address this species is Lock Closure. While there are no federally listed fish species, there are 22 federally listed mussel species within the GLMRIS-BR System-Wide Study Area that could potentially be impacted by the establishment of Bighead Carp, Silver Carp, and *A. lacustre*. In addition, there are potentially 69 state-listed fish species and 43 state-listed mussel species that could be impacted within the GLMRIS-BR System-Wide Study Area (Appendix B, Planning). The USFWS Draft Fish and Wildlife Coordination Act Report (USFWS 2016) provides more information on threatened and endangered species of the GLB (Appendix A, Draft FWCAR).

Action Alternatives

The NSA would have "no effect" on federally listed threatened or endangered species within the GLMRIS-BR Site-Specific Study Area (Table 7-2). Correspondence from the USFWS in reference to a Request to Comment letter, dated February 18, 2015, stated that there are no federally listed species at or near the BRLD location. Therefore, the USFWS does not have specific concerns about the potential effects of control technologies on federally listed species at or near the BRLD (Appendix K, Coordination). The USACE also followed up with the USFWS in a letter dated November 18, 2016, requesting its concurrence with the "no effect" determination (Appendix K, Coordination). While the NSA would have a "no effect" determination on federally listed species within the vicinity of the BRLD, there could be short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. The NSA includes nonstructural measures similar to those carried out under the NNFA; however, these activities would likely occur with a greater level of effort. In addition, the NSA includes increased contracted commercial fishing within the GLMRIS-BR Illinois Waterway Study Area. The potential short-term direct impacts of these actions were discussed under the NNFA. The NSA also includes the construction of two boat launches on USACE property within the vicinity of the BRLD. The construction of the boat launches is expected to have "no effect" on federally listed species, since no federally listed species are present within the GLMRIS-BR Site-Specific Study Area.

The NSA could also have a potential indirect impact on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The potential consequences of ANS, specifically Bighead Carp, Silver Carp, and *A. lacustre*, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. Refer to the discussion under the NNFA for the number of federally and state-listed species that could potentially be indirectly impacted. While implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and under the NNFA are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

Similar to the NSA, the TAEB would have "no effect" on federally listed threatened or endangered species within the GLMRIS-BR Site-Specific Study Area (Table 7-2). Refer to the NSA for discussion on the "no effect" determination. While the TAEB would have "no effect" on federally listed species within the vicinity of the BRLD, there could be short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the

Table 7-2 Federally Listed Species Determination of Impacts

Species	Status	Determination of Impacts[a]
Plants		
Eastern Prairie Fringed Orchid (*Platanthaera leucophaea*)	Threatened	No effect
Lakeside Daisy (*Hymenopsis herbacea*)	Threatened	No effect
Leafy-prairie Clover (*Dalea foliosa*)	Endangered	No effect
Mead's Milkweed (*Asclepias meadii*)	Threatened	No effect
Reptiles and Amphibians		
Eastern Massassagua (*Sistrurus catenatus*)	Threatened	No effect
Mammals		
Northern long-eared bat (*Myotis septentrionalis*)	Threatened	No effect
Invertebrates		
Hine's Emerald Dragonfly (*Somatochlora hineana*)	Endangered	No effect
Rattlesnake-master Borer Moth (*Papaipema eryngii*)	Candidate	No effect
Rusty Patched Bumble Bee (*Bombus affinis*)	Endangered	No effect
Sheepnose Mussel (*Plethobasus cyphyus*)	Endangered	No effect

[a] The determination of impacts was made for the GLMRIS-BR Site-Specific Study Area.

GLMRIS-BR System-Wide Study Area. Short-term direct impacts would be primarily related to the nonstructural measures whose potential impacts were discussed under the NSA. Long-term indirect impacts could occur from operation of the electric barrier continuously, which would indirectly impact the reestablishment of federal- and state-listed fish and mussel species in the upper Des Plaines River. Fish would most likely be prevented from moving upstream of the BRLD when the electric barrier is operating. With regard to listed native mussel species, the federally endangered sheepnose mussel was extirpated from the Des Plaines River, but stable populations are found in the Kankakee River. Mussel larvae (i.e., glochidia) of the sheepnose mussel are believed to attach to Sauger for transformation and ultimately dispersal. Therefore, operation of the electric barrier continuously could subsequently prevent glochidia transfer from the lower Des Plaines River to the upper Des Plaines River, and indirectly impact the potential reestablishment of certain mussel species in the upper Des Plaines River. For a discussion on the impact on connectivity between the lower and upper Des Plaines River, refer to the TAEB in Section 7.2.3, Aquatic Resources. The USACE will continue to coordinate with the USFWS on potential impacts on federally listed threatened or endangered species and whether mitigation measures are needed. Some potential mitigation measures are outlined in Section 7.7, Mitigation, as well as in Appendix A, Draft FWCAR. The TAEB also includes the construction of a new mooring location downstream of the

BRLD. The new mooring location is expected to have “no effect” on federally listed threatened and endangered species, because none occur within the proposed location of the mooring area.

In addition, similar to the NSA, the TAEB could have a potential indirect impact on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The potential consequences of ANS, specifically Bighead Carp, Silver Carp, and *A lacustre*, if they were to become established, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. Refer to the discussion under the NNFA for the number of federally and state-listed species that could potentially be indirectly impacted. While implementation of the TAEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and under the NNFA are applicable to the TAEB. However, the TAEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACN would have “no effect” on federally listed threatened or endangered species within the GLMRIS-BR Site-Specific Study Area (Table 7-2). Refer to the NSA for discussion on the “no effect” determination. While the TACN would have “no effect” on federally listed species within the vicinity of the BRLD, there could be short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Short-term direct impacts would be primarily related to the nonstructural measures whose potential impacts were discussed under the NSA. It is uncertain whether the operation of complex noise would have long-term indirect impacts which could impact federally and state-listed fish and mussel species reestablishment in the upper Des Plaines River. For a discussion on the uncertainty of potential impacts on native fish species and mussels, refer to the TACN in Section 7.2.3, Aquatic Resources. In addition, similar to the NSA, the TACN could have a potential indirect impact on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The indirect impact could occur if ANS, specifically Bighead Carp, Silver Carp, and *A. lacustre*, were to become established in the lake and river systems where they currently do not exist (e.g., upper Des Plaines River, Chicago River, and the Great Lakes and connecting tributaries). Refer to the discussion under the NNFA for the number of federally and state-listed species that could potentially be impacted. The potential consequences of these species if they were to become established are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. While implementation of the TACN would likely reduce the probability of establishment for Bighead and Silver Carp over the NSA and NNFA, a likelihood of establishment would still remain.

The TACNEB would have “no effect” on federally listed threatened or endangered species within the GLMRIS-BR Site-Specific Study Area (Table 7-2). Note, as formulated, it was assumed that the TACNEB’s electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB’s electric barrier may be greater than the TACNEB’s electric barrier. Refer to the NSA for discussion on the “no effect” determination for the nonstructural measures. While the TACNEB would have “no effect” on federally listed species within the vicinity of the BRLD, there could be short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. The TACNEB is a combination of the TAEB and TACN alternatives, whose potential impacts have been previously discussed under these specific alternatives. The TACNEB also includes nonstructural measures whose potential impacts were discussed under the NSA. While implementation of the TACNEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and under the NNFA are applicable to the TACNEB. However, the TACNEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA would have "no effect" on federally listed threatened or endangered species within the GLMRIS-BR Site-Specific Study Area (Table 7-2). Refer to the NSA for discussion on the "no effect" determination. While the LCA would have "no effect" on federally listed species within the vicinity of the BRLD, there could be short-term direct impacts and long-term indirect impacts on threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. The short-term direct impacts are primarily related to implementation of nonstructural measures, whose potential impacts were discussed under the NSA. Long-term indirect impacts would likely occur from closure of the lock, which would sever connectivity between the lower Des Plaines River and the upper Des Plaines River. This would indirectly impact federally and state-listed fish and mussel species located within the lower Des Plaines River and its tributaries from potentially reestablishing in the upper Des Plaines River. Lastly, although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes, and under the NNFA are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.3 Cultural and Archeological Resources

The USACE has been coordinating and consulting with the Illinois SHPO and other interested and consulting parties, since December 2014 with regard to GLMRIS-BR. This consultation is promulgated under Section 106 of the NHPA. A Distribution List of more than 200 mailing addresses of interested and consulting parties was developed for the project to share information concerning historic properties. Agencies, tribes, individuals, organizations, and other interested parties were provided an opportunity to review and comment on the effects of this undertaking during the consultation process.

The USACE recognizes that changes to the landscape could affect sacred sites and properties of traditional religious and cultural importance, which have significance to tribes and others on the Distribution List. In order to preserve, conserve, and encourage the continuation of the diverse traditional prehistoric, historic, ethnic, and folk cultural traditions, GLMRIS-BR will be implemented in compliance with E.O. 13007, the NHPA, and other USACE guidance. The USACE will continue the identification and notification of traditional religious and sacred sites by tribes and others throughout the planning process. The USACE was not informed of any sacred sites or traditional historic properties.

The USACE has investigated its trust responsibilities from federally recognized tribes and associated treaty rights and trust responsibilities. No direct treaty responsibilities were found to preclude project implementation within the GLMRIS-BR Site-Specific Study Area or GLMRIS-BR System-Wide Study Area. Thus far, comments have been received from Citizen Potawatomi Nation (Appendix K, Coordination, e-mail dated November 4, 2015), Miami Tribe of Oklahoma (Appendix K, Coordination, letter dated February 10, 2016), and the Pokagon Band of Potawatomi (Appendix K, Coordination; letter dated July 16, 2015). In their comments, the tribes all stated that they had no knowledge of any impacts on the project. The Citizen Potawatomi Nation, Miami Tribe of Oklahoma, and Pokagon Band of Potawatomi all asked to be contacted if any archaeological resources were uncovered during the implementation of a project and expressed their desire for continued coordination. The USACE has continued consultation with the aforementioned tribes.

In letters dated December 9, 2014, June 25, 2015, and January 22, 2016, the USACE contacted the Illinois SHPO to initiate consultation for all archeological historic properties to determine any potential impacts resulting from implementation of the project. By copies of that correspondence, the consultation included the Advisory Council on Historic Preservation (ACHP), federal and state agencies, Native American tribes, landowners, historical societies, and other parties. The SHPO concurred with the USACE's finding within the GLMRIS-BR Site-Specific Study Area of no historic properties within the Des Plaines River watercourse and a parcel of corporate land called Tract 3 (Figure 7-2). Tract 3 was previously disturbed by the construction of what is presumed to be a fly ash pit. Tract 3 is the proposed location for staging of construction activities, as well as the operational support facilities associated with the TAEB, TACN, and TACNEB. The Corps correspondence documented no historic archaeological properties within the BRLD Historic District, Tract 3, and the Des Plaines River, and also recommended a Phase I archeological survey for Tract 2, since this area had some limited potential to contain archaeological properties (Appendix K, Coordination; response dated February 11, 2015, IHPA LOG# 0020201015; concurrence letter dated July 15, 2015, IHPA LOG# 0020201015; and stamped "concur" returned letter dated February 18, 2016, IHPA LOG# 0020201015).

The USACE's recommendation for Phase I surveys for archeological sites on Tracts 1 and 2 (Figure 7-2) are documented in the following reports:

> *Phase I Intensive Archeological and Geomorphological Investigations at the BRLD, Will County, Illinois*, prepared by David W. Benn and Lowell Blikre of Bear Creek

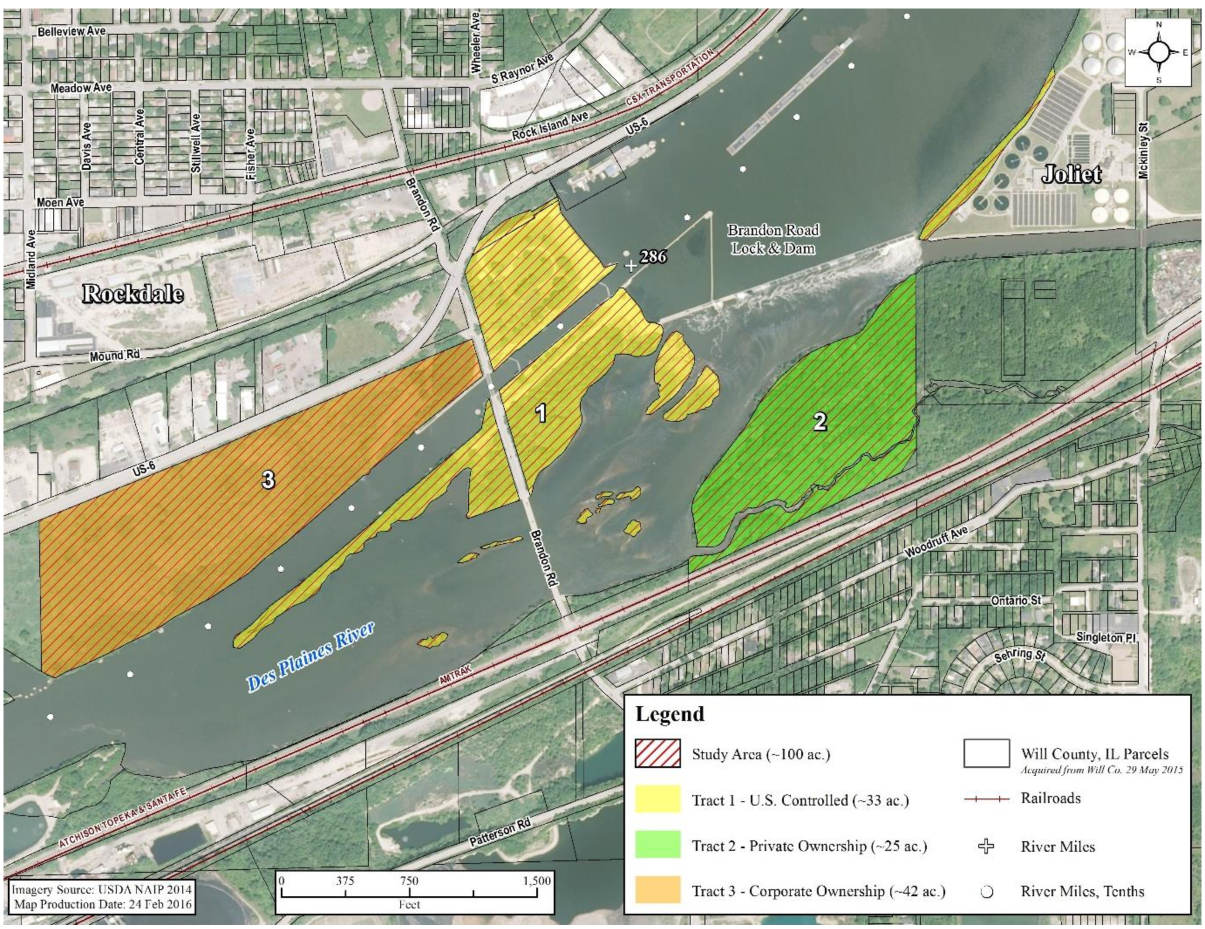

Figure 7-2 Parcels within the Vicinity of the GLMRIS-BR Site-Specific Study Area

Archaeology (September 2015) for the Rock Island District under Contract Number W912EK-12-D-001, Work Order 0018.

Phase I Intensive Archeological and Geomorphological Investigations at the BRLD, Will County, Illinois, prepared by David W. Benn and Lowell Blikre of Bear Creek Archaeology (January 2016) for the Rock Island District under Contract Number W912EK-12-D-0001, Work Order 0018, Modification Number 2.

The Phase I reports discovered and evaluated two archeological sites inventoried as 11WI4159 and 11WI4165. The Illinois SHPO concurred with the USACE that these sites were ineligible for the NRHP (Appendix K, Coordination; letter dated January 14, 2016, IHPA LOG# 002021015; and stamped "concur" returned letter dated February 17, 2016, IHPA LOG# 002021015) and concurred with the USACE that no archeological properties would be affected by construction efforts within those two tracts. All final Phase I archeological reports have been provided for the permanent files of the IHPA and are part of the USACE's permanent record of compliance under Section 106 of the NHPA, as amended, and its implementing regulation 36 CFR Part 800, "Protection of Historic Properties."

By an e-mail comment dated February 17, 2016, the ACHP reserved the right to participate once the USACE makes a determination(s) of effect for GLMRIS-BR (Appendix K, Coordination; e-mail dated February 17, 2016). On March 8, 2016, the USACE coordinated with the Illinois SHPO and those on the Distribution List on the proposed alternatives, compliance, and potential effects on significant historic properties listed on the NRHP (Appendix K, Coordination; letter dated March 8, 2016). As an update, the USACE provided a revised map of the Area of Potential Effect (APE), due to a reduction in acreage from approximately 114 (46.1 ha) to approximately 100 total acres (40.5 ha). The majority of the land removed from the APE was on the left descending backline of the Des Plaines River in Tract 3 and of corporate ownership.

In addition to the alternatives, the USACE recognized that mooring cells may be required to facilitate navigational traffic if an alternative with an electric barrier were constructed in the downstream approach channel to BR Lock. The proposed moorings are four large circular structures formed of sheet piling and filled with concrete, which is typical of mooring cells found elsewhere along major waterways. The proposed mooring cells would be approximately 400 ft (121.9 m) apart for tow docking and staging adjacent to the IWW (Des Plaines River reach) between IWW river miles 276 and 285. The report on submerged historic properties by Custer and Custer (1997) indicated no vessel wrecks or other significant documented underwater archeological sites within this reach. The IHPA concurred that no historic properties would be affected by placement of mooring cells within this reach of the IWW (Appendix K, Coordination; letter dated August 29, 2016, IHPA Log #01012015).

These listed properties are the BRLD and the I&M Canal, adjacent properties listed on the NRHP. Portions of the I&M Canal were designated a National Historic Landmark in 1964. The junction lock at the northeastern terminus of the I&M Canal was constructed by the USACE and contributes to the BRLD Historic District. The TAEB, TACN, TACNEB, and LCA were determined to potentially have a conditional no adverse effect on the BRLD Historic District, as shown in Table 7-3.

Table 7-3 GLMRIS-BR Brandon Road Lock and Dam Historic District Determination of Effect

Alternative	Effect on NRHP BRLD Historic District
NNFA	No effect
NSA	No effect
TAEB	Conditional no adverse effect[a]
TACN	Conditional no adverse effect[a]
TACNEB	Conditional no adverse effect[a]
LCA	Conditional no adverse effect[a]

[a] Conditional requirements necessary to fulfill NRHP compliance.

7.3.1 No New Federal Action Alternative

The NNFA is expected to have “no effect” on cultural and archaeological resources within the GLMRIS-BR Site-Specific Study Area. Formal concurrence on this determination was received March 25, 2016 (Appendix K, Coordination).

7.3.2 Action Alternatives

The NSA is expected to have “no effect” on cultural and archaeological resources within the GLMRIS-BR Site-Specific Study Area. Formal concurrence on this determination was received March 25, 2016 (Appendix K, Coordination).

With regard to alternatives TAEB, TACN, TACNEB, and LCA, the USACE acknowledged that the additions or modification to the original fabric of the dam and the new construction within the BRLD Historic District boundaries may be considered to have adverse and visual effects. However, any new structures and alterations would, in part, retain the existing navigable lock profile and use concrete coloration that adheres to the Secretary of the Interior’s Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings. It is, therefore, the USACE’s opinion that the modifications to the BR Lock would retain the overall historical nature or engineering attributes and characteristics under 36 CFR §60.4, Criteria A and C. The major constituents and attributes of the BR Lock and esplanade would remain as a significant contribution to the BRLD Historic District. Formal concurrence with the finding of the “conditional no adverse effect” for the TAEB, TACN, TACNEB, and LCA was requested by the USACE in a letter dated March 8, 2016 (Appendix K, Coordination; letter dated March 8, 2016). The USACE received concurrence with the Illinois SHPO for a conditional no adverse effect (Appendix K, Coordination; letter dated March 25, 2016, IHPA LOG# 002021015).

The USACE made a determination of conditional no adverse effect, with the conditions that the USACE would contract with the National Park Service (NPS) to, “…produce and publish a book for historical and educational purposes focusing in the significance of the history and engineering in the IWW system…” The Deputy State Historic Preservation Officer, IHPA, Springfield, Illinois, concurred with the conditional no adverse effect in March 23, 2016 (Appendix K, Coordination; letter dated March 23, 2016, IHPA Log# 002021015). This information will be partially gleaned from the final NRHP Nomination Registration Form (http://www.nationalregisterofhistoricplaces.com/il/will/state.html), combined with the NPS of the Department of the Interior’s Historic American Engineering Record for the IWW Navigation Facilities.

The USACE will fund the NPS to complete the following:

1. An illustrated history of the IWW (Publication) commensurate in scale, subject matter/pictures, layout, and scope to:

   O'Brien, William Patrick, Mary Yeater Rathbun, and Patrick O'Bannon, 1992, *Gateways to Commerce*. Funded by the NPS and the USACE and published as part of the Division of Cultural Resource, Rocky Park Regions, National Park Service, Denver, Colorado (http://www.nps.gov/parkhistory/online_books/rmr/2/index.htm);

2. The publication and distribution of one hard copy to all those on this Distribution List, libraries located in the county seat, and the county historical societies in those 22 counties within the state of Illinois that border the IWW; and

3. A digital copy of the publication will be placed on the NPS site similar to that for Gateways to Commerce depicted (http://www.npshistory.com/series/archeology/rmr/2/index.htm) for a minimum of 5 years; and

4. The NPS contract will be funded, and published versions distributed, within 3 years of the date of the authorized funding for the construction of the tentatively accepted plan (preferred alternative).

Those on the Distribution List of the Illinois SHPO Coordination Letter were notified that they would continue to be provided with public meeting announcements, special releases, and notifications of the availability of report(s), as stipulated by 36 CFR §800.5 and the NHPA. Although the USACE has provided documentation of no significant archeological properties within the GLMRIS-BR Site-Specific Study Area, if any undocumented historic properties are identified or encountered during the implementation of an alternative, the USACE would discontinue all construction and dredged material placement activities, and resume coordination with the Illinois SHPO and those on the Distribution List to identify the significance of the historic property and determine potential effects under Section 106 of the NHPA and 36 CFR §800.

7.3.3 Infrastructure

No New Federal Action Alternative

The NNFA is not expected to have any short-term or long-term direct or indirect impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. Under the NNFA, operation of the BRLD and use of the associated buildings and surrounding lands would continue. The NNFA would also include the continuation of nonstructural measures, albeit at a reduced level. None of these activities are expected to have any impacts on infrastructure within the vicinity of the BRLD.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. Under the NSA, nonstructural activities would occur, as well as increased contracted commercial fishing and monitoring for *A. lacustre*. The NSA includes the construction of two boat launches near the BRLD. Construction of the boat launches includes minimal excavation needed for preparation of the site and placement of gravel to create the correct slope for the launches as well as floating docks. Construction of the boat launches is not expected to have any impacts on infrastructure within the vicinity of the BRLD. Public use of the boat launches would not be permitted.

All boat launches are sited on a USACE-operated facility that requires access restrictions for security and safety because of proximity to lock facilities.

The TAEB could have potential short-term and long-term direct impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts could occur during construction activities that would be associated with the engineered channel. Controlled blasting would need to occur to enlarge the downstream approach channel in order to facilitate the placement of the engineered channel and maintain current depth of the channel. Potential short-term impacts related to controlled blasting could be the vibration of nearby structures. Controlled blasting specifications typically include requirements for monitoring both vibration (i.e., in wave velocity) and air-blast (i.e., decibel) and establish maximum allowable limits to these. A properly designed controlled blasting plan may also minimize potential impacts on nearby structures due to vibrations. The operation of the electric barrier continuously could potentially impact nearby infrastructure such as the BR Lift Bridge and the BR Lock due to effects from ground current. Ground currents have the potential to accelerate corrosion of metallic structures on land in the vicinity of an electric barrier, such as piping, concrete reinforcing steel, and fence posts. This is commonly referred to in the industry as "stray current." The stray current pattern consists of a pick-up of stray current from the earth at one or more locations and the subsequent discharge of stray current to the earth at one or more locations. When a current transfers from a metallic structure to earth, it must do so via an oxidation reaction that converts electronic current to ionic current. On an iron or steel structure without cathodic protection (i.e., a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell), the oxidation reaction is usually the dissolution (corrosion) of the metal. The corrosion of the metal items is limited to the areas where the electrical potentials can be detected. To mitigate for any potential impacts on infrastructure resultant of operation of an electric barrier continuously at the BRLD, studies would likely need to be performed once it is functioning to map the presence of ground currents from the barrier on nearby infrastructure. In addition, the implementation of an electric barrier includes an engineered channel (Chapter 6, Structural Measures, Engineered Channel). If designed appropriately, an engineered channel may reduce potential off-site impacts such as stray current. The TAEB also includes nonstructural measures whose potential impacts were discussed under the NSA. The construction of the new mooring location under the TAEB is also not expected to have any impacts on nearby infrastructure.

The TACN is not expected to have any long-term direct impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. Short-term direct impacts are possible during construction of the engineered channel and the associated controlled blasting. For a discussion of these potential short-term impacts due to controlled blasting, refer to the discussion of controlled blasting under the TAEB. While the decibel level that the complex noise would be operated at is unknown at this time, it is not believed that the operation of this feature would have any impact on nearby infrastructure. The TACN also includes nonstructural measures whose potential impacts were discussed under the NSA.

The TACNEB could potentially have short-term and long-term direct impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN, whose potential impacts on infrastructure are discussed under these alternatives. Note, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB's electric barrier may be greater than the TACNEB's electric barrier.

The LCA is not expected to have any direct or indirect impacts on infrastructure within the GLMRIS-BR Site-Specific Study Area. However, the LCA could have potential indirect impacts on infrastructure within the GLMRIS-BR Illinois Waterway Study Area. For example, if companies utilizing river transportation had to shift transportation of their goods to rail or tractor trailer, due to closure of the lock, there could be impacts on infrastructure (e.g., roads, bridges, and railways) within the GLMRIS-BR Illinois Waterway Study Area from increased use. For reference, 1 standard dry cargo barge can move as much cargo as 16 rail cars or 70 tractor trailers (Kruse et al. 2012). Overall, the addition of rail cars and/or tractor trailers to the railways and roadways within the GLMRIS-BR Illinois Waterway Study Area, as a response to the LCA, could result in an increased need for maintenance of area roads, bridges, and railways, or additional infrastructure beyond what is currently available (e.g., new roads and new railways).

Public Facilities

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future. No further short-term or long-term direct or indirect impacts on public facilities would be expected as a result of the NNFA.

Action Alternatives

The NSA is not expected to have any short-term or long-term direct or indirect impacts on public facilities within the GLMRIS-BR Site-Specific Study Area. The only public facility is the BR Lock, and access to this facility would not change with the implementation of the NSA.

The TAEB, TACN, and TACNEB are not expected to have any short-term or long-term direct or indirect impacts on public facilities within the GLMRIS-BR Site-Specific Study Area. The only public facility is the BR Lock, and access to this facility would not change with the implementation of the TAEB.

The LCA could have potential long-term direct impacts on public facilities within the GLMRIS-BR Site-Specific Study Area. The LCA would likely include closure of the BR Lock Station, since operations at the lock would cease under this alternative. However, operations of the BR Dam would continue to occur.

7.4 Socioeconomic and Human Resources

7.4.1 Treaty Rights and Subsistence Fishing

No New Federal Action Alternative

The NNFA could potentially have long-term indirect impacts on treaty rights and subsistence fishing within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. The potential consequences of ANS establishment, specifically Bighead Carp, Silver Carp, and *A. lacustre*, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. In general, per the USFWS Draft FWCAR (USFWS 2016), there are 27 federally recognized Native American tribes residing within the U.S. portion of the GLB, and more than half of the tribes are part of negotiated treaty settlements with the U.S. Government. Management jurisdiction within treaty-ceded waters is held by the federal court system. Fishery resources within each treaty boundary are allocated among tribal and state governments through a federal court order. Fisheries are co-managed by federal, state, and tribal governments to meet target levels of harvest based on the presence of available native and stocked fish populations at the time of signing each Consent Decree. Any action that substantially impacts achieving the harvest goals and objectives within the various treaty waters could result in reopening of the terms of the decrees and cause each of the parties to spend considerable resources to renegotiate the terms of the decrees. Therefore, if Bighead Carp and Silver Carp were to become established within the GLB and impacts on target harvest levels within treaty-ceded waters were realized, then adverse impacts on treaty rights and subsistence fishing could occur.

Action Alternatives

Similar to the NNFA, the NSA could potentially have long-term indirect impacts on treaty rights and subsistence fishing within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA and in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the NSA. However, the NSA would reduce the likelihood the ANS will establish in the GLB and cause adverse impacts.

The TAEB, TACN, TACNEB, and LCA could all potentially have long-term indirect impacts on treaty rights and subsistence fishing within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. While implementation of any of these alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA and in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the TAEB, TACN, TACNEB, and LCA. However, implementation of any of these alternatives would reduce the likelihood the ANS will establish in the GLB and cause adverse impacts.

7.4.2 Commercial Fishing

No New Federal Action Alternative

The NNFA could potentially have long-term indirect impacts on commercial fishing within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. The potential consequences of ANS establishment, specifically Bighead Carp, Silver Carp, and *A. lacustre*, are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin.

Action Alternatives

Similar to the NNFA, the action alternatives could potentially have long-term indirect impacts on commercial fishing within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. Although implementation of any of the action alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA and in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to any of the action alternatives. However, the action alternatives would reduce the likelihood the ANS will establish in the GLB and cause adverse impacts.

7.4.3 Navigation

Commercial Navigation

No New Federal Action Alternative

The NNFA could potentially have direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. The NNFA includes the continuation of nonstructural measures throughout the GLMRIS-BR Illinois Waterway Study Area, albeit at a reduced level of effort. The NNFA also includes contingency response actions that could be implemented if changes to the population of Bighead and Silver Carp are observed (e.g., increase in population size and upstream movement by the main population front). Depending on the contingency response action that is implemented, if a contingency response were warranted, short-notice closures of the waterway for undefined periods of time could occur, which would impact commercial navigation. In addition, if the population of Bighead and Silver Carp below the BRLD increased to such an extent, Congress could authorize closure of a lock on the upper IWW to halt their progress. As an example, a congressional mandate permanently closed the Upper St. Anthony Falls Lock in Minnesota in an effort to prevent the spread of Bighead and Silver Carp up the Mississippi River.

Action Alternatives

The NSA could have short-term and long-term direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. The NSA includes nonstructural measures similar to those being carried out under the NNFA, whose potential impacts are discussed under that alternative. The NSA also includes the construction of two boat launches; however, the location of the boat launches would not be within the navigable portion of the waterway open to commercial vessels. Therefore, no impacts on commercial navigation are anticipated as a result of their construction.

The TAEB could have short-term and long-term direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area. The potential impacts of the nonstructural measures are discussed under the NSA. Construction of the engineered channel and the various technology components of the alternative may impact commercial navigation transiting the BRLD due to scheduled, temporary lock closure events to allow for construction activities. However, these impacts are expected to be short term, and would be scheduled periodically throughout the construction period, which is estimated to be less than 3 years. Estimated impacts on navigation during this time include a one-time 40-day scheduled lock closure event followed by temporary, periodic closures of 1 to 8 hours for the remainder of the construction period. All temporary closure schedules would be coordinated with navigation lock users. During the PED phase, additional design and a value engineering (VE) study will be conducted with the goal of reducing the duration of construction impacts on navigation.

In addition to short-term impacts during the construction period, the operation of the BR electric barrier could have long-term impacts on commercial navigation. As an example, the CSSC-EB have a restricted navigation area (RNA) which requires that personnel be within the wheelhouse or below deck when transiting the CSSC-EB. Any RNA restrictions at the BR electric barrier would need to be tailored to account for the potential safety and operational risks associated with the location. The RNA at BR electric barrier differs from that of the CSSC-EB because of the differences between the channel configuration at the two locations and their proximity to BRLD. Any potential RNA restrictions would be developed by the USCG in coordination with USACE in order to minimize the life safety impacts on navigators as they transit the project. Such RNA restrictions could affect commercial navigation transit times and operational costs. The CSSC-EB RNA was used as a guide for developing the assumptions to estimate the impacts on navigation. However, the actual extent of the elevated electric field at the BRLD is currently unknown and would be unknown until the electric barrier was constructed and in operation and testing could be conducted.

The TAEB also includes the construction of a new mooring area to allow navigators to prepare to transit the project safely and to minimize the impacts of the continuously operated electric barrier on navigation. To comply with any RNA restrictions, tows may need to reconfigure prior to entering the BR Lock downstream approach channel. Given that the closest fleeting area is about 7 mi (11.3 km) downstream of the BRLD, the construction of four mooring cells approximately 2 mi (3.2 km) downstream of the BRLD would reduce the distance that tows would have to move in a constrained configuration. Construction of these mooring cells would not occur within the navigable channel of the waterway where commercial vessels would be present; therefore, this action is not expected to have any adverse short-term or long-term direct impacts on commercial navigation.

The operation of the flushing lock could also have long-term impacts on commercial navigation. During lock flushing, vessels would be required to tie up downstream of the lock and would not be permitted to enter the BR Lock chamber until flushing is complete, thereby increasing the processing time. During the PED phase, additional analysis will be conducted with the goal of reducing the duration of construction impacts on navigation.

The impacts on navigation are included as an NED cost of the alternatives and were included as project costs in the CE/ICA analysis. The estimated impacts on navigation account for all project phases, including construction and the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of ANS controls. A summary of these impacts is presented in Section 6.6.6, Impacts on Navigation. For a more detailed discussion, refer to Appendix D, Economics.

The TACN could have short-term and long-term direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area. Construction of the engineered channel and the various technology components of the alternative may impact commercial navigation transiting the BRLD due to scheduled, temporary lock closure events to allow for construction activities. However, these impacts are expected to be short term, and would be scheduled periodically throughout the construction period, which is estimated to be less than 3 years. Estimated impacts on navigation during this time include a one-time 40-day scheduled lock closure event followed by temporary, periodic closures of 1 to 8 hours for the remainder of the construction period. All temporary closure schedules would be coordinated with navigation lock users. During the PED phase, additional design and a VE study will be conducted with the goal of reducing the duration of construction impacts on navigation.

Long-term impacts for the TACN would primarily be due to the operation of the flushing lock. During lock flushing, vessels would be required to tie up downstream of the lock and would not be permitted to enter the lock chamber until flushing is complete, thus increasing the processing time. Potential delays to navigation from operation of the flushing lock may be minimized based upon model testing during PED.

The impacts on navigation are included as an NED cost of the alternatives and were included as project costs in the CE/ICA analysis. The estimated impacts on navigation account for all project phases, including construction and the OMRR&R of the TACN. A summary of these impacts is presented in Section 6.6.6, Impacts on Navigation. For a more detailed discussion, refer to Appendix D, Economics.

The TACNEB could potentially have short-term and long-term direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area. This alternative is a combination of the TAEB and TACN, whose estimated impacts on commercial navigation are discussed under these alternatives. Note that, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels are approaching the approach channel, as they travel through the approach channel, and while they are in the lock. As such, the identified impacts for operation of the TAEB's electric barrier may be greater than the TACNEB's electric barrier. The impacts on navigation are included as an NED cost of the alternatives and were included as project costs in the CE/ICA analysis. The estimated impacts on navigation account for all project phases, including construction and the OMRR&R of the TACNEB. A summary of these impacts is presented in Section 6.6.6, Impacts on Navigation. For a more detailed discussion, refer to Appendix D, Economics.

The LCA is expected to have long-term direct impacts on commercial navigation within the GLMRIS-BR Site-Specific Study Area, and potentially the GLMRIS-BR Illinois Waterway Study Area. The LCA would cause businesses that currently ship goods through the BR Lock to shift to less-efficient land modes of transportation, or to shift to less-efficient waterway (and associated overland traffic) origin-destination combinations. If commercial navigation ceased through the BR Lock, this would negatively impact navigation and result in higher transportation costs (NED costs). The average annual increase in transportation costs (NED costs) for the 50-yr period of analysis (2021–2070) were estimated at $318.7 million (2016 prices). This is approximately 8 to 10 times greater in magnitude than the loss in transportation cost savings accrued by implementing any of the technology alternatives. A summary of these impacts is presented in Section 6.6.6, Impacts on Navigation. For a more detailed discussion, refer to Appendix D, Economics.

Noncargo Navigation

No New Federal Action Alternative

The NNFA could potentially have long-term direct and indirect impacts on noncargo navigation within the GLMRIS-BR Site-Specific Study Area, the GLMRIS-BR Illinois Waterway Study Area, and the GLMRIS-BR System-Wide Study Area. Noncargo navigation users of the BRLD primarily consist of federal government vessels, non-federal government vessels, and recreational vessels. The potential impacts of the NNFA are similar to those discussed under Commercial Navigation in Section 7.4.3, Navigation.

With regard to potential long-term indirect impacts on noncargo navigation, refer to Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources.

Action Alternatives

The NSA could have potential long-term direct and indirect impacts on noncargo navigation. Although the NSA reduces the likelihood that ANS would become established in the GLB, there is still the probability that they could become established. Therefore, the discussion on potential impacts under the NNFA is also relevant for the NSA.

The TAEB could have potential short-term and long-term direct impacts on noncargo navigation within the GLMRIS-BR Site-Specific Study Area, as well as long-term indirect impacts on noncargo navigation within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. Potential impacts of the nonstructural measures are discussed as part of the NSA. Construction of the engineered channel and the various technology components of the alternative may impact noncargo vessels transiting through the BR Lock due to temporary lock closure events to allow for construction activities. However, these impacts are expected to be short term, lasting only as long as it takes to complete construction, which is estimated to be less than 3 years. Estimated impacts on navigation during this time include a one-time 40-day scheduled lock closure event followed by temporary, periodic closures of 1 to 8 hours for the remainder of the construction period. All temporary closure schedules would be coordinated with navigation lock users. Long-term impacts on recreational vessels would primarily be due to the continuous operation of the electric barrier. For example, the CSSC-EB have an RNA, which does not permit the transit of vessels smaller than 20 ft (6.1 m) through the CSSC-EB or the transit of personal watercraft such as kayaks, canoes, or jet skis. Federal and non-federal vessels would likely not be able to transit the electric barrier in the case of an emergency near the BRLD. Consistent with existing operating procedures at the CSSC-EB located in Romeoville, Illinois, the USACE personnel would alert the Fire Department in the case of an emergency. While it is uncertain what restrictions would be included in an RNA implemented at the BRLD electric barrier, it is likely that noncargo navigation, especially smaller vessels, would be impacted to some degree by such restrictions. In addition, the actual extent of the elevated electric field at the BRLD is currently unknown and would be unknown until the electric barrier was constructed and in operation, and testing could be conducted. It is possible that the elevated electric field could extend to the tailwaters of the dam, which could impact recreational boaters who may fish in this area, as well as hunters (i.e., waterfowl hunters) who may utilize the tailwaters of the dam.

Although implementation of the TAEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TAEB. However, the TAEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACN could have short-term direct impacts on recreational navigation within the GLMRIS-BR Site-Specific Study Area, as well as long-term indirect impacts on noncargo navigation within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. Potential impacts of the nonstructural measures are discussed as part of the NSA. Construction of the engineered channel and the various technology components of the alternative may impact noncargo vessels transiting through the BR Lock due to temporary lock closure events to allow for construction activities. However, these impacts are expected to be short term, lasting only as long as it takes to complete construction, which is estimated to be less than 3 years. Estimated impacts on navigation during this time include a one-time 40-day scheduled lock closure event followed by temporary, periodic closures of 1 to 8 hours for the remainder of the construction period. All temporary closure schedules would be coordinated with navigation lock users. Complex noise is not expected to have a long-term impact on noncargo vessels. There could be potential risks to boaters if they fell in the water and were submerged; however, the risk is believed to be fairly low.

Although implementation of the TACN would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TACN. However, the TACN attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACNEB could have potential short-term and long-term direct impacts on noncargo navigation within the GLMRIS-BR Site-Specific Study Area, as well as long-term indirect impacts on noncargo navigation within the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area. The TACNEB is a combination of both the TAEB and TACN, whose potential impacts have already been discussed under these respective alternatives. Note that, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB's electric barrier maybe greater than those for the TACNEB's electric barrier. Although implementation of the TACNEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TACNEB. However, the TACNEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA is expected to have long-term direct impacts on noncargo navigation within the GLMRIS-BR Site-Specific Study Area as well as the GLMRIS-BR Illinois Waterway Study Area. Noncargo vessels would no longer be able to transit through the Brandon Road Lock. Federal government vessels would need to modify operations and/or increase costs to maintain same level of service if they operate on both sides of BRLD. Non-federal government vessels such as those of police departments, fire departments, and all other rescue boats, would need to change operations in order to maintain the same level of service. This could entail having duplicate services (i.e., boats, divers, and equipment) on both sides of the BRLD. The Illinois DNR would need to modify and/or enhance its current management, protection, and sustainability program to account for the separation of the water body. All recreational vessels would no longer be able to transit the Brandon Road Lock.

Although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.4 Injury or Mortality Potential

No New Federal Action Alternative

The NNFA is not expected to increase the injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area. The USCG Maritime Information Exchange Incident Investigation Reports website was queried to see how many accidents have been investigated within the GLMRIS-BR Site-Specific Study Area. This website provides information about closed investigations or reportable marine casualties the USCG has investigated from October 2002 to the present. A query conducted for Brandon Road between October 1, 2002, and July 31, 2017, returned two results. In 2005, an empty barge struck a protection cell while exiting the lock, and in 2013, a vessel struck the BR Bridge. No injuries were reported for either incident. The NNFA may have long-term indirect impacts in the GLMRIS-BR Illinois Waterway Study Area and GLMRIS-BR System-Wide Study Area with regard to the injury or mortality potential associated with Asian carp and noncargo navigation, as discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources.

Action Alternatives

The NSA could have increased injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. The increased potential would be associated with the additional contracted commercial fishing effort which could include more commercial fishing crews (i.e., vessels) operating on the waterway and/or commercial fishing crews operating more frequently on the waterway. With additional personnel on the waterway and/or operating on the waterway more frequently, there is an increased likelihood of accidents (e.g., vessel collision, exposure of personnel to hazardous weather); this in turn could lead to an increased risk of injury or mortality potential. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TAEB could have increased injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. A potential short-term increase in the likelihood of injury or mortality could occur during construction of the TAEB. Construction personnel would be working and operating equipment in the waterway as well as on the adjacent land. At times during construction, vessels would still be permitted to move through lock. All of these factors combined could increase the likelihood of injury (e.g., falls, slips, trips, exposure to hazardous weather) or mortality to waterway users as well as lock and construction personnel. Long-term increased potential to waterway users is primarily due to the operation of the electric barrier, which creates an elevated electric field area in the water and stray current on the land. A study conducted by the USCG Engineering Research and Development Center (RDC) on the CSSC-EB regulated navigation area concluded that the largest contributor to marine safety risk within the RNA was person in the water related electric shock (Lewandowski et al. 2013). Contributors to the person in the water related electric shock were associated with (1) personnel on the shore in the RNA, (2) personnel entering the water from vessels approaching the RNA, and (3) persons receiving electric shock due to operation of recreational vessels 20 ft (6.1 m) or less (and personal watercrafts) (Lewandowski et al. 2013). Persons in the water within the elevated electric field may experience ventricular fibrillation and involuntary muscular contraction. Stray current from the elevated electric field on land and structures may cause shock hazards from metal objects, also increasing life safety risks to waterway users and BR Lock personnel. The potential for increase in injury or mortality from implementation of the nonstructural measures is discussed under the NSA. Although implementation of the TAEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TAEB. However, the TAEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACN could have increased injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. A potential short-term increase in the likelihood of injury or mortality could occur during construction of the TACN. Construction personnel would be working and operating equipment in the waterway as well as on the adjacent land. At times during construction, vessels would still be permitted to move through lock. All of these factors combined could increase the likelihood of injury (e.g., falls, slips, trips, exposure to hazardous weather) or mortality to waterway users as well as lock and construction personnel. Long-term increased injury potential to waterway users is primarily due to the operation of complex noise and a person in the water situation. In this type of scenario, complex noise could potentially damage ear tissue depending on the ultimate operating parameters for the speakers, the duration a person is submerged, and the person's proximity to the speaker(s). This alternative also includes nonstructural measures, engineered channel, water jets, and flushing lock. The potential for increase in injury or mortality from implementation of the nonstructural measures is discussed under the NSA. Although implementation of the TACN would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TACN. However, the TACN attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TACNEB could have increased injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. This alternative is a combination of the TAEB and TACN, whose potential impacts on waterway users and personnel were discussed under these alternatives, respectively. Note that, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB's electric barrier may be greater than those for the TACNEB's electric barrier. The potential for increase in injury or mortality from implementation of the nonstructural measures is discussed under the NSA. Although implementation of the TACNEB would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the TACNEB. However, the TACNEB attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA could have increased injury or mortality potential to waterway personnel within the GLMRIS-BR Site-Specific Study Area, as well as the GLMRIS-BR Illinois Waterway Study Area. A potential short-term increase in the likelihood of injury or mortality could occur during construction of the LCA. Construction personnel would be working and operating equipment in the waterway as well as on the adjacent land. These factors combined could increase the likelihood of injury (e.g., falls, slips, trips, exposure to hazardous weather) or mortality to primarily to lock and construction personnel. In addition, there is an increase in potential linked to the implementation of the nonstructural measures. For a discussion of the potential impacts, refer to the NSA. Although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed in Section 5.3.7, International Boater Safety and Reduction in the Perceived Value of Aquatic Resources, are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

Indirect impacts of the LCA, due to a potential transportation mode shift from barge to semi-trucks, were evaluated using the Navigation Investment Model (NIM) and the Waterway Analysis Model (WAM). This safety analysis specifically looked at the potential for roadway injury or mortality within the vicinity of the BRLD due to a potential transportation mode shift. The analysis found that the LCA results in significant increases of fatality, injury, and property damage costs when compared to the technology alternatives. Combined using the mid value, these costs average approximately $19.4 million a year throughout the analysis period for the LCA, compared to approximately $1.5 million a year for the technology alternatives. Since there is no diverted traffic associated with the NSA, the safety impacts are estimated to be zero. Additional details can be found in Appendix D, Economics (Section D.4.6).

7.4.5 Displacement of People

No New Federal Action and Action Alternatives

There are no residential properties within the GLMRIS-BR Site-Specific Study Area that would be impacted; therefore, it is inferred that no people would be displaced by the NNFA or action alternatives.

7.4.6 Aesthetic Values

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future. No further short-term or long-term direct or indirect impacts are expected on aesthetic values near the GLMRIS-BR Site-Specific Study Area as a result of the NNFA.

There is the potential for long-term indirect impacts on aesthetic values within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the NNFA.

Action Alternatives

No short-term or long-term direct impacts on aesthetic values within the GLMRIS-BR Site-Specific Study Area would result from the action alternatives. There would be a temporary stockpile of rock that would be placed near the BR Lock during construction of the engineered channel. Since the industrial character of the surrounding area would remain unchanged, no significant decline in aesthetic values would be anticipated.

There is the potential for long-term indirect impacts on aesthetic values within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. Although implementation of any of the action alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to all of the action alternatives. However, the action alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.7 Community Cohesion

No New Federal Action

Because of the lack of a residential community within the GLMRIS-BR Site-Specific Study Area, no impacts on community cohesion would be anticipated by the NNFA. There is the potential for long-term indirect impacts on community cohesion within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the NNFA (see Appendix D, Economics, for additional details on the economic importance of the Great Lakes.

Action Alternatives

Similar to the NNFA, no impacts on community cohesion would be anticipated within the GLMRIS-BR Site-Specific Study Area due to the lack of a residential community. There is the potential for long-term indirect impacts on community cohesion within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. Although implementation of any of the action alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and discussed in Appendix D, Economics, are applicable to the action alternatives. However, the action alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.8 Desirable Regional and Community Growth

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future resulting in little impacts on the economic growth that depends on navigation in this area. However, the NNFA has the potential to indirectly impact desirable regional and community growth within the GLRMIS-BR System-Wide Study Area, with the potential increase in the probability of invasive species entering the GLB. In light of the uncertainty and range of possible environmental and aesthetic changes associated with invasive species in the GLB, there is a range of possible ways that communities and the regional economy of the Great Lakes states could be affected. Invasive species could potentially alter the abundance, size distributions, and length-weight relationships of resident species in the GLB. As such, several fishing activities could be impacted, including commercial fishing (by state-licensed and tribal operators), recreational fishing, charter fishing, professional fishing tournaments, and subsistence fishing. Nonfishing activities potentially affected by invasive species include recreational boating, other shoreline activities, and the use of coastal and riparian properties. Although some GLB fishing occurs from private boats, potentially half of all Great Lakes boating does not involve fishing. Boating could be affected through equipment damage and personal injuries from jumping fish (e.g., Silver and Bighead Carp) and through losses in enjoyment of boating due to jumping fish. Invasive species have the potential to affect the significant amount of nonfishing shoreline recreational activities, including swimming and beach going. For instance, participation in these activities could be altered if invasive species become prevalent in the recreational areas of interest and reduce their aesthetic appeal. Coastal and riparian properties and their values could be affected if the willingness of people to live near these water bodies was altered in any way by invasive species. Each of these uses of the Great Lakes is integral to the surrounding communities and regional economy. Invasive species could impact these uses (see Appendix D, Economics, for details on the economic importance of the Great Lakes).

Action Alternatives

The NSA is not anticipated to have short-term or long-term direct or indirect impacts on desirable regional and community growth within the GLMRIS-BR Site-Specific Study Area. There may be an indirect impact on desirable regional and community growth within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish

The TAEB, TACN, and TACNEB would allow barge traffic to continue with some possible modifications to current operations. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The technology alternatives could increase shipping costs for industries that ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the technology alternatives could impact regional economic activity and/or growth supported by this important navigation system. In addition, although implementation of any of the technology alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the technology alternatives. However, implementation of any of the technology alternatives attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA is anticipated to impact navigation, as the BR Lock will no longer be in operation. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The LCA would increase shipping costs for industries that would need to rely on alternative modes of transportation to ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the LCA could impact the regional economic activity and/or growth supported by this important navigation system (see Section 4.7, Navigation, for details on the extensive use of the BR Lock). In addition, although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the LCA. However, the implementation of the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.9 Tax Revenues

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future, resulting in little impacts on the economic growth that depends on navigation in this area. However, the NNFA has the potential to indirectly impact tax revenues within the GLRMIS-BR System-Wide Study Area, with the potential increase in the probability of invasive species entering the GLB. There is a broad range of uses and activities that would be potentially affected by invasive species entering the GLB, including commercial and recreational fishing activities; recreational boating; nonfishing shoreline recreational activities, including swimming and beach going; as well as adjacent property values. Changes in these uses and values due to invasive species could impact the economy of the Great Lakes states. For instance, if invasive species altered the availability of fish species targeted by recreational anglers, this could result in a decreased number of fishing trips and reduced spending at local restaurants, gas stations, and other fishing-related goods and services. Reduced business revenues could impact tax revenues (see Section 4.6.2, Fishing, for details on the significance of commercial fisheries in the Great Lakes).

Action Alternatives

The NSA is not anticipated to have short-term or long-term direct or indirect impacts on regional tax revenues within the GLMRIS-BR Site-Specific Study Area. There may be an indirect impact on tax revenues within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TAEB, TACN, and TACNEB would allow barge traffic to continue with some possible modifications to current operations. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The technology alternatives could increase shipping costs for industries that ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in their competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the technology alternatives could impact the regional tax revenues supported by this important navigation system. In addition, there may be an indirect impact on tax revenues within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of any of the technology alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to any of the technology alternatives. However, the technology alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA is anticipated to impact navigation, as the BR Lock will no longer be in operation. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The LCA would increase shipping costs for industries that would need to rely on alternative modes of transportation to ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the LCA could impact the regional tax revenues supported by this important navigation system (see Appendix D, Economics, for details regarding changes to the regional economy due to each alternative plan). In addition, there may be an indirect impact on tax revenues within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.10 Property Values

No New Federal Action

There are no residential properties within the GLMRIS-BR Site-Specific Study Area that would be impacted by the NNFA or action alternatives. Since the industrial character of the surrounding area would remain unchanged, no significant decline in property values would be anticipated. There is the potential for long-term indirect impacts on property values within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the NNFA (see Appendix D, Economics, for additional details on the economic importance of the Great Lakes.

Action Alternatives

Similar to the NNFA, no impacts on property values would be anticipated within the GLMRIS-BR Site-Specific Study Area due to the industrial character of the surrounding area. There is the potential for long-term indirect impacts on community cohesion within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area, if Asian carp were to become established in the GLB. Although implementation of any of the action alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, and discussed in Appendix D, Economics, are applicable to the action alternatives. However, the action alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.11 Public Services

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future. No further short-term or long-term direct or indirect impacts on public services are expected as a result of the NNFA.

Action Alternatives

The NSA, TAEB, TACN, and TACNEB would allow barge traffic to continue with some possible slight modifications to the current operations. Adaptive management practices would minimize the potential impacts on navigation.

The LCA is anticipated to impact navigation as the BR Lock will be no longer be in operation, and navigation access will be terminated. The current activities of both commercial and recreational vessels utilizing this Lock are extensive (see Section 4.7, Navigation, for details on the use of the BR Lock).

7.4.12 Employment

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future resulting in little impacts on the economic growth that depends on navigation in this area. There may be an indirect impact on employment within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. As discussed in Section 7.4.8, Desirable Regional and Community Growth, there is a broad range of uses and activities that would be potentially be affected by invasive species entering the GLB, including: commercial and recreational fishing activities; recreational boating; nonfishing shoreline recreational activities, including swimming and beach going; as well as adjacent property values. Changes in these uses and values due to invasive species could impact the economy of the Great Lakes states. For example, if invasive species altered the availability of fish species targeted by recreational anglers, this could result in a decreased number of fishing trips and reduced spending on local restaurants, gas stations, and other fishing-related goods and services, which in turn could change the distribution and level of employment in the Great Lakes states.

Action Alternatives

The NSA is not anticipated to have short-term or long-term direct or indirect impacts on employment within the GLMRIS-BR Site-Specific Study Area. There may be an indirect impact on employment within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The TAEB, TACN, and TACNEB would allow barge traffic to continue with some possible modifications to current operations. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The technology alternatives could increase shipping costs for industries that ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the technology alternatives could impact the regional employment supported by this important navigation system. In addition, there may be an indirect impact on employment within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of any of the technology alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to any of the technology alternatives. However, the technology alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

The LCA is anticipated to impact navigation, as the BR Lock will no longer be in operation. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The LCA would increase shipping costs for industries that would need to rely on alternative modes of transportation to ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the LCA could impact the regional employment supported by this important navigation system (see Appendix D, Economics, for details regarding changes to the regional economy due to each alternative plan). In addition, there may be an indirect impact on employment within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish.

7.4.13 Business and Industrial Activity or Manmade Resources

No New Federal Action Alternative

The NNFA includes the continued operation of the BRLD into the future. No further short-term or long-term direct or indirect impacts on business and industrial activity or man-made resources within the GLMRIS-BR Site-Specific Study Area are expected as a result of the NNFA. The NNFA could potentially have long-term indirect impacts on the economy within the GLMRIS-BR System-Wide Study Area if Bighead and Silver Carp were to become established in the GLB. The potential impacts on the economy if Bighead Carp and Silver Carp were to become established in the GLB are discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin.

Action Alternatives

The NSA is not anticipated to have short-term or long-term direct or indirect impacts on regional business activity within the GLMRIS-BR Site-Specific Study Area. There may be an indirect impact on regional business activity within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the NSA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the NSA. However, the NSA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish within the GLB (see Appendix D, Economics, for details regarding changes to the regional economy due to each alternative plan).

The TAEB, TACN, and TACNEB would allow barge traffic to continue with some possible modifications to current operations. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The technology alternatives could increase shipping costs for industries that ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the technology alternatives could impact the regional business activity supported by this important navigation system. In addition, there may be an indirect impact on regional business activity within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of any of the technology alternatives would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to any of the technology alternatives. However, the technology alternatives attempt to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish within the GLB (see Appendix D, Economics, for details regarding changes to the regional economy due to each alternative plan).

The LCA is anticipated to impact navigation, as the BR Lock will no longer be in operation. The economic impacts on the Chicagoland area would be accrued by industries that use the BR Lock to access markets. The LCA would increase shipping costs for industries that would need to rely on alternative modes of transportation to ship goods past the BRLD location, resulting in higher selling prices for those goods. Therefore, the firms that depend on the BRLD to transport their goods would face a reduction in competitive advantage relative to other firms not impacted by the increased cost in shipping. Overall, the LCA could impact regional business activity supported by this important navigation system. In addition, there may be an indirect impact on regional business activity within the GLMRIS-BR Illinois Waterway Study Area and the GLMRIS-BR System-Wide Study Area. Although implementation of the LCA would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exists. The potential GLB impacts discussed under the NNFA are applicable to the LCA. However, the LCA attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish within the GLB (see Appendix D, Economics, for details regarding changes to the regional economy due to each alternative plan).

7.4.14 Environmental Justice

Environmental justice is institutionally significant because of E.O. 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” and the U.S. Department of Defense’s Strategy on Environmental Justice of 1995, directing federal agencies to identify and address any disproportionately high adverse human health or environmental effects of federal actions on minority and/or low-income populations.

Minority populations are those persons who identify themselves as Black, Hispanic, Asian American, American Indian/Alaskan Native, and Pacific Islander. A minority population exists where the percentage of minorities in an affected area either exceeds 50% or is meaningfully greater than in the general population.

Low-income populations as of 2000 are those whose annual income are at or below $23,850.00 for a family of four and are identified using the Census Bureau’s statistical poverty threshold. The Census Bureau defines a “poverty area” as a Census tract with 20% or more of its residents below the poverty threshold, and an “extreme poverty area” as one with 40% or more below the poverty level. (This is updated annually at http://aspe.hhs.gov/poverty/14poverty.cfm).

This resource is technically significant because the social and economic welfare of minority and low-income populations may be positively or disproportionately impacted by the proposed actions. This resource is publicly significant because of public concerns about the fair and equitable treatment (fair treatment and meaningful involvement) of all people with respect to environmental and human health consequences of federal laws, regulations, policies, and actions.

A potential disproportionate impact may occur when the percentage minority (50%) and/or percentage low-income (20%) population in an environmental justice study area are greater than those in the reference community. The primary study area is the BRLD and its immediate vicinity. The EPA mapping tool was used to identify low-income and minority populations within the project area (http://www.epa.gov/environmentaljustice/mapping.html). A point marker was placed on the BRLD and a 5-mi (8.0-km) buffer around the marker was used for purposes of this analysis. Within the study area, 53% of the population consists of minorities, which is equal or higher than 71% of the state of Illinois, which has an average minority population of 36%. With regard to EPA Region 5 (includes Minnesota, Wisconsin, Illinois, Indiana, Michigan, and Ohio), the minority population within the vicinity of the BRLD is equal to or higher than 84% of the region, which has an average minority population of 24%. Thirty-nine percent of the population within the vicinity of the BRLD is considered low-income, which is equal to or higher than 68% of the state of Illinois, which has an average low-income population of 31%. In regard to EPA Region 5, the low-income population within the vicinity of the BRLD is equal or higher than 67% of the region, which has an average low-income population of 32% (Table 7-4).

Table 7-4 Percentage of Minority and Low-Income Populations within the Vicinity of the BRLD and Comparison to State of Illinois, EPA Region 5, and U.S. Demographics

Demographic Indicators	Raw Data	State Avg.	% in State	EPA Region Avg.	% in EPA Region	U.S. Avg.	% in U.S.
Minority Population	53%	36%	71	24%	84	36%	71
Low-Income Population	39%	31%	68	32%	67	34%	63

No New Federal Action Alternative

The NNFA is not expected to disproportionately impact minority or low-income populations within the vicinity of the BRLD.

Action Alternatives

None of the action alternatives are expected to disproportionately impact minority or low-income populations within the vicinity of the BRLD. While results of the Environmental Justice View Mapping tool show that minority and low-income populations are greater within the vicinity of the BRLD than within the state of Illinois, EPA Region 5, and the United States, the project is considered aquatic ecosystem restoration and is not expected to adversely impact these communities directly or indirectly.

7.5 Hazardous, Toxic, and Radioactive Waste

7.5.1 No New Federal Action Alternative

The NNFA would not have an impact on any existing, identified, or unidentified, environmental issues related to soil, sediment, air, or water issues.

7.5.2 Action Alternatives

Under all of the action alternatives, future sediment disturbance would require compliance with Sections 401 and 404 of the CWA. The USACE plans to follow the Inland Testing Manual (EPA and USACE 1998) for any sediment evaluation.

With regard to Tract 3 (Figure 7-2), the parcel adjacent to the downstream approach channel at the BRLD, the TAEB, TACN, and TACNEB would all have potential similar impacts since Tract 3 would be used for supporting operational support facilities and equipment needed for operation of the various technologies. A complete investigation of the property (including on the ground surveys) has not yet been conducted; however, a review of historic aerials indicates that the property may already be impacted due to past uses (see Appendix G, Phase I Environmental Site Assessment (Hazardous, Toxic, and Radioactive Waste [HTRW]), for additional discussion on the property. It is anticipated that additional site investigation of Tract 3 will be conducted prior to design. Specifically, existing conditions that may require regulatory action or that would impact project implementation will be investigated, as will the geotechnical conditions of the site. Alternatives to the use of that property will be considered depending on the results of the investigation. Alternative sites for support features could include the left descending bank (the “island”) and the land north of the lock, which is already owned by the USACE.

The LCA is not expected to impact any existing environmental conditions.

7.6 Irreversible and Irretrievable Commitment of Resources

7.6.1 No New Federal Action Alternative

The NNFA would not involve the irreversible or irretrievable commitment of resources associated with any new proposed actions.

7.6.2 Action Alternatives

All of the action alternatives would require irreversible and irretrievable commitments. The expenditure of funding, energy, labor, and materials would be required for each action alternative. In addition, the loss of connectivity between the lower Des Plaines River and the upper Des Plaines River with the implementation of the TAEB, TACNEB, or LCA could also be considered irreversible and irretrievable. In theory, if constructed, components of these action alternatives could be turned off or removed in the future; however, it is unknown how realistic this is. Severing the connectivity of the Des Plaines River and the potential associated impacts were discussed in Section 7.2.3, Aquatic Resources. In general, irreversible and/or irretrievable commitments associated with severing the connectivity are associated with native species in the lower Des Plaines River and tributaries being unable to recolonize or repopulate the upper Des Plaines River.

7.7 Mitigation

USACE policy is to ensure that adverse impacts on significant resources have been avoided or minimized to the extent practicable and that remaining, unavoidable impacts have been compensated to the extent justified.

Although the USACE assessment of the alternative impacts reveals that impacts are expected to be minor overall, the Illinois DNR and USFWS (Appendix A, Draft FWCAR) have voiced their concern that the reduction in connectivity within the Des Plaines River will need to be mitigated if the TAEB, TACN, TACNEB, or LCA are implemented. Therefore, in-kind mitigation is being proposed if any of the aforementioned alternative plans are selected for implementation. In-kind mitigation would not be required for the NNFA or the NSA. Further technical evaluation and site-specific project analysis and development would be needed prior to determining what type of mitigation activities are needed and/or appropriate. While the details of the proposed in-kind mitigation are still being coordinated among the USFWS, Illinois DNR, and USACE, a list of general concepts and request for mitigation proposed by the Illinois DNR were provided in the USFWS Draft FWCAR (Appendix A). The following list of mitigation measures has been proposed. This list should not be considered all-inclusive, and needs may change over time.

- Stocking sport fish and nongame native fishes to meet management goals over the life of the project (Draft Des Plaines River management plan outlines strategy and priorities).

- Stocking of, or translocation of mussel species and host species to meet management goals over the life of the project (Draft Des Plaines River management plan outlines strategy and priorities).

- Aquatic habitat enhancement to support and enhance fish and mussel populations of the Des Plaines River.
  - Enhance dam removal projects in select basins;
  - Enhance or create key habitat features identified in the Draft Des Plaines River management plan to maintain and meet Des Plaines River management goals (e.g., vegetation (water willow), establishment of native aquatic vegetation, rock bar creation, and other physical habitat improvements;
  - Water quality, landscape-level educational outreach to reduce nonpoint source pollution (e.g. EPA Low Impact Development, incorporating green infrastructure); and
  - Mitigation of select point source pollution activities, if opportunities present themselves.

- Enhance ongoing ANS surveillance, monitoring, and surveys both below the BRLD and within the Des Plaines River.

- Continue and/or enhance ongoing harvesting of Asian carp in the Upper IWW.

- Assisted fish migration planning for select priority species (e.g., American Eel passage).

- Support sport fish enhancement in the Des Plaines River and elsewhere.

- Support nongame fish enhancement in the Des Plaines River.

- Support mussel enhancement, use, and recolonization of the Des Plaines River.
- Establish monitoring protocols and resources to assess status, movement, and habitat use of select fish species in the lower Des Plaines watershed (species and strategies are identified in the current Draft Illinois DNR Des Plaines River management plan).
- Support stakeholder outreach and education to further promote appropriate management of aquatic resources for which mitigation actions are needed, and in support of current Illinois DNR management plans (e.g., engage with "Friends of Groups" to meet the variety of water user needs under an altered Des Plaines River with BRLD modifications).
- Support appropriate outreach and education to prevent overland or unintentional transport of ANS through or around additional control measures at the BRLD (e.g., signage, community involvement, and area school curriculum).

7.8 Cumulative Impacts

Section 1508.7, 40 CFR, promulgated by the President's CEQ to implement NEPA, defines cumulative impact as:

> the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions.

Consideration of cumulative effects requires a broader perspective than examining just the direct and indirect effects of a proposed action. It requires that reasonably foreseeable future effects be assessed in the context of past and present effects on important resources. The analysis should include a larger geographic area than the immediate "project" area. One of the most important aspects of cumulative effects assessment is that it requires consideration of how actions by others (including those actions completely unrelated to the proposed action) have and will affect the same resources. In assessing cumulative effects, the key determinant of importance or significance is whether the incremental effect of the project will alter the sustainability of resources when added to other present and reasonably foreseeable future actions.

Cumulative environmental effects for the proposed ecosystem protection project were assessed in accordance with guidance provided by the President's CEQ (EPA 1999). This guidance provides an 11-step process for identifying and evaluating cumulative effects in NEPA analyses.

Scope

In this EIS cumulative effect issues and assessment goals are established, the spatial and temporal boundaries are determined, and the reasonably foreseeable future actions are identified. Cumulative effects are assessed to determine if the sustainability of any of the resources is adversely affected, with the goal of determining the incremental impact on key resources that would occur as a result of implementation of the recommended plan.

The spatial boundary for the assessment has been broadened to consider effects beyond the study area and to include the far-reaching influence this action would have on the Great Lakes ecosystem.

The temporal boundaries considered are:

- Past – 1920s: the approximate time that the modification of the IWW was complete providing an unimpeded dispersal route to and from the GLB and MRB.
- Present – 2017: when the decision is being made on a recommended plan that would aid in preventing MRB ANS from spreading to the GLB.
- Future – 2017–end of 2070: the time frame used for implementing a recommended plan to address the issue of interbasin dispersal of ANS.

In a broad sense, projecting the reasonably foreseeable future actions is difficult at best. The proposed action for the waterways is reasonably foreseeable; however, the actions by others that may affect the same resources are not as clear. Projections of those actions must rely on judgement as to what are reasonable based on existing trends and where available, projections from qualified sources. Reasonably foreseeable does not include unfounded or speculative projections. In this case, reasonably foreseeable future actions include:

- Continued restoration of the Des Plaines River and other waterways, to the extent possible, given the restrictions of urban and suburban development;
- Continued navigation in the IWW, CSSC, and Cal-Sag Channel;
- Continued impacts on floodplain profiles due to development and land use change;
- Continued introduction of nonnative ANS;
- Continued application of environmental requirements, such as those under the CWA and water quality improvement;
- Implementation of various programs and projects to deal with runoff and waste water pollution and to restore degraded environments; and,
- Completion of the McCook and Thornton Reservoirs, which will result in fewer overflows to the CAWS from combined sewer and stormwater systems.

Cumulative impacts were assessed for the NNFA and the action alternatives. The analysis revealed that there were potential cumulative impacts with regard to energy consumption (physical resources), connectivity of the Des Plaines River (biological resources), establishment of MRB ANS in the Des Plaines River and GLB (biological resources), the BRLD Historic District (cultural and archaeological resources), and injury or mortality potential of waterway users (economic, social, and aesthetic values).

7.8.1 Cumulative Effects on Physical Resources

Energy Consumption for the Alternatives

Long-term energy usage is of concern due to the link to GHG emissions (and other air pollutants), climate change, and the consumption of fossil fuels. This issue is directly related to the sustainability of the selected alternative, as well as to the cost of operation and maintenance. The various alternatives under consideration represent a wide range of energy consumption. Table 7-5 presents a relative evaluation of the energy usage.

The largest energy consumption would come from the operation of the electric barrier. The power usage can be estimated based on the operation of the CSSC-EB at Romeoville, Illinois. At that location, as of fall 2016, two barriers are operating full time, and one additional barrier is under construction. The power usage of a single barrier installation varies seasonally, with greater power usage in cold weather months. The two operating barriers also are slightly different in configuration and power usage. It is expected that a new barrier (including the one currently under construction in Romeoville) would use a similar amount of power as the existing Barrier IIB; a monthly power consumption of 1,033.1 MWh is the current estimated usage for cold weather months. The warm weather usage is on the order of 804.6 MWh. The total annual power consumption of one barrier, continuously operated, is approximately 10,800.0 MWh.

For comparison to the scale of this usage, an average household in Illinois in 2009 used approximately 10,000 kWh (EIA 2009). Adding one electric barrier would be similar to adding approximately 1,080 households to the Joliet area. Currently, the Joliet area has approximately 47,000 households (U.S. Census Bureau 2016). The electric barrier operation would be similar in electrical energy usage to a 2% increase in the number of households.

Most electricity in Illinois is generated by burning fossil fuels. Traditionally, coal was a major energy source; however, due to issues with coal (particulates and other air pollutants, mining and transportation costs), Illinois has seen a shift to natural gas for electrical generation. Nuclear, wind, water (hydropower), geothermal, and solar power are also used to varying degrees, but none of these are as significant in Illinois as the use of natural gas (EIA 2009). Burning natural gas produces carbon dioxide (CO_2) and also

Table 7-5 Energy Consumption by Alternative

Alternative	Energy Use	Comments
NNFA	None	No systematic long-term activities and no systematic energy consumption.
NSA	Lowest	Fuel would be needed for monitoring activities, but no large installations or long-term energy usage.
TAEB	Highest	A long-term, high-power usage would be required (discussed further, below).
TACN	Moderate	Energy would be needed long term for noise generation; however, the energy consumption is anticipated to be much lower than that needed for an electrical barrier.
TACNEB	Moderate–Highest	The electrical barrier operation would require much more power than the complex noise, so the overall energy usage would depend on the duration of electrical barrier operation.
LCA	None from the facility. Change in transportation fuel consumption.	The lock closure would actually result in a decrease in energy usage at the lock facility. This gain in efficiency would be offset by increases in fuel consumption for the transportation of goods, if materials moved by barge will instead be moved by land-based transportation modes (rail, truck). This issue is discussed further in the general conformity evaluation.

small amounts of other air pollutants. A new electrical barrier, using commercially produced electricity from a natural-gas-fired power plant, would require approximately 109 million cubic feet (cf) of natural gas and would result in the production of approximately 13.2 million pounds of CO_2 annually (EIA 2009). Compared to the annual Illinois residential use of 479 billion cf of natural gas and the associated 57.8 billion pounds of CO_2 produced, the new barrier would represent a 0.02% increase in natural gas usage and CO_2 production. This is a relatively insignificant increase in both fuel/electricity usage as well as in pollutant production, although not a small amount. No direct impacts on the local community are expected with the relatively small percentage increase in power usage from an electrical barrier. Other alternatives would use less power and have an even lower impact proportionately.

7.8.2 Cumulative Effects on Biological Resources

Connectivity of the Des Plaines River

The Des Plaines River has always naturally flowed west into the MRB. Historically, prior to human interference, during large rainfall events, the Des Plaines River would change its course and flow into the Chicago and Calumet Rivers, which were composed of large wetland complexes that flowed eastward into the GLB intermittently. This provided a temporary connection between the MRB and the GLB. In addition, the Chicago River and Calumet River would also inundate flat areas during large rainfall events, creating a surface water connection between the Des Plaines River at Mud Lake and Saganashkee Slough. A constant connection between the GLB and MRB was not established until 1848, when construction of the I&M Canal was completed, which connected the Chicago River to the Illinois River. Eventually, the I&M Canal was replaced by the larger CSSC in 1900. Construction of the CSSC required that a 16-mi (25.7-km) section of the Des Plaines River be channelized (USFWS 2016). The CSSC and Des Plaines River run parallel to each other for nearly 24 mi (38.6 km), until they join just downstream of Lockport Lock and Dam.

While human interference began changing the landscape surrounding the Des Plaines River with the draining of wetlands for agriculture and development in the 1800s, major hydrologic modifications to the mainstem Des Plaines River did not begin until the early 1900s. Table 7-6 lists some of the more significant modifications that occurred to the mainstem Des Plaines River and the year they were completed.

In addition, there were numerous hydrologic modifications to the tributaries of the upper Des Plaines River. According to the USFWS, there are 44 dams located within the Des Plaines River watershed (USFWS 2016). The majority of these dams are low-head, run of the river type structures. They were originally designed to maintain a minimum channel depth during low flows for water quality and recreational purposes. Several were once used as fords across the river for livestock and vehicles. Channel modifications and reservoirs were constructed within the Des Plaines River watershed to combat flooding caused by urban development.

The portion of the upper Des Plaines River within Illinois is highly urbanized. As of 2001, land use in the Illinois portion of the watershed consisted of 57.4% urban, 23% open space, and 19.6% agriculture. Due to hydrologic modifications, urbanization, and agriculture, water quality within the Des Plaines River has been degraded. Within the Illinois portion of the watershed, runoff, storm sewers, combined sewer overflows, and contaminated sediments in the waterway are commonly identified causes for water quality impairment. Other impairments include municipal point sources, or wastewater treatment plants, discharges, and hydrostructure flow regulation and modification.

Table 7-6 Hydrologic Modifications to the Mainstem Des Plaines River

River or Tributary	Project	Size	Year Completed	Year Removed (if applicable)
Des Plaines River	Dam #1 downstream of Hintz Rd. (RM 73.5)	4 ft (1.2 m) tall	1918	2014
	Dam #2 downstream of Euclid Ave. (RM 69.0)	4 ft (1.2 m) tall	1920	2014
	Dam #4 upstream of Higgins Rd. (RM 59.5)	2 ft (0.6 m) tall	1922	TBD[a]
	Dam #3 upstream of Touhy Ave. (RM 61.2)	2 ft (0.6 m) tall	1920s	TBD
	Brandon Road Lock and Dam		1930	
	Channel modification (Hofmann Dam to North Ave.)	8 mi (12.9 km)	1932	NA[b]
	Channel Modification (upstream of Wadsworth Rd.)	0.3 mi (0.5 km)	1935	NA
	Ryerson Dam downstream of Deerfield Rd. (RM 78.6)	2 ft (0.6 m) tall	1956	2011
	Dam near Armitage Ave. (RM 51.5)	2 ft (0.6 m) tall	1957	2012
	Hofmann Dam replacement (RM 43.5)	12 ft (3.7 m) tall	1950	NA
	Dam #3 upstream of Touhy Ave. rebuilt (RM 61.2)	2 ft (0.6 m) tall	1960s	NA
	Dam downstream of Dempster St. (RM 63.5)	2 ft (0.6m) tall	1960s	2016
	Berm at Big Bend Lake (RM 66.1–66.5)	0.4 mi (0.6 km)	1978	NA
	Levee at North Libertyville Estates (RM 91.1–90.2)	1 mi (1.7 km)	1999	NA
	Hofmann Dam Notching (RM 43.5)	12 ft (3.7 m) tall	2012	2012
	Dam # 4 upstream of Higgins Rd. rebuilt (RM 59.5)	2 ft (0.6 m) tall	1960s	NA
	Wright Dam upstream of Half Day Rd. (RM 83.4)	2 ft (0.6 m) tall		2016

[a] TBD = to be determined.
[b] NA = not applicable.

Because of the aforementioned impairments, aquatic resources within the Des Plaines River have suffered. Surveys conducted by the Illinois DNR in the mid-1970s produced very few fish species throughout the watershed (included CAWS and CSSC), and, in 1983, basin-wide surveys yielded 21 native fish. However, due likely to improvements in water quality since the 1970s, improvements to the native fish community have been observed. Surveys conducted in 1997 at the same locations as those conducted in 1983, yielded 37 native species. In addition, the percentage of tolerant species has decreased throughout the years, a sign of water quality improvement within the watershed. In 1983, 72% of the species collected were considered tolerant; 45% collected in 2008 were considered tolerant; and in 2013, only 18% of the species collected were considered tolerant of poor water quality. It was also noted that no intolerant species were collected in 1983; however, in 2013, five intolerant species were collected (USFWS 2016).

Recent efforts have been undertaken by the Lake County Forest Preserve District, Forest Preserve District of Cook County, Illinois DNR, and USACE to remove the dams from the mainstem of the Des Plaines River and restore hydrologic connectivity and flow regimes. In 2011, the Ryerson Woods Dam was removed by the Lake County Forest Preserve District. In January and February 2012, the Armitage and Fairbanks Dams were removed, respectively. Following in September 2012, the Hofmann Dam was notched. Removal of the Armitage and Fairbanks Dams, and notching of the Hofmann Dam reconnected 58 mi (93.3 km) of riverine habitat and allowed recolonization of portions of the upper Des Plaines River by species from the lower Des Plaines River. In 2014, Dam #1 and Dam #2 in Cook County were removed, and, in the fall of 2016, the MacArthur Woods and Daniel Wright Woods Dams were removed by the Lake County Forest Preserve District. The Dempster Avenue Dam was also removed in 2016. The remaining two low-head dams (i.e., Dam #4 and Touhy Avenue Dam) on the mainstem of the Des Plaines River are scheduled for demolition in the near future.

While the direct effect of the dam removals is unknown, the collection of native species within the Des Plaines River has increased since basin wide-surveys began in 1983. During the 2013 Basin Study, 61 native species were collected, as well as two state-threatened species – Banded Killifish and Iowa Darter. It is believed that the Banded Killifish entered the Des Plaines River from Lake Michigan; however, the Rosyface Shiner was also collected, and populations of this species are known to occur within the Kankakee River, suggesting that upstream movement of species from the lower Des Plaines River to the upper Des Plaines River is occurring now that impediments to upstream movement have been removed (USFWS 2016). The Rosyface Shiner is also an intolerant species, which further indicates that water quality within the Des Plaines River is improving. Another species, the Freckled Madtom, was also collected in the lower Des Plaines River. This species has been collected on several occasions 22 mi (35.4 km) downstream of the BRLD, further suggesting that native species are moving through the BRLD to recolonize the upper Des Plaines River.

The Illinois DNR also notes, that prior to the removal of the Hofmann Dam from the mainstem Des Plaines River, very few large-bodied riverine species were collected upstream of this dam on the mainstem. However, since the removal of Hofmann Dam, 11 large-bodied riverine species have been found above the removal site, with the Channel Catfish showing significant repopulation. In addition, another large-bodied riverine species that has never been recorded from the upper Des Plaines River, the Longnose Gar, was collected in fall 2016 (Veraldi 2016). Several large-bodied species were also found below the dam site that had not been seen prior to 2013. The Illinois DNR stated that the most likely source of these species is the lower Des Plaines River/Illinois River where these species are common (USFWS 2016).

There are also other proposed projects with the aim of restoring habitat and connectivity within the Des Plaines River. In 2015, the USACE released the *Upper Des Plaines River and Tributaries, Illinois and Wisconsin Integrated Feasibility Report & Environmental Assessment* (i.e., authorized in the

2016 WRDA), which recommended alternative plans that included fish passage at all mainstem dams on the Des Plaines River and one on a tributary to the Des Plaines River, Salt Creek (USACE 2015c). In addition, the *Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment,* March 2007, references the USACE's desire to increase connectivity of the Des Plaines River with the Illinois River while reducing the transfer of nonnative ANS (USACE 2007b). For more detailed descriptions of these projects see Section 2.3, Studies, Reports, and Existing Water Projects within the Study Area; Section 2.3.3, Des Plaines River; and Section 2.3.4, Illinois River.

The cumulative impacts analysis for connectivity of the Des Plaines River looks at how implementation of a GLMRIS-BR alternative would potentially reduce connectivity within the Des Plaines River. As described above, connectivity within the Des Plaines River has been disrupted since the early 1900s. However, efforts are currently being undertaken to restore connectivity, and improvements within the watershed are being observed as a result of these undertakings.

In general, the NNFA and NSA are not expected to have any adverse cumulative impacts on the connectivity of the Des Plaines River. Both of these alternatives include the continuation of monitoring and removal efforts, among other activities, within the upper IWW and lower Des Plaines River. However, no structural measures are proposed as part of either of these alternatives; therefore, no disruption to the connectivity of the Des Plaines River is expected.

The cumulative impacts of the TACN on the connectivity of the Des Plaines River is unknown at this time. Preliminary research and results on complex noise suggest that it can be used to target specific species. If further research supports these preliminary results and confirms that complex noise can be operated in such a way that it only impacts behavior of targeted species, then no disruption to the connectivity of the Des Plaines River would be expected, since presumably only nonnative species would be impacted by the control point; native species would be expected to still be able to traverse the control point at the BRLD. However, if further research shows that other species in addition to the target species are impacted by the operating parameters of the complex noise, then native species could be impacted and connectivity of the Des Plaines River could be adversely affected. Impacts on connectivity and the secondary impacts this disruption and connectivity would cause are discussed in detail below for the remaining three alternatives.

The TAEB, TACNEB, and LCA are expected to impact connectivity of the Des Plaines River. The electric barrier component of the control point is a nonselective control and would target nonnative and native species equally. Note, as formulated, it was assumed that the TACNEB's electric barrier would be turned off when vessels were approaching the approach channel, as they traveled through the approach channel and while they were in the lock. As such, the identified impacts for operation of the TAEB's electric barrier may be greater than those for the TACNEB's electric barrier. The USFWS Draft FWCAR (USFWS 2016) evaluated the potential impact on interjurisdictional species and federally threatened and endangered species if one of the above alternatives were to be implemented and subsequent connectivity within the Des Plaines River were to be impacted. With regard to interjurisdictional fish, fish populations whose management and allocation of use are the collective responsibility of two or more states, tribes, and/or nations, the American Eel is the only species within the study area that has been observed on occasion within the Illinois River and CAWS. In addition, the USFWS recently collected this species in 2016 from the Hanson Materials East Pit and just below the BRLD. This species has also been listed by the State of Illinois as threatened. The dispersal of the American Eel from the lower Des Plaines River to the upper Des Plaines River could be affected by the implementation of one of the aforementioned control points at the BRLD. However, although the USFWS notes in its Draft FWCA (USFWS 2016) that the American Eel is the only federal trust species in the Des Plaines River that may be affected by the GLMRIS-BR project, it only rarely occurs in the basin. Therefore, no adverse effects on this species are expected.

With regard to federally threatened and endangered species, there are none currently within the Des Plaines River; however, there are two federally threatened and endangered mussel species (i.e., scaleshell and sheepnose) located within the upper Illinois River and Kankakee River that would be impacted from reestablishing within the upper Des Plaines River if a control point were to be established at the BRLD that either contained an electric barrier or closed the lock. In addition, the Illinois DNR expressed concern about a third federally threatened and endangered mussel species, the Spectaclecase.

The scaleshell mussel is federally endangered and is typically found in medium to large rivers with low to moderate gradients in a variety of stream habitats (USFWS 2010). The scaleshell mussel does require a specific host species, the Freshwater Drum, which is found in both the Great Lakes and Illinois River. According to the USFWS Recovery Plan (2010) for the scaleshell, in Illinois, the species historically occurred within the Wabash (Ohio River tributary), Kaskaskia, Illinois, and Sangamon (Illinois River tributary) Rivers, tributaries to the middle Mississippi River. This species was believed to have been extirpated from most of the middle Mississippi River, including all streams east of the Mississippi River. In 2013, a single specimen was collected in the upper Illinois River between Marseilles and Morris, Illinois (INHS Mollusk Database #44305) (Kanter 2013). Prior to the 2013 collection, the species had not been collected within the state of Illinois for more than a century (Kanter 2013). With regard to the Des Plaines River in Illinois, the scaleshell mussel is not historically known to have occurred there, according to Price et al. (2012a) in their technical report on freshwater mussels of the Des Plaines River and Lake Michigan tributaries to Lake Michigan. In addition, the species was not found within the Des Plaines River or tributaries to Lake Michigan (e.g., relict, dead, or alive) during surveys conducted in 2009 and 2011 (Price et al. 2012a), nor within the Kankakee River or its tributaries during a 2010 survey (Price et al. 2012b).

The sheepnose mussel is also federally endangered and is typically found in larger streams and rivers with shallow shoal habitats and moderate to swift currents. The cited fish host for the sheepnose is Sauger; however, this comes from a 1914 report that found glochidia attached to Sauger in the wild, with no confirmation of successful transformation of the glochidia (Wilson and Clark 1914). Recent laboratory studies have successfully transformed sheepnose glochidia on Fathead Minnow, Creek Chub, Central Stoneroller, and Brook Stickleback; however, in the wild, interactions between these fish and sheepnose seem rare and infrequent due to habitat preferences. Overall, it is likely that Sauger, and fish like it that frequent medium to large rivers, are more likely to act as host for the sheepnose in the wild. According the USFWS Final Rule (2012), extant populations of Sheepnose were known to occur within the Mississippi, Kankakee, Ohio, and Rock Rivers of Illinois. Within the Illinois River, the only stable population was considered to be in the Kankakee River. The species was believed to be extirpated from the Illinois River, Fox River, Des Plaines River, and the I&M Canal. For the Des Plaines River, the sheepnose mussel is historically known to have occurred there. Price et al. (2012a), in their technical report on freshwater mussels of the Des Plaines River and Lake Michigan tributaries in Illinois, listed Sheepnose as historically occurring within the Des Plaines River. This species was not collected (e.g., relict, dead, or alive) during surveys conducted in 2009 and 2011 (Price et al. 2012a). However, two live specimens and two relict shells were collected at four different sites on the mainstem of the Kankakee River during a 2010 survey (Price et al. 2012b).

The spectaclecase mussel is also a federally endangered mussel typically found in large rivers, and is found in microhabitats sheltered from the main force of current. According to the USFWS Final Rule (2012), no extant populations of spectaclecase are believed to exist in Illinois. The species is considered extirpated from the Rock, Illinois, Des Plaines, Kankakee, and Kaskaskia Rivers. Surveys of the Des Plaines River in 2009 and 2011, the Kankakee River in 2010, and additional tributaries of the upper, middle, and lower Illinois River in 2009–2012 did not collect spectaclecase (Stodola et al. 2013).

In summary, the scaleshell mussel is not known to have historically occurred within the Des Plaines River according to available literature. For the species to become established in the Des Plaines River, glochidia attached to the species fish host (i.e., Freshwater Drum) would need to travel from the upper Illinois River to the Des Plaines River before being expelled from the fish host. The sheepnose mussel, according to available literature, historically occurred within the Des Plaines River. The species was not collected in the Des Plaines River during recent surveys (e.g., 2009 and 2011); however, it was collected in the Kankakee River where it is considered to have a stable population. For the species to become reestablished in the Des Plaines River, glochidia attached to the species fish host (i.e., Sauger) would need to travel from the Kankakee River to the Des Plaines River before being expelled from the fish host. Lastly, the spectaclecase mussel, according to available literature, is known to have historically occurred within the Des Plaines River; however, the species is considered extirpated from Illinois and was not collected in the Des Plaines River (e.g., 2009 and 2011), Kankakee River (e.g., 2010), or Illinois River (e.g., 2009–2012) during recent surveys. The closest stable populations appear to occur within the Meramec and Gasconade Rivers of Missouri. Therefore, for the species to become reestablished in the Des Plaines River, glochidia attached to the species host (i.e., unknown) would need to travel from the Meramec or Gasconade Rivers, upstream to the Mississippi River, upstream to the Illinois River, and then upstream to the Des Plaines River before being expelled from the host. In its Draft FWCA Report (2016), the USFWS stated that it did "not anticipate any effects to these federally listed species because they do not occur within the action area; however, if water quality and mussel habitat continue to improve in the Des Plaines River, it may be suitable for these species in the future."

With regard to state-listed threatened and endangered species, the American Eel is a state-listed threatened species, and as discussed above, no adverse effects on this species are expected. Additional state-listed species include the Banded Killifish and the Iowa Darter. Both of these species have been collected in the Des Plaines River; however, biologists with the Illinois DNR believe that these fish originated from Lake Michigan and entered the Des Plaines River through the CSSC (USFWS 2016). The state- threatened Blackchin Shiner has also been found in the Des Plaines River.

Although no adverse effects are expected on interjurisdictional species or federally threatened and endangered species, the implementation of the TAEB, TACNEB, and LCA are expected to impact the connectivity of the Des Plaines River. In addition, it is unknown whether the TACN would impact connectivity of the Des Plaines River as discussed previously. Therefore, in-kind mitigation is being proposed if any of the aforementioned alternative plans are selected for implementation. In-kind mitigation would not be required under the NNFA or the NSA. The details of the proposed in-kind mitigation are still being coordinated with the USFWS and Illinois DNR. For an additional discussion, refer to Section 7.7, Mitigation.

Impact of Mississippi River Basin Aquatic Nuisance Species on the Aquatic Resources of the Des Plaines River and Great Lakes Basin

The potential impacts on the GLB if MRB ANS were to become established – specifically if Bighead Carp, Silver Carp, and *A. lacustre* were to become established – are discussed in detail in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin. While these consequences of ANS establishment could be realized for all of the alternative plans, the probability at which they occur is reduced depending on the alternative plan that is selected and implemented. The following alternatives are listed in order of increasing probability of establishment for the aforementioned ANS – LCA, TACNEB, TAEB, TACN, NSA, and NNFA. Therefore, Lock Closure has the lowest probability of establishment, and thereby the lowest likelihood that the consequences described in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, will be realized. In contrast, the NNFA has the greatest probability of establishment, and thereby the greatest likelihood that the consequences described in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, will be realized.

7.8.3 Cumulative Effects on Cultural and Archaeological Resources

Brandon Road Lock and Dam Historic District

It is the opinion of the USACE that no cumulative effects on archeological properties will occur. The TAEB, TACN, TACNEB, and LCA are potentially determined to have an adverse effect on the BRLD Historic District. The USACE acknowledged that the additions or modification to the original fabric of the dam and the new construction within the BRLD Historic District boundaries may be considered to have adverse and visual effects as a result of the Technological Alternatives or the LCA. To mediate those effects, the USACE made a finding permissible under 36 CFR §800.5(b) for a conditional no adverse effect. The cumulative effects on the BRLD Historic District and the IWW Navigation Facilities (http://www.nationalregisterofhistoricplaces.com/il/will/state.html) will be offset by the condition of producing an educational publication that focuses on the importance of the IWW System and its national role as a significant waterway.

7.8.4 Cumulative Effects on Economic, Social, and Aesthetic Values

Injury and Mortality Potential to Waterway Users

There are potential cumulative effects on the life safety of waterway users within the upper IWW and CAWS. For the NNFA, NSA, TACN, and LCA, the qualitative life safety risk is considered low. The primary risk for these alternatives would be the continued operation of the CSSC-EB in Romeoville, Illinois.

At the CSSC-EB, the USCG has established an RNA. These actions place navigational, environmental, and operational restrictions on all vessels transiting the navigable waters located adjacent to, and over, the CSSC-EB. The RNA includes all waters of the CSSC between RM 295.5 and RM 297.2. Regulations in the RNA include:

1. All up-bound and down-bound barge tows that consist of barges carrying flammable liquid cargos (Grade A through C, flashpoint below 140°F (60°C), or heated to within 15°F (–9.4°C) of flash point) must engage the services of a bow boat at all times until the entire tow is clear of the RNA.

2. Vessels engaged in commercial service, as defined in 46 USC §2101(5), may not pass (meet or overtake) in the RNA and must make a SECURITE call (i.e., marine radio transmission that begins with the phrase "Securite" and means that what follows is important safety information) when approaching the RNA to announce intentions and work out passing arrangements.

3. Commercial tows transiting the RNA must be made up with only wire rope to ensure electrical connectivity between all segments of the tow.

4. All vessels are prohibited from loitering in the RNA.

5. Vessels may enter the RNA for the sole purpose of transiting to the other side and must maintain headway throughout the transit. All vessels and persons are prohibited from dredging, laying cable, dragging, fishing, conducting salvage operations, or any other activity, which could disturb the bottom of the RNA.

6. Except for law enforcement and emergency response personnel, all personnel on vessels transiting the RNA should remain inside the cabin, or as inboard as practicable. If personnel must be on open decks, they must wear a Coast Guard-approved personal flotation device.

7. Vessels may not moor or lay up on the right or left descending banks of the RNA.

8. Towboats may not make or break tows if any portion of the towboat or tow is located in the RNA.

9. Persons on board any vessel transiting this RNA are advised that they do so at their own risk.

10. Vessels must be greater than 20 ft (6.1 m) in length.

11. Vessels must not be a personal watercraft of any kind (e.g., jet skis, wave runners, and kayaks).

The NNFA and LCA would have the lowest potential for injury or mortality associated with transit through the CSSC-EB only. Under the NSA, commercial fishing is expected to increase. This could include an increase in the number of fishing crews on the waterway and/or an increased level of effort. If there are more fishing crews on the waterway, it is within reason that the potential for injury or mortality of those waterway users could increase due to additional vessel traffic. This potential for injury or mortality would also be relevant for the action alternatives, which include nonstructural measures. Under the TACN, the potential for injury or mortality could increase for waterway users that are transiting the control point at the BRLD in addition to the CSSC-EB. While the qualitative risk rating for complex noise is considered among the lowest, there are potential impacts on waterway users if they were to fall into the waterway and become submerged while the complex noise is being operated. In a man overboard situation, complex noise potentially could damage ear tissue depending on the ultimate operating parameters for the speakers, duration a person is submerged, and the person's proximity to the speaker(s).

The TAEB is considered to have moderate to highest potential for injury or mortality due to vessels having to traverse an electric barrier downstream of the BRLD. These life safety risks are compounded then if vessels have to transit the CSSC-EB as well. In addition to transiting the electric barriers at the CSSC-EB, vessels would be required to transit an electric barrier at the BRLD, thus increasing the potential for injury or mortality of vessel personnel. Regarding an electric barrier downstream of the BRLD, it is uncertain what, if any, safety zones and/or regulated navigation areas may be enforced. Safety testing once the electric barrier is operational would need to occur to determine the extent of the elevated electric field before any regulations would be administered by the USCG. Currently, lookouts are needed on the front of tows entering the BRLD to help navigate safely into the lock chamber as well as to cut and tie off double lockage tows. Lock personnel are required to operate the gates and pull out the first cut of double lockages. Vessel and lock personnel have duties that prevent them from being within the wheelhouse of a vessel or within the lock house, thus increasing their chances of potentially falling in the water. With regard to the CSSC-EB, the potential for injury or mortality is not as great since transit through this portion of the CAWS does not require personnel to be out on the deck of a vessel (i.e., there is no lock).

The TACNEB is considered to have moderate to highest potential for injury or mortality. Potential for injury or mortality would be similar to that described for the TAEB and the TACN; however, the TACNEB would be operated so as to minimize impacts on navigation while maximizing the effectiveness of the alternative. Depending on the results of safety testing and design, the electric barrier may have to be turned off while vessels transit. Therefore, injury or mortality potential could be highest or moderate depending on operation of the electric barrier downstream of the BRLD.

7.9 Compliance with Environmental Statutes

The alternative plans presented in the integrated EIS are in compliance with appropriate statutes, executive orders, and memoranda, including the NHPA of 1966, the ESA of 1973, the FWCA, and E.O. 12898 ("Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations"). The alternative plans are also potentially in compliance with the CAA, CWA, and NEPA. There were no adverse environmental effects identified which cannot be avoided or mitigated should an alternative plan be selected and implemented [40 CFR 1502.16 (citing section 102(2)(C)(ii) of NEPA)]. Table 7-7 provides a summary of the compliance status for the primary environmental requirements associated with GLMRIS-BR.

Section 7 of the Endangered Species Act – Preliminary consultation with the USFWS under Section 7 is documented in the Draft FWCAR (2016). The USFWS notes that there are no federally listed species within the vicinity of the GLMRIS-BR Site-Specific Study Area. Coordination will continue through the NEPA process.

Fish and Wildlife Coordination Act – Coordination under the FWCA has been initiated and documented with the Draft FWCAR (Appendix K, Coordination). Information from the letter has been incorporated into this draft FS and EIS.

Section 404(b)(1) of the Clean Water Act – A Section 404(b)(1) evaluation was completed in accordance with Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR §230). Details of the evaluation are in Appendix B, Planning. Since the USACE does not issue permits under 404(b)(1) for projects implemented under the Civil Works Program, the evaluation is being coordinated with the IEPA as part of the Section 401 Water Quality Certification.

Section 401 of the Clean Water Act – Section 401, Water Quality Certification, would be sought if any of the technology alternatives were implemented. These include the construction of an engineered channel and a new mooring location approximately 1.8 mi (2.9 km) downstream from the BRLD. The new mooring location would require dredging, while the construction of the engineered channel would require blasting and placement of concrete wall liners.

Section 106 of the Natural Historic Preservation Act – The NHPA established a program for the preservation of additional historic properties throughout the nation, and for other purposes, approved October 15, 1966. Section 106 of the NHPA, as amended, and its implementing regulations 36 CFR §800, "Protection of Historic Properties," establishes the primary policy, authority for preservation activities, and compliance procedures. The Proposed Project, as proposed, required coordination and compliance promulgated under the NHPA and its implementing regulations at 36 CFR §800, "Protection of Historic Properties." The NHPA ensures early consideration of historic properties preservation in federal undertakings and the integration of these values into each agency's mission. In compliance with these requirements, the USACE is coordinating with the Illinois SHPO and others, as discussed in more detail in Section 7.3, Cultural and Archeological Resources.

Archaeological Investigation – The Archeological Resources Protection Act (P.L. 96-95; 16 USC §470aa-470mm) provides for the protection of archaeological sites located on public and Indian lands, establishes permit requirements for the excavation or removal of cultural properties from public or Indian lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange,

Table 7-7 Compliance with Environmental Laws, Regulations, and Executive Orders Relative to the Recommended Plan

Reference	Environmental Statutes/Regulations	Project Compliance[a]
16 USC §1531, et seq.	Endangered Species Act, as amended	C
16 USC §470a, et seq.	National Historic Preservation Act, as amended	C
16 USC §661	Fish and Wildlife Coordination Act, as amended	C
16 USC §703, et seq.	Migratory Bird Treaty Act of 1918, as amended	C
16 USC §469, et seq.	Archaeological and Historical Preservation Act, as amended	C
25 USC §3001, et seq.	Native American Graves Protection and Repatriation Act	C
33 USC §1251, et seq.	Clean Water Act of 1977, as amended	C
42 USC §1962, et seq.	Water Resources Planning Act of 1965	C
42 USC §1996	American Indian Religious Freedom Act of 1978	C
42 USC §201	Safe Drinking Water Act of 1986, as amended	C
42 USC §4321, et seq.	National Environmental Policy Act (NEPA), as amended	C
42 USC §6901, et seq.	Resource Conservation and Recovery Act of 1976, as amended	C
42 USC §7401	Clean Air Act of 1970 as amended	C
42 USC §9601	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980	C
7 USC §4201, et seq.	Farmland Protection Policy Act	C
CEQ Memo Aug 11, 1980	Prime and Unique Agricultural Lands and NEPA	C
E.O. 11514	Protection and Enhancement of Environmental Quality	C
E.O. 11593	Protection and Enhancement of the Cultural Environment	C
E.O. 11988	Floodplain Management	C
E.O. 11990	Protection of Wetlands	C
E.O. 12088	Federal Compliance with Pollution Control Standards	C
E.O. 12898	Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	C
E.O. 13007	Indian Sacred Sites	C
E.O. 13045	Protection of Children from Environmental Health Risks and Safety Risks	C
E.O. 13112	Invasive Species	C
E.O. 13186	Responsibilities of Federal Agencies to Protect Migratory Birds	C
E.O. 13340	Great Lakes Designation of National Significance to Promote Protection	C
E.O. 13751	Safeguarding the Nation From the Impacts of Invasive Species	C
AC 150/5200-33B	Hazardous Wildlife Attractants On or Near Airports	C

[a] Designations: C = compliance; CEQ = Council on Environmental Quality; E.O. = Executive Order; USC = *United States Code*.

or other handling of archaeological resources. A detailed discussion on compliance with regard to archeological sites in the project vicinity is set forth in Section 7.3, Cultural and Archeological Resources.

Clean Air Conformity Rule – The CAA (42 USC §7401, et seq.), as amended in 1977 and 1990, was established to protect and enhance the quality of the nation's air resources to promote public health and welfare and the productive capacity of its population. The Act authorizes the EPA to establish National Ambient Air Quality Standards to protect public health and environment. The Act establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. The Act requires the states to develop implementation plans applicable to particular industrial sources. Title IV of the Act includes provisions for complying with noise pollution standards. The alternative plans are expected to be in compliance with the Act, as discussed in more detail in Section 7.1.8, Air Quality.

Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, E.O. 12898 – Environmental justice refers to executing a policy of the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws. Increasing concern with environmental equity or justice evolved from a series of studies, conducted in the late 1980s and early 1990s, that suggested that certain types of government and corporate environmental decisions may adversely affect low-income and minority populations to a greater extent than the general population. This finding was particularly the case with locally unpopular lands uses, such as landfills and toxic waste sites. Recent guidelines addressing environmental justice include President Clinton's 1994 E.O. 12898 and accompanying memorandum, the 1996 draft guidelines for addressing environmental justice under NEPA issued by the CEQ, and the 1997 interim guidelines issued by the EPA. None of the alternative plans are expected to disproportionately affect in a negative manner the low-income and/or minority populations, as discussed in more detail in Section 7.4.13, Environmental Justice.

Chapter 8 Comparison of Alternative Plans*

Each of the final array of alternative plans was compared to demonstrate the positive and negative effects of various plans. The evaluation of effects, or comparison of the future with-project and future without-project conditions for each alternative plan, is a requirement of NEPA and E.R. 1105-2-100. The evaluation assessed or measured the differences between each future with-project and future without-project condition and appraised those differences.

8.1 Alternative Plan Evaluation Criteria

8.1.1 Reduction in the Probability of Establishment in the GLB

Quantitative estimates of P(establishment) were prepared to provide a means of differentiating between the relative effectiveness of the alternative plans formulated to prevent the establishment of Asian carp and *A. lacustre* in the GLB by transferring through the CAWS pathway. Refer to Chapter 6, Alternative Formulation, and Appendix C, Risk Assessment, for a description of the P(establishment) methodology.

Estimates of the P(establishment) of Asian carp due to transfer through the CAWS and into the GLB were prepared from quantities elicited from qualified experts. P(establishment) estimates from the experts ranged from almost impossible to almost certain. Inputs from three experts led to very low-probability estimates, one led to a high-probability estimate, and the remaining two fell between these two extremes, albeit closer to the low end than the high end of the scale. The range in values indicates a great degree of uncertainty among the experts regarding the quantities used to estimate the P(establishment) of Asian carp due to transit through the CAWS aquatic pathway. The experts' opinions, however, agreed on rank order of the alternative plan based on effectiveness, meaning the individual P(establishment) estimates for each expert ranked the alternative plans in the same order of effectiveness. This order of effectiveness is also reflected in the ranking of the composite expert (Figure 8-1).

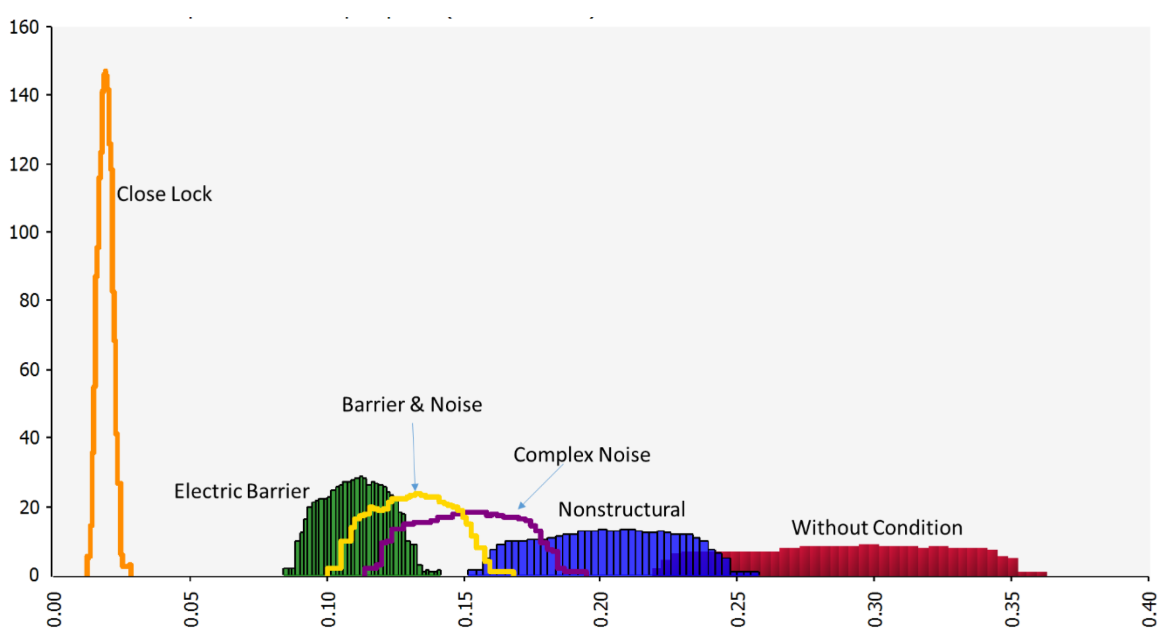

Figure 8-1 Composite Expert Estimated Asian Carp P(Establishment) Distributions for NNFA and Action Alternatives through 2071

Estimates for P(establishment) for *A. lacustre* due to transfer through the CAWS and into the GLB are nearly identical for the NNFA and NSA. All of the technology alternatives have essentially the same negligible effect on the P(establishment) values for *A. lacustre* as well. The technology alternatives do not include measures that are anticipated to be effective in reducing P(establishment) for *A. lacustre*. The composite distributions are presented in Figure 8-2, which shows little difference among P(establishment) estimates for five of the six alternative plans. The Lock Closure Alternative was identified as the only alternative that noticeably reduces the probability of establishment estimates for *A. lacustre*. Even so, considerable uncertainty remains, with a range from 17 to 78% and a median probability of 42%. The reason for this range of uncertainty is that the elicited experts were concerned that this species may have already passed through the CAWS and become established in the GLB. This concern was based on the understanding that (1) *A. lacustre* has been established in the Dresden Island Pool since 2008, (2) the species primarily moves by attachment to vessels, and (3) the area between Dresden Island Pool and Lake Michigan is heavily navigated.

As noted in the Chapter 6 analysis of P(establishment) for *A. lacustre*, this species typically moves upstream by attaching to vessels, and where it is currently known to be established (i.e., Dresden Island Pool) the waterway is a regulated navigation channel with year-round traffic. During the elicitation, the experts stated that this species may have already established in the GLB because it has been found in the Dresden Island Pool (i.e., the pool immediately downstream of BRLD) since 2008. The experts' opinion that the species may have already established in the GLB is demonstrated by the estimates of P(establishment) for *A. lacustre* that the experts provided. In addition, the LCA is the only alternative that addresses the hitchhiker mode of transport; however, because the experts believe *A. lacustre* may have already established, they found that lock closure would not be very effective. Lock closure was the only alternative formulated to address hull-fouling species.

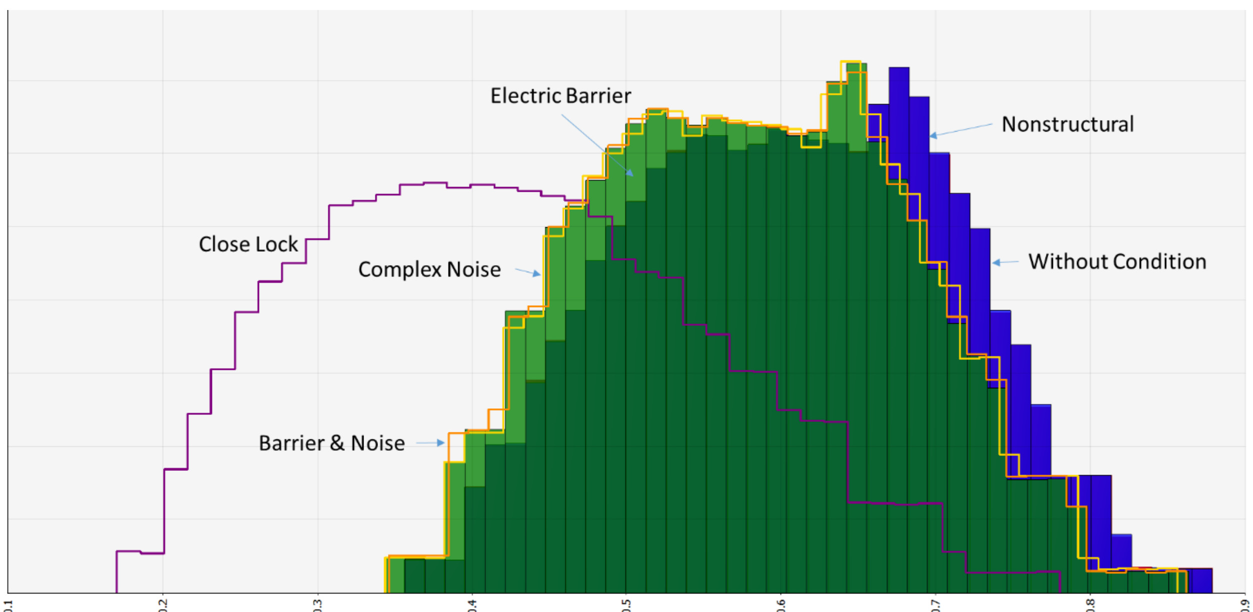

Figure 8-2 Estimated *A. lacustre* P(Establishment) Distributions for Composite Expert for NNFA and Action Alternatives through 2071

8.1.2 Cost-Effectiveness and Incremental Cost Analysis

Cost-effectiveness and incremental cost analysis (CE/ICA) are two distinct analyses that must be conducted to evaluate the effects of alternative plans according to USACE policy. First, cost-effectiveness analysis must show that an alternative plan's output cannot be produced more cost-effectively by another alternative plan. Cost-effective means that, for a given level of non-monetary output, no other plan costs less and no other plan yields more output at a lower cost.

Incremental cost analysis takes the cost-effective alternative plans and identifies the increment of additional cost required for an additional output. The subset of cost-effective plans is examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. Those most efficient plans are called "best buys." They provide the greatest increases in output for the smallest increases in cost; they have the lowest incremental costs per unit of output. In most analyses, there will be a series of best-buy plans, in which the relationship between the quantity of outputs and the unit cost is evident. As the scale of the best-buy plans increases (in terms of output produced), the average costs per unit of output and incremental costs per unit of output will increase as well. Usually, the incremental analysis by itself will not point to the selection of any single plan. Instead, the results of the incremental analysis must be synthesized with other decision-making criteria (i.e., significance of outputs, acceptability, completeness, effectiveness, efficiency, risk and uncertainty, reasonableness of costs) to help select and recommend a particular alternative plan.

There are a number of ways to conduct CE/ICA, thereby determining which alternative plans are cost-effective and, from the set of cost-effective plans, identifying those alternative plans that are most efficient in producing outputs (i.e., best buys). The USACE's Institute for Water Resources (IWR) developed procedures and software to assist in conducting CE/ICA. The IWR Planning Suite Beta MCDA software package was used to conduct this analysis. Table 8-1 shows the values that were put into the IWR Planning Suite and used for cost-effectiveness and incremental cost analysis.

Table 8-1 Summary of Alternative Costs and Outputs Used in CE/ICA

Alternative	Acronym	Average Annual Cost[a]	Output (Probability of No Establishment)					
			Bighead and Silver Carp			*A. lacustre*		
			Min.	Med.	Max.	Min.	Med.	Max.
No New Federal Action	NNFA	**$0**	64	71	78	12	39	64
Nonstructural	NSA	**$11,500,000**	74	80	85	12	39	64
Technology Alternative – Electric Barrier	TAEB	**$60,600,000**	86	89	92	14	42	66
Technology Alternative – Complex Noise	TACN	**$43,000,000**	81	85	89	14	42	66
Technology Alternative – Complex Noise with Electric Barrier	TACNEB	**$56,200,000**	83	87	90	14	42	65
Lock Closure	LCA	**$328,200,000**	97	98	99	22	58	83

[a] Average annual cost includes construction, nonstructural measures, O&M, adaptive management, LERRDs, and impacts on navigation (NED costs).

The values input into CE/ICA included the average annual cost of the alternative plan (i.e., cost) and the alternative benefits (i.e., output). The average annual cost of an alternative plan included the costs for construction (to include PED and construction management); nonstructural measures; operation and maintenance; adaptive management; land, easements, rights-of-way, relocation, and disposal areas (LERRDs); and impacts on navigation (NED costs). The alternative benefits are the increase in the likelihood that MRB ANS will **not** establish in the GLB; this is referred to as the Probability of No Establishment, P(No Establishment). The following equation was used to calculate the value of P(No Establishment):

$$P(\text{No Establishment}) = [1 - P(\text{Establishment}) \times 100]$$

Where P(Establishment) refers to composite expert values based on the results of the expert elicitation (described in Chapter 6, Alternative Formulation.)

The composite expert estimate includes minimum, median, and maximum values. This project is unique in the sense that, unlike other CE/ICA analyses, there are considerable uncertainties with P(No Establishment) values; therefore it was appropriate to examine the full range of P(No Establishment) values. Consequently, CE/ICA was run using the median as well as the minimum and maximum composite expert P(No Establishment) values. For additional discussion on the uncertainty and the minimum, median, and maximum values. Refer to Chapter 6, Alternative Formulation.

Cost-Effectiveness

The cost-effectiveness analysis screened out alternative plans if they produced the same amount of output or less output at a higher cost than other alternative plans did with a lesser cost. The six alternative plans were analyzed for cost-effectiveness using outputs for both Bighead and Silver Carp and *A. lacustre*.

Bighead and Silver Carp

Table 8-2 shows the results of the cost-effectiveness analysis for Bighead and Silver Carp. For the minimum, median, and maximum range of probability of no establishment, CE/ICA identified the same cost-effective and best-buy plans under each scenario. Best-buy plans included the NNFA, NSA, TAEB, and LCA. Both the TACN and TACNEB were identified as cost-effective plans (Table 8-2). Therefore, for simplicity, only the median output results are shown in the CE/ICA output figures (Figures 8-3 through 8-6). For the minimum and maximum CE/ICA output figures, refer to Appendix B, Planning. As shown in the summary Table 8-2, the alternative plans identified as cost-effective and best buy did not vary among the minimum, median, and maximum outputs.

Table 8-2 Summary of Cost-Effectiveness Analysis for Bighead and Silver Carp Outputs (Probability of No Establishment)

Minimum		Median		Maximum	
Cost-Effective	Best Buy	Cost-Effective	Best Buy	Cost-Effective	Best Buy
TACN TACNEB	NNFA NSA TAEB LCA	TACN TACNEB	NNFA NSA TAEB LCA	TACN TACNEB	NNFA NSA TAEB LCA

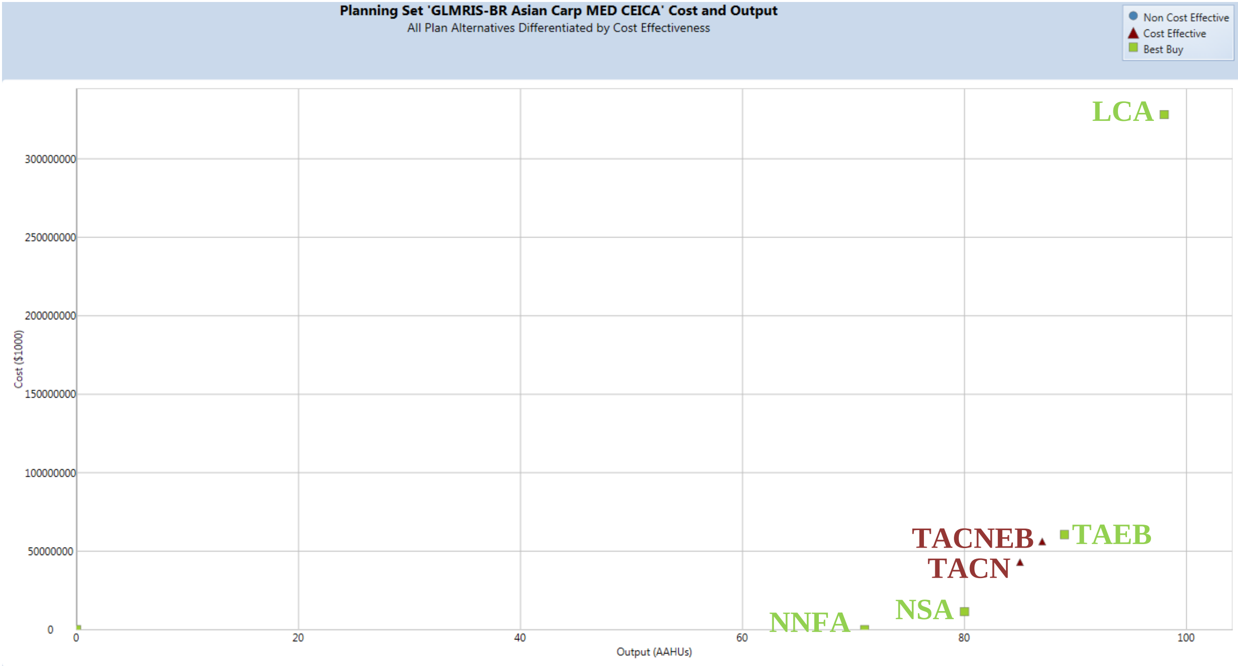

Figure 8-3 Cost and Output Results of Alternative Plans for Bighead and Silver Carp (Cost Is in Dollars and the Output Is the Probability of No Establishment)

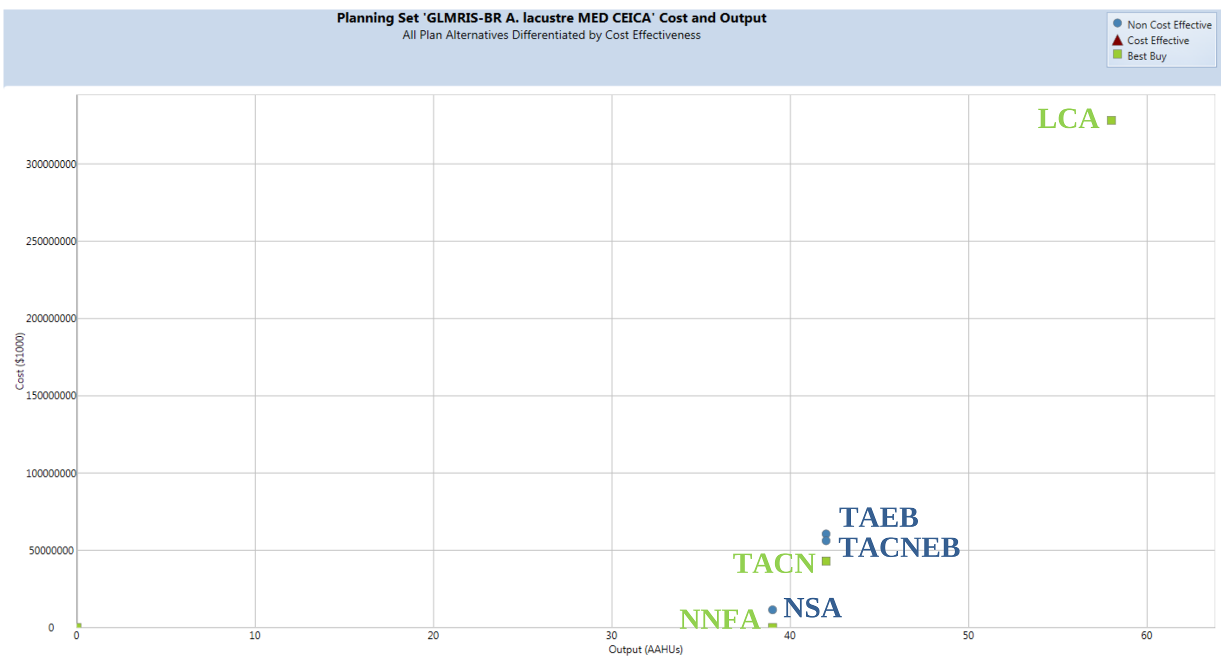

Figure 8-4 Cost and Output Results of Alternative Plans for *A. lacustre* (Cost Is in Dollars and the Output Is the Probability of No Establishment)

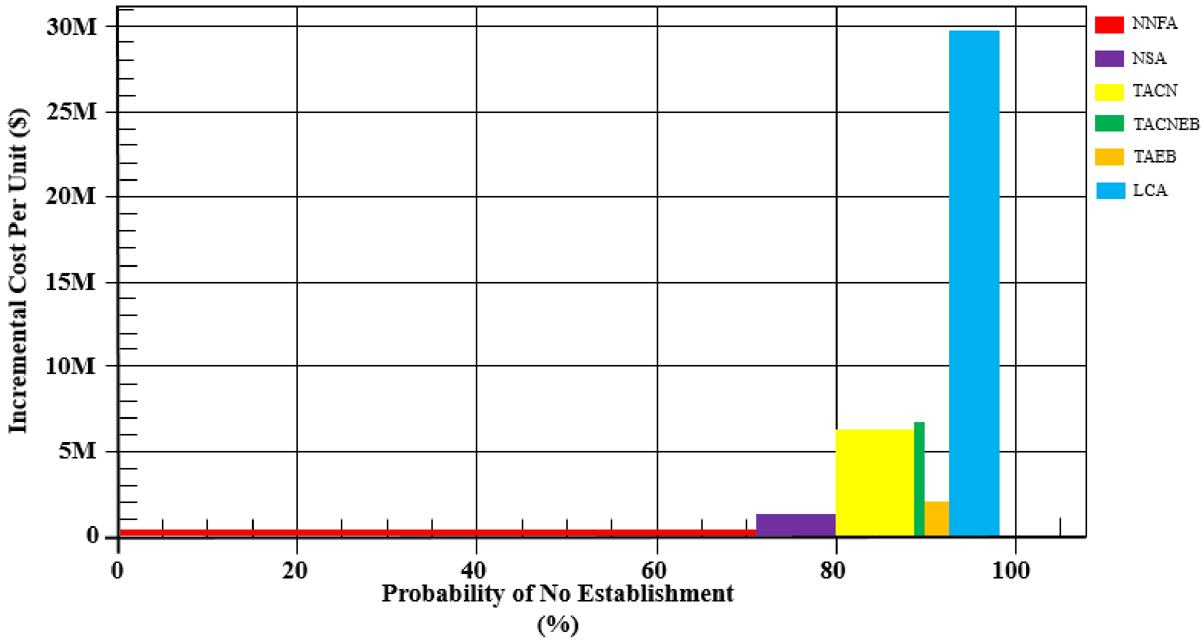

Figure 8-5 Incremental Cost and Output of Best-Buy Alternative Plans for Bighead and Silver Carp Using Median Outputs for Probability of No Establishment

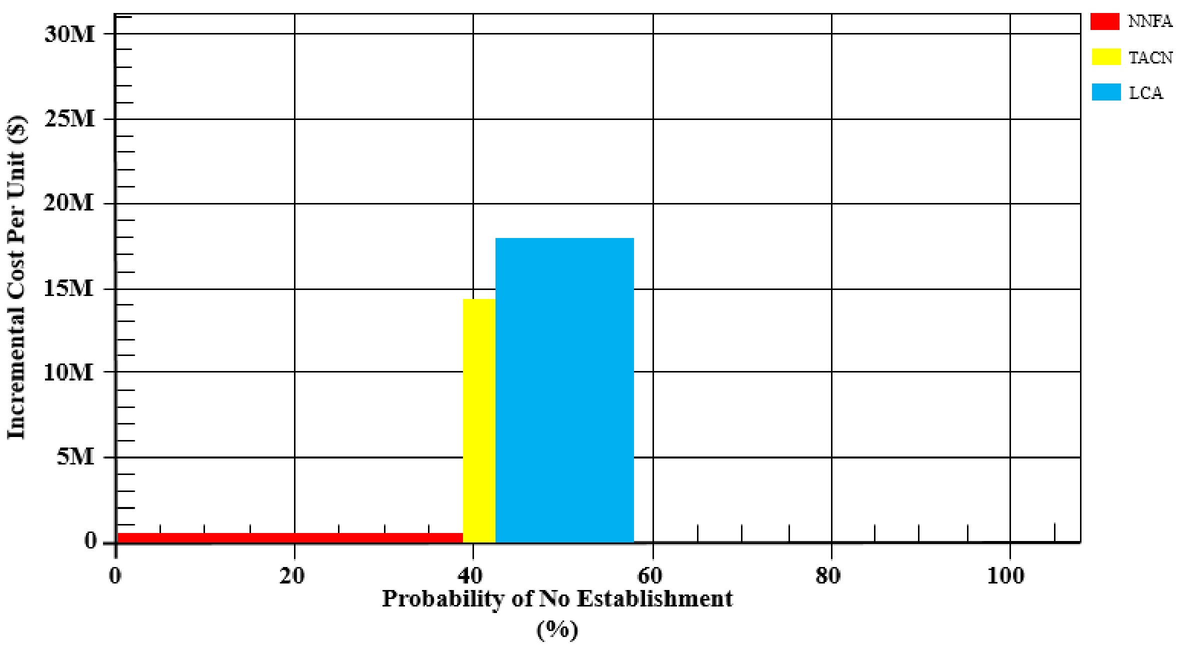

Figure 8-6 Incremental Cost and Output of Best-Buy Alternative Plans for *A. lacustre* Using Median Outputs for Probability of No Establishment

As discussed above, only the median output results are shown in Figure 8-3. For the minimum and maximum figures, refer to Appendix B, Planning. Table 8-3 shows the median output values (highlighted dark blue) and the average annual costs (highlighted orange) for the alternatives that were put into the IWR Planning Software for the cost-effectiveness analysis. Figure 8-3 shows the cost-effectiveness results for Bighead and Silver Carp.

Table 8-3 Summary of Alternative Costs and Outputs Used in CE/ICA

Alternative	Acronym	Average Annual Cost[a]	Output (Probability of No Establishment)					
			Bighead and Silver Carp			*A. lacustre*		
			Min.	Med.	Max.	Min.	Med.	Max.
No New Federal Action	NNFA	**$0**	64	**71**	78	12	39	64
Nonstructural	NSA	**$11,500,000**	74	**80**	85	12	39	64
Technology Alternative – Electric Barrier	TAEB	**$60,600,000**	86	**89**	92	14	42	66
Technology Alternative – Complex Noise	TACN	**$43,000,000**	81	**85**	89	14	42	66
Technology Alternative – Complex Noise with Electric Barrier	TACNEB	**$56,200,000**	83	**87**	90	14	42	65
Lock Closure	LCA	**$328,200,000**	97	**98**	99	22	58	83

[a] Average annual cost includes construction, nonstructural measures, O&M, adaptive management, LERRDS, and impacts on navigation (NED costs).

A. lacustre

Table 8-4 shows the results of the cost-effectiveness analysis for *A. lacustre*. For the minimum, median, and maximum range of P(No Establishment), CE/ICA identified the same cost-effective plans for the minimum and median scenarios. Best-buy plans included the NNFA, TACN, and LCA. No additional plans were identified as cost-effective under these two scenarios. Under the maximum scenario, the NNFA and LCA were both identified as best-buy plans, while the TACN was identified as cost-effective.

Table 8-4 Summary of Cost-Effective Analysis for *A. lacustre* Outputs (Probability of No Establishment)

Minimum		Median		Maximum	
Cost-Effective	Best Buy	Cost-Effective	Best Buy	Cost-Effective	Best Buy
-	NNFA TACN LCA	-	NNFA TACN LCA	TACN	NNFA TACN LCA

For simplicity, only the median output results will be shown in the following figures. For the minimum and maximum figures refer to Appendix B, Planning. As shown in Table 8-4, the cost-effectiveness or best-buy designation did not vary among the minimum and median outputs. For maximum outputs, TACN was designated as being cost-effective, when under minimum and median outputs it was designated as a best-buy alternative. Besides this difference, cost-effectiveness and best-buy designations for the remaining alternatives did not differ from their designations using minimum, median, and maximum outputs.

As described above, only the median output results are shown in the following figure (Figure 8-4). For the minimum and maximum figures, refer to Appendix B, Planning. Table 8-5 shows the median output values (highlighted dark blue) and the average annual costs (highlighted orange) for the alternatives that were put into the IWR Planning Software for the cost-effectiveness analysis. Figure 8-4 shows the cost-effectiveness results for *A. lacustre*.

Table 8-5 Summary of Alternative Costs and Outputs Used in CE/ICA

Alternative	Acronym	Average Annual Cost[a]	Output (Probability of No Establishment)					
			Bighead and Silver Carp			*A. lacustre*		
			Min.	Med.	Max.	Min.	Med.	Max.
No New Federal Action	NNFA	**$0**	64	71	78	12	**39**	64
Nonstructural	NSA	**$11,500,000**	74	80	85	12	**39**	64
Technology Alternative – Electric Barrier	TAEB	**$60,600,000**	86	89	92	14	**42**	66
Technology Alternative – Complex Noise	TACN	**$43,000,000**	81	85	89	14	**42**	66
Technology Alternative – Complex Noise with Electric Barrier	TACNEB	**$56,200,000**	83	87	90	14	**42**	65
Lock Closure	LCA	**$328,200,000**	97	98	99	22	**58**	83

[a] Average annual cost includes construction, nonstructural measures, O&M, adaptive management, LERRDs, and impacts on navigation (NED costs).

Incremental Cost Analysis

The objective of the incremental cost analysis is to assist in determining whether the additional output provided by each successive alternative plan is worth the additional cost. This incremental analysis compares the alternative plans for ecological protection that were considered for selection as the Tentatively Selected Plan (TSP).

Bighead and Silver Carp

An incremental cost analysis was performed for alternative plans that were designated as cost-effective and/or best buys under the minimum, median, and maximum outputs. The results of the incremental cost analysis for the minimum and maximum outputs can be found in Appendix B, Planning. The results of the incremental cost analysis for the median outputs (Table 8-3) are shown in Table 8-6 and Figure 8-5.

Table 8-6 Summary of CE/ICA Best-Buy Alternative Plans for Bighead and Silver Carp

Alternative Plan	Cost-Effective/Best-Buy Designation	Output (Probability of No Establishment)	Average Annual Cost	Average Cost ($/Probability of No Establishment)	Inc. Cost	Incremental Output (Probability of No Establishment)	Incremental Cost Per Output
NNFA	Best buy	71	$0	$0	-	-	-
NSA	Best buy	80	$11,500,000	$140,000	$11,500,000	9	$1,300,000
TACN	Cost-effective	85	$43,000,000	$510,000	$31,500,000	5	$6,300,000
TACNEB	Cost-effective	87	$56,200,000	$650,000	$13,200,000	2	$6,600,000
TAEB	Best buy	89	$60,600,000	$680,000	$4,400,000	2	$2,200,000
LCA	Best buy	98	$328,200,000	$3,300,000	$267,600,000	9	$29,700,000

A. lacustre

An incremental cost analysis was performed on the plans that were designated as best buys under the minimum, median, and maximum outputs. The results of the incremental cost analysis for the minimum and maximum outputs can be found in Appendix B, Planning. The results of the incremental cost analysis for the median outputs (Table 8-5) are shown in Table 8-7 and Figure 8-6.

8.1.3 Significance of Ecosystem Outputs

Due to the challenges associated with comparing non-monetized benefits, the concept of output significance plays an important role in ecosystem restoration evaluation. Along with information from cost-effectiveness and incremental-cost analyses, information on the significance of ecosystem outputs will help determine whether the proposed investment is worth its cost and whether a particular alternative should be recommended. Statements of significance provide qualitative information to help decision makers evaluate whether the value of the resources of any given restoration alternative are worth the costs incurred to produce them. The significance of the project outputs is herein recognized in terms of institutional, public, and/or technical importance.

The following three sections – Institutional Recognition, Public Recognition, and Technical Recognition – contain information that was provided by the USFWS in their Draft Fish and Wildlife Coordination Act Report (2016).

Institutional Recognition

Significance based on institutional recognition of the importance of an environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies, rules and regulations, treaties, and other policy statements of the federal government; plans, laws, resolutions, and other policy statements of states with jurisdiction in the planning areas; laws, plans, codes, ordinances, and other policy statements of regional and local public entities with jurisdiction in the planning area; and charters, bylaws, and other policy statement of private groups.

National Environmental Policy Act of 1969 – A national policy that includes promoting efforts that will prevent or eliminate damage to the environment and biosphere. The planning objective for the GLMRIS-BR is “to prevent the upstream transfer of ANS from the MRB to the GLB through the CAWS in the vicinity of the BRLD through the planning period of analysis.”

Coastal Zone Management Act of 1972, as amended – Provides for the management of the nation’s coastal resources, including the Great Lakes. The goal is to “preserve, protect, develop, and where possible, to restore or enhance the resources of the nation’s coastal zone.”

Endangered Species Act of 1973 – All federal departments and agencies shall seek to conserve endangered species and threatened species. The purpose of the act is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a program for the conservation of such endangered and threatened species.

Fish and Wildlife Conservation Act of 1980 – All federal departments and agencies to the extent practicable and consistent with the agency’s authorities should promote the conservation of non-game fish, wildlife, and their habitats.

Table 8-7 Summary of CE/ICA Best-Buy Alternative Plans for *A. lacustre*

Alternative Plan	Cost-Effective/Best-Buy Designation	Output (Probability of No Establishment)	Average Annual Cost	Average Cost ($/Probability of No Establishment)	Incremental Cost	Incremental Output (Probability of No Establishment)	Incremental Cost Per Output
NNFA	Best buy	39	$0	$0	-	-	-
TACN	Best buy	42	$43,000,000	$1,000,000	$43,000,000	3	$14,300,000
LCA	Best buy	58	$328,200,000	$5,700,000	$285,200,000	16	$17,800,000

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended – An act to prevent and control infestations of the coastal inland waters of the United States by the zebra mussel and other nonindigenous aquatic nuisance species.

Executive Order 11514, Protection and Enhancement of Environmental Quality – The federal government shall provide leadership in protecting and enhancing the quality of the nation's environment to sustain and enrich human life.

Executive Order 12962, Recreational Fisheries – Federal agencies shall, to the extent permitted by law and where practicable, improve the quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreation opportunities.

Executive Order 13112, Invasive Species – Mandates that federal agencies, to the extent permitted by law and where practicable, improve the quality, function, and sustainable productivity and distribution of U.S. aquatic resources for increased recreational fishing opportunities.

Executive Order 13751, Safeguarding the Nation from Impacts of Invasive Species – amended E.O. 13112, Invasive Species, and directed actions to continue coordinated federal prevention and control efforts related to invasive species.

In regard to the aforementioned Acts and Executive Orders regarding protection of resources from ANS, all of the alternatives, including the NNFA and the action alternatives, would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would be expected to reduce the likelihood of the potential consequences of ANS establishment within the Great Lakes and connected tributaries, as discussed in Chapter 5, Consequence of ANS Establishment in the Great Lakes Basin, from being realized. The effectiveness of the NNFA and action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

Public Recognition

Public recognition means that some segment of the general public recognizes the importance of an environmental resource, as evidenced by people engaged in activities that reflect an interest or concern for that particular resource. Such activities may involve membership in an organization, financial contributions to resource-related efforts, and providing volunteer labor and correspondence regarding the importance of the resource.

Stakeholder Organizations. Many private citizens of the area are concerned about the overall health of the GLB and the problem associated with the transfer of ANS. Organizations exist throughout the area to promote better water quality, invasive species removal and control, restoration of natural habitat, and the cleaning up of potential sources of pollutants. These stakeholder organizations recognize the significance of the Great Lakes and would support the removal of any threat to the health of the Great Lakes. The following list of stakeholder organizations was compiled from the Great Lakes Information Network (http://www.great-lakes.net/links/envt/).

- Cooperative Institute for Limnology and Ecosystems Research (CILER)
- Council of Great Lakes Governors
- Great Lakes Commission
- Great Lakes Fishery Commission
- Great Lakes Protection Fund

- Great Lakes Radio Consortium
- Great Lakes Science Center
- Great Lakes Sea Grant Network
- International Association for Great Lakes Research
- International Joint Commission (IJC)
- Northeast-Midwest Institute
- Ecological Monitoring and Assessment Network
- Environment Canada, Our Great Lakes
- Great Lakes Environmental Research Laboratory (GLERL)
- Great Lakes Science Center
- Ontario Conserves/ConservAction Ontario
- EPA Great Lakes National Program Office (GLNPO)
- Alliance for the Great Lakes
- American Shore and Beach Preservation Association
- Canadian Environmental Law Association
- Citizens Environment Alliance (CEA) of Southwestern Ontario and Southeastern Michigan
- Clean Water Action Council
- Clean Wisconsin
- Environmental Defense Canada
- Environmental Defense
- Global Rivers Environmental Education Network (GREEN)
- Great Lakes Sport Fishing Council
- Great Lake United
- Hoosier Environmental Council
- Indiana Environmental Organizations
- Indiana Lakes Management Society
- Inland Sea Society
- Inland Seas Education Association
- Lake Michigan Forum
- LakeNet
- Michigan Entomological Society
- Michigan Environmental Council
- Michigan Land Use Institute
- Michigan Look Preservation Association
- Michigan United Conservation Clubs
- Midwest Center for Environmental Science and Public Policy
- Midwest Environmental Advocates
- National Wildlife Federation, Great Lakes Natural Resource Center
- Natural Resources Foundation of Wisconsin
- Nature Conservancy of Canada
- PennEnvironment
- Rivers Unlimited
- Save the Dunes Council
- Sierra Club, Great Lakes Program
- Sigurd Olson Environmental Institute
- The Nature Conservancy's Great Lakes Program
- Tip of the Mitt Watershed Council
- Toronto and Region Conservation Authority
- Waukegan Harbor Citizens Advisory Group

Technical Recognition

Technical recognition means that the resource qualifies as significant based on its “technical” merits, which are based on scientific knowledge or judgment of critical resource characteristics. Whether a resource is determined to be significant may of course vary based on differences across geographical areas and spatial scale. Although the technical significance of a resource may depend on whether a local, regional, or national perspective is undertaken, typically a watershed or larger (e.g., ecosystem, landscape, or ecoregion) context should be considered. Technical significance should be described in terms of one or more of the following criteria or concepts: scarcity, representation, status and trends, connectivity, limiting habitat, and biodiversity.

Scarcity is a measure of a resource’s relative abundance within a specified geographic range. Generally, scientists consider a habitat or ecosystem to be rare if it occupies a narrow geographic range (i.e., limited to a few locations) or occurs in small groupings. Unique resources, unlike any others found within a specified range, may also be considered significant, as well as resources that are threatened by interference from both human and natural causes.

The five Great Lakes cover about 302,000 mi^2 (782,176.4 km^2) and include part or all of the eight U.S. states of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York, and the Canadian provinces of Ontario and Quebec. The GLB covers an area of 295,700 mi^2 (766,000 km^2) and spans over 900 mi (1,448.4 km) from east to west and about 700 mi (1,126.5 km) from north to south. With the exception of Lake Michigan, the Great Lakes straddle the Canada–United States border and together are the world’s largest freshwater system (20% of the world’s fresh surface water). The GLB features an extensive watershed that includes approximately 5,000 tributaries, more than 1,000 mi (1,609.3 km) of shoreline, and approximately 35,000 islands.

The GLB contains diverse habitat types, starting with boreal forests in the north and transitioning to mixed and deciduous forest and tallgrass prairie in the south (USACE 2008). Other vital habitats represented in the GLB include wetlands, bogs, marshes, swamps, and fens. These habitats support several plant species that are unique to the GLB, including some that are considered globally imperiled, such as Houghton’s goldenrod and eastern prairie fringed orchid (refer to Section 4.4.2, Plant Communities). In addition, these plant communities provide important habitat (e.g., breeding and rearing areas) for wetland-dependent animals including waterfowl and other migratory birds (refer to Section 4.4.3, Wildlife Resources), and over 150 native fish species (including federally and state-listed species) (refer to Section 4.4.4, Aquatic Resources). Currently, 46 species of plants and animals are unique to the GLB. In addition, there are also approximately 279 species and habitat types within the GLB that have been documented as globally rare. Refer to Section 4.4, Biological Resources, for a detailed description of plant, wildlife, and aquatic resources that are unique to the GLB.

While the GLB supports scarce habitat types and species, nonnative and invasive organisms pose a threat to these unique and endemic species of the GLB. Invasive species have already changed the Great Lakes by competing with native species for food and habitat. It is estimated that over the past 200 years, more than 180 nonnative species have entered the Great Lakes (Sharp 2007). The NNFA and the action alternatives would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would protect the Great Lakes and their scarce resources. The effectiveness of the NNFA and action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

Representation is a measure of a resource's ability to exemplify the natural habitat or ecosystems within a specified range. The presence of a large number and percentage of native species – and the absence of exotic species – implies representation, as does the presence of undisturbed habitat.

Ecologically, the Great Lakes' landscape features and complex habitat types are globally unique, supporting a rich and diverse variety of species. Important migration corridors and critical breeding, feeding, and resting areas are present for numerous species of migratory and resident birds – especially waterfowl, colonial nesting birds, and neotropical migrants (Chapter 4 Affected Environment [Existing Conditions], Section 4.4.3 Wildlife Resources). Areas within the Great Lakes shoreline zones are some of the most diverse and productive areas of the watershed. Examples include relatively warm and shallow waters near the shore, coastal wetlands, and the lands directly affected by lake processes. An estimated 300,000 ac (121,405 ha) of coastal wetlands play a pivotal role in the aquatic ecosystem of the Great Lakes, storing and cycling nutrients and organic material from the land into the aquatic food web. Coastal wetlands provide food and habitat for a diversity of fish and wildlife, including several species that are not found outside of the watershed (see Section 4.4.3, Wildlife Resources, and Section 4.4.4, Aquatic Resources). Further, amphibians and invertebrates depend on coastal wetlands for critical portions of their life cycles (Section 4.4.3, Wildlife Resources). Wetlands also play an essential role in sustaining a productive fishery; many species of Great Lakes fish depend on coastal wetlands for successful reproduction. More than 200 species of fish inhabit the rivers, streams, and coastal areas of the Great Lakes watershed (Section 4.4.4, Aquatic Resources). In addition, streams provide habitat for many other aquatic organisms throughout various stages of their life cycles. The NNFA and the action alternatives would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would protect the Great Lakes and their associated resources. The effectiveness of the NNFA and action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

Status and Trends measures the relationship between previous, current, and future conditions. In the past, the fragile nature of the Great Lakes was not recognized, and the lakes were mistreated for economic gain, placing the ecosystem under tremendous stress from human activities. History has shown that the Great Lakes are highly sensitive to biological and chemical stresses. Efforts are underway at federal, state, and local levels to improve and restore portions of the GLB (refer to Section 2.3, Studies, Reports, and Existing Water Projects within the GLMRIS-BR System-wide Study Area for restoration projects within the GLB). Recently, the GLRI supplied resources to federal agencies to strategically target the greatest threats to the Great Lakes ecosystem. The GLRI was launched in 2010 to accelerate efforts to protect and restore the largest system of fresh surface water in the world: the Great Lakes. These projects focus primarily on (1) cleaning up Great Lakes Areas of Concern, (2) preventing and controlling invasive species, (3) reducing nutrient runoff that contributes to harmful/nuisance algal blooms, and (4) restoring habitat to protect native species. GLRI currently supports a number of ACRCC efforts focused on the control of Silver and Bighead Carp. The Illinois DNR, Illinois EPA, USGS, and USFWS are also providing support on efforts related to monitoring and the development of new monitoring methodology. Additional regional initiatives include ongoing efforts by the Great Lakes Commission and the St. Lawrence Seaway Cities Initiative to develop a collaborative solution to the transfer of ANS between the GLB and MRB. The NNFA and the action alternatives would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would protect the restoration efforts occurring within the Great Lakes and their connected tributaries. The effectiveness of the NNFA and the action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

Connectivity is the measure of a resource's connection to other significant natural habitats. Connectivity within the Great Lakes may be described at both the regional scale and the national scale. At the regional scale, the Great Lakes cover about 302,000 mi^2 (782,176.4 km^2) and include part or all of the eight U.S. states of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York, and the Canadian provinces of Ontario and Quebec. The GLB also features an extensive watershed with approximately 5,000 tributaries, more than 1,000 mi (1,609.3 km) of shoreline, and approximately 35,000 islands. Within the region are significant ecological communities (sand dunes, cobble beaches, coastal wetlands, alvars, prairies, savannas, forests, fens, etc.) that are globally unique and support approximately 279 species plus habitat types that have been documented as globally rare. The aforementioned ecological communities are all significant habitats at the regional scale that are connected to some extent by the Great Lakes and their contributing tributaries. In addition, as described in the Status and Trends section, numerous restoration projects have occurred or are underway within the region. Many of these restoration projects target areas of concern, or significant natural habitats that have been degraded by past uses. All of these restoration projects are connected to some extent by the Great Lakes and their tributaries.

At the national scale, significant natural habitats within the Great Lakes Region that are used by migrating birds as resting or breeding sites are connected to other significant natural habitats outside the region by two of the four principal North American flyways: the Atlantic and the Mississippi Flyways. The longest migration route in the Western Hemisphere is the Mississippi Flyway; extending from the Arctic Coast of Alaska to Patagonia, some shorebird species fly this nearly 3,000 mi (4,828.0 km) route twice a year. Parts of all four of the North American Flyways (i.e., Atlantic, Mississippi, Central, and Pacific) merge over Panama. The boundaries of the Mississippi Flyway are not always sharply defined; however, its eastern boundary for the most part runs along Lake Erie and the western boundary is ambiguous as it merges into the Central Flyway. Nearly half of North America's bird species and about 40% of its waterfowl spend at least part of their lives in the Mississippi River Flyway. The NNFA and the action alternatives would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would promote and protect aquatic connectivity within the Great Lakes and their tributaries. The effectiveness of the NNFA and action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

Limiting Habitat measures the resources that support significant species. A recent survey of biological diversity identified 130 globally endangered or rare plant and animal species that inhabit the Great Lakes ecosystem. There are approximately 36 federally listed species within the GLB. There are approximately 907 plant, 26 reptile and amphibian, 15 mammal, 62 bird, 204 invertebrate, and 58 fish state-listed species (refer to Section 4.4.5, Threatened and Endangered Species, for additional discussion). According to information provided by the USFWS in their Draft FWCAR (see Appendix A, Draft FWCAR), at least 60 fish species are federally or state-listed as threatened or endangered or are considered special concern in the Great Lakes. The following are just a few of the fish species listed in the Great Lakes: Spoonhead Sculpin, Deepwater Sculpin, Lake Sturgeon, Mooneye, Lake Herring, Kiyi, Short-jaw Cisco, River Redhorse, Greater Redhorse, Sauger, Round Whitefish, Brook Trout, Northern Madtom, River Darter, Eastern Sand Darter, Channel Darter, Pugnose Minnow, Bigmouth Shiner, Silver Shiner, Bridle Shiner, Striped Shiner, Silver Chub, Lake Chubsucker, Northern Brook Lamprey, Spotted Gar, Northern Redbelly Dace, and Redside Dace.

In addition, the USFWS Draft FWCAR (see Appendix A, Draft FWCAR) also lists numerous mussel species as being federally or state listed as threatened or endangered in the Great Lakes. Mussel species include clubshell, northern riffleshell, rabbitsfoot, rayed bean, snuffbox mussel, spectaclecase, purple wartyback, scaleshell, black sandshell, threehorn wartyback, hickorynut, round hickorynut, round pigtoe, kidney shell, fawnsfoot, lilliput, paper pondshell, fat pocketbook, white catspaw, wavyrayed lampmussel, salamander mussel, and Higgins eye pearly mussel. In addition, a large number of mussel species in the Great Lakes watershed are considered species of concern but are not yet listed.

Although much of the Great Lakes coastal aquatic and terrestrial landscape that once supported migrating birds has been lost or degraded, the watershed still supports hundreds of millions of migrants during both spring and fall migration. Several migratory bird species are federally or state listed as threatened or endangered or are considered species of concern in the Great Lakes. These include the piping plover, red knot, whooping crane, black tern, and common tern.

The NNFA and the action alternatives would reduce the likelihood of MRB ANS transferring through the CAWS and becoming established in the Great Lakes and their connected tributaries. Therefore, the alternative plans would protect threatened and endangered species from MRB ANS within the Great Lakes and their tributaries. The effectiveness of the NNFA and the action alternatives at preventing MRB ANS transfer through the CAWS into the GLB varies by alternative. For a more detailed discussion on the effectiveness of each alternative, refer to Chapter 6, Alternative Formulation.

8.1.4 Acceptability, Completeness, Effectiveness, and Efficiency

The four evaluation criteria specified in the P&G are acceptability, completeness, effectiveness, and efficiency (see Water Resources Council 1983, Section V, E-38). The four accounts were established to facilitate the evaluation and display of effects of alternative plans.

Acceptability

Acceptability is the workability and viability of the alternative plan with respect to acceptance by federal and nonfederal entities and the public and compatibility with existing laws, regulations, and public policies. Two primary dimensions to acceptability are implementability and satisfaction. Implementability means that the alternative is feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives. If it is not feasible due to any of these factors, then it cannot be implemented, and therefore is not acceptable. The second dimension to acceptability is the satisfaction that a particular plan brings to government entities and the public. A plan should be acceptable to state and federal resource agencies and local governments. There should be evidence of broad-based public consensus and support for the plan. The tentatively recommended plan must be acceptable to the nonfederal cost-sharing partner.

Acceptability of the alternative plans was evaluated using the following criteria: life safety risk, sociopolitical consequences of ANS establishment, and reduction in navigation cost savings.

Life Safety Risks

The life safety risks associated with the various alternative plans were qualitatively evaluated. Figure 8-7 depicts how the alternative plans are ranked relative to one another according to increasing life safety risks. The NNFA, NSA, TACN, and LCA are considered to have the lowest potential for life safety risks. Both the TAEB and TACNEB are considered to have moderate to highest potential for life safety risks.

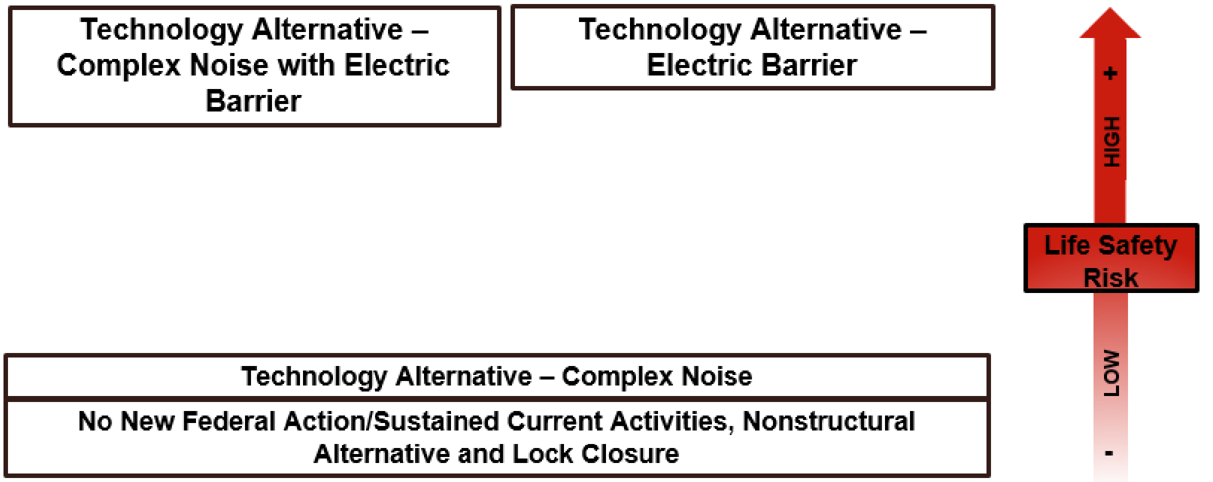

Figure 8-7 Qualitative Risk Rating of the GLMRIS-BR Alternative Plans (Alternative Plan Rating Is Relative to the Other Alternatives)

To understand the potential qualitative range of life safety risks associated with the TAEB and TACNEB, a Navigation Safety Workshop was hosted on August 8, 2016, with the navigation community (e.g., barge operators and representatives of the inland navigation industry, USCG, and Illinois DNR) to discuss their concerns regarding the operation of an electric barrier at BRLD. There are two primary safety issues when operating an electric barrier: (1) a person falling into the water where there is an elevated electric field, because exposure to elevated electric fields may cause ventricular fibrillation and involuntary muscular contraction; and (2) stray current on land and structures, which may cause metal objects to present shock hazards. These issues affect those who navigate through the BRLD, hunters, fishermen who use the water surrounding the BRLD, and BRLD personnel. Design of an electric barrier downstream of BRLD would take into account the aforementioned safety issues and attempt to mitigate them. To address the issue of stray current, mitigation includes the construction of an engineered channel with nonporous concrete. This is expected to reduce potential stray current impacts on those navigating the waterway as well as impacts on those working at the BRLD.

During the Navigation Safety Workshop, attendees discussed ways to navigate over an electric barrier downstream of BRLD with lookouts on the end of a tow. For upstream transit, having lookouts move to the front of vessels after passing over the elevated electric field would likely not be an option, because lookouts are needed on the front and outside corners of a tow prior to entering the BRLD downstream approach channel. Relocating lookouts between barges so they are more protected from falling into the water was also discussed, but this was not thought to be viable because it would reduce lookout visibility from what it would be if a lookout were standing on the front outside corners of a tow.

Attendees also discussed staging lookouts prior to transit across the elevated electric field and tethering the lookouts. The USCG mentioned that harnesses and tethers would require their agency to promulgate additional regulations and inspection requirements, and such devices may be subject to OSHA requirements. Representatives of the navigation industry responded that a tie-off point would need to be retrofitted onto all the barges that use the upper IWW and CAWS. For frequent users of the upper IWW and CAWS, this requirement may not be overly burdensome; however, it would likely be unrealistic for vessels that make infrequent transits to be aware of and prepare for this requirement. Using technology, such as onboard cameras, was suggested as a way of eliminating lookouts when passing over the elevated electric field. Representatives of the navigation industry reported that cameras are not reliable during adverse weather conditions (e.g., fog, rain, snow), and the depth perception of the visual display is an issue.

If the TAEB or TACNEB were chosen as the TSP, further consideration would be required to reduce the potential life safety risks associated with the elevated electric field. It is uncertain whether it will be possible to operate the electric barrier at optimal operating parameters when vessels travel through the downstream approach channel for two reasons: (1) coordination with USCG regarding navigator safety and (2) operating parameters of the barrier, which may prohibit operation when vessels travel over the barriers (the water depth in the Brandon Road approach channel is about 10 ft (3 m) less than the water depth at the CSSC barriers, which vessels can safely travel over). If the TACNEB were chosen as the TSP, complex noise would be used to deter fish during intermittent or altered operation of the electric barrier. The electric barrier downstream of BRLD would be operated to optimize effectiveness while minimizing safety impacts.

Sociopolitical Consequences of ANS Establishment

For social and political consequences of ANS establishment, the GLMRIS-BR PDT reviewed the best available information gathered from published information, letter requests, and phone interviews with relevant state agencies and Canada. Consequences of ANS establishment in the Great Lakes and other waters of the nation are well documented; existing information is available from evaluations of the impacts from the introduction and establishment of Sea Lamprey and zebra/quagga mussels. The social and political consequences of ANS establishment would be the same for all of the GLMRIS-BR alternative plans. However, the likelihood that these consequences would be realized is based on the effectiveness of the alternative plans at reducing ANS passage through the BRLD. The potential social and political consequences are discussed in Chapter 5, Consequence of ANS Establishment in the Great Lakes Basin.

Impacts on Navigation (NED Costs)

The impacts on navigation are included as an NED cost of the alternatives and were included as project costs in the CE/ICA analysis. The estimated impacts on navigation account for all project phases, including construction and the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of ANS controls.

Normally, fewer resources are required to move bulk commodities via waterways (waterborne transportation) than on land (i.e., via truck and rail). In these instances, the difference between the costs of moving commodities on land and the cost of moving them on a waterway is called “transportation cost savings.” The NED benefits of navigation projects are the increases in transportation cost savings (increased efficiency of using the waterway to transport commodities).

However, the navigation economic analysis completed in support of GLMRIS-BR found that several of the alternatives include measures that would *reduce* the efficiency of moving commodities on the waterway, consequently *increasing* transportation costs. Therefore, the GLMRIS-BR project alternatives are expected to result in navigation NED costs rather than NED benefits. In other words, there would be an overall reduction in transportation cost savings. Project alternatives that impose greater impacts on navigation are those that yield greater navigation NED costs.

For each project alternative, increases in transportation costs (NED costs) are attributed to one or more of the following: reduced waterway efficiency, shifts from waterway to less efficient modes or routes, and/or shifts to less efficient origin-destination pairs.

Uncertainty. Estimates of delay and total transit times at BR Lock for the No New Federal Action Alternative and the Action Alternatives were developed using the USACE's certified navigation economic models (Waterway Investment Model and Navigation Investment Model). They used the best available economic data (e.g., USACE Waterborne Commerce Statistics Center and Lock Performance Management System), shipper response surveys (completed in support of the GLMRIS Report and GLMRIS-BR), and the best available engineering information about the construction and the OMRR&R that would be required for the ANS controls. Uncertainty remains about what the *actual* processing, delay, and total transit times would be if any of the project alternatives were implemented. Additional engineering and economic analysis, safety testing, and coordination with navigation stakeholders and the USCG would be completed during the PED phase to better inform these estimates.

In summary, the NNFA and NSA are not expected to have annual losses in transportation cost savings. The TAEB, TACN, and TACNEB have average annual losses in transportation cost savings that range between $26,000,000 and $31,400,000 (Table 8-8). The LCA has the greatest average annual loss in transportation cost savings, $318,700,000. The average annual losses in transportation cost savings as a result of LCA are between 10 to 12 times greater than the estimated average annual losses in transportation cost savings for the technology alternatives.

Table 8-8 Potential Impacts on Navigation (NED Costs) for the GLMRIS-BR Alternatives

Alternative	Average Annual Loss in Transportation Cost Savings
NNFA	–
NSA	–
TAEB	$31,400,000
TACN	$26,000,000
TACNEB	$26,200,000
LCA	$318,700,000

The potential for roadway injury or mortality within the vicinity of BRLD was also assessed using NIM and WAM. The analysis is an application of the safety benefit estimation methods outlined in the USACE-certified Great Lakes System Analysis of Navigation Depths (GL-Sand) model. This safety analysis identifies changes to safety benefits as a result of using various transport modes (e.g., waterways, rail, and truck) to transport commercial cargo. Monetization of changes in annual safety benefits is presented for three categories: (1) fatal accidents/trespass fatalities, (2) nonfatal accidents/incidents, and (3) value of physical damages. All procedures used in the estimate process are in accord with the procedures used by the Federal Railroad Administration (FRA) to evaluate the economic impact of proposed FRA safety regulations. The safety analysis was conducted to analyze the additional impacts associated with traffic diverting from a route that includes barge transportation, to a least costly all-overland route. The GLMRIS-BR navigation economic analysis also accounts for the following: (1) diverted traffic due to anticipated plant closures during construction, and (2) lost traffic during scheduled maintenance events. Because overland modes typically have higher fatality, injury, and property damage rates when compared to the inland towing industry, these traffic diversions give rise to externalized costs.

Closure of Brandon Road Lock would result in significant increases of fatality, injury, and property damage costs when compared to the technology alternatives. Combined using the middle value, these costs average approximately $19.4 million a year throughout the analysis period for the LCA, compared to approximately $1.5 million a year for the technology alternatives. Because there is no diverted traffic associated with the NSA, the safety impacts are estimated to be zero (see Appendix D, Economics, for additional information on this analysis).

Completeness

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. To establish the completeness of an alternative plan, it is helpful to list those factors that are beyond the control of the planning team and are required to make the plan's effects (benefits) a reality.

Completeness of the alternative plans was evaluated using the following two criteria: probability of establishment and system performance robustness.

Probability of Establishment

The purpose of the GLMRIS-BR assessment approach was to evaluate (1) the probability of Bighead Carp, Silver Carp, and *A. lacustre* entering and becoming successfully established in the GLB via the CAWS, and (2) the consequences that establishment would have on ecological, economic, social, and political resources. This model does not address nonaquatic pathways such as bait bucket transfer or aquatic pathways outside the CAWS. The risk assessment for the Bighead Carp and Silver Carp considered the species together in a single analysis due to their similarities. The results of this risk assessment were used in the identification and evaluation of potential control measures for reducing, to the maximum extent possible, the risk of interbasin ANS transfer via surface water connections (continuous pathways) between the basins.

Probability of establishment addresses the effectiveness of an alternative plan by identifying which alternative plans more effectively reduce the risk of MRB transferring upstream to the GLB through the CAWS in the vicinity of BRLD. Figure 8-8 shows how the alternative plans were ranked in increasing order of effectiveness. The NNFA has the lowest effectiveness, while LCA has the highest effectiveness.

The P(Establishment) model used for plan evaluation incorporated each expert's characterization of the probability of a small, medium, or large Asian carp population density developing in the Dresden Island Pool at specific time periods during the course of the 50-yr period of analysis. P(Establishment) model scenarios were run using these actual inputs provided by the experts as well as hypothetical scenarios that assumed either a large or a small population in Dresden Island Pool during the entire period of analysis (see Appendix B, Planning). The results of this scenario analysis indicated that the density of the population of Asian carp in the Dresden Island Pool has a significant effect on the P(Establishment) of Asian carp in the GLB, because Asian carp passage upstream of BRLD increases with the population size below BRLD. Therefore, the presence of a large population in the Dresden Island Pool through 2071 greatly reduces the efficacy of all of the technology alternatives in preventing Asian carp establishment in the GLB. Conversely, the efficacy of all of the technology alternatives is significantly enhanced if the Asian carp population density remains small through 2071. Nonstructural measures that target Asian carp populations below BRLD are part of all of the technology alternatives. If these measures are effective in keeping the currently small population density in Dresden Island Pool from increasing to medium or large, the efficacy of all of the technology alternatives would be significantly enhanced.

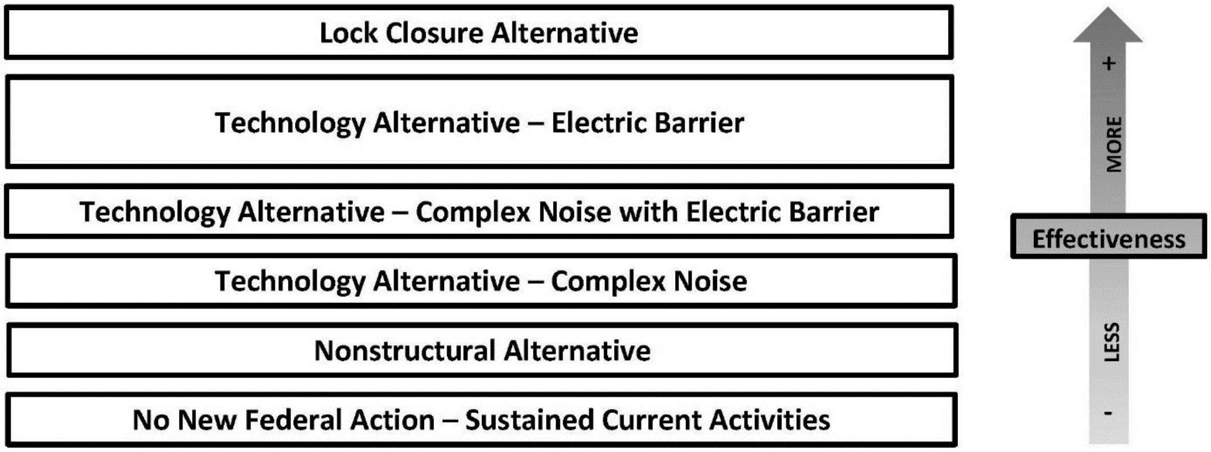

Figure 8-8 Effectiveness of GLMRIS-BR Alternative Plans

The density of the population of Asian carp in the Dresden Island Pool has a significant effect on the probability of establishment for Asian carp. The P(Establishment) used for plan evaluation is based on each expert's characterization of the uncertainty associated with population density. In every case, this involved some probability of a low-, medium-, or high-density population. If the nonstructural measures included in the alternatives are effective in keeping population density low throughout the period of analysis through 2070, this would significantly enhance the efficacy of all of the technology alternatives. Thus, if the Asian carp population density remains low in the vicinity of the BRLD, the probability of establishment for Technology Alternative – Complex Noise with Electric Barrier would be even lower than the composite expert estimate discussed in Chapter 6, Alternative Formulation.

System Performance Robustness

System performance robustness is a criterion that addresses the alternative's robustness to address current and future ANS threats in the waterway. Robustness considers (1) ability to cycle in nonstructural measures, (2) ability to cycle in structural measures, (3) number of structural control points within the GLMRIS-BR Illinois Waterway Study Area, and (4) number of modes of transport the alternative controls. Table 8-9 shows the ability of each alternative to cycle in nonstructural and structural controls, and the modes of transport addressed by each alternative plan.

With regard to robustness associated with providing a platform for future nonstructural and structural controls, the NNFA and NSA do not include a platform for future structural control measures. The technology alternatives include an engineered channel that serves as a platform for these technologies. The engineered channel provides a platform where both nonstructural and structural technologies may be added to address the various modes of transport, which in turn increases the robustness of the alternative. The Lock Closure alternative does not include a platform.

The NNFA and NSA include one structural control point, the CSSC-EB. Although activities such as monitoring and commercial fishing would occur under these two alternative plans, these activities only monitor the location where ANS may be and cull a percentage of the population; there are no additional control points to deter upstream movement. The CSSC-EB is a structural control point.

Table 8-9 Modes of ANS Transport Addressed by the GLMRIS-BR Alternative Plans

Alternative	Cycle Nonstructural	Cycle Structural	Modes of ANS Transport		
			Swimming	**Floating**	**Hitchhiking**
					
No New Federal Action	No	No	Addresses		
Nonstructural	Yes	No	Addresses		
Technology Alternative – Electric Barrier	Yes	Yes	Addresses	Addresses	
Technology Alternative – Complex Noise	Yes	Yes	Addresses	Addresses	
Technology Alternative – Complex Noise with Electric Barrier	Yes	Yes	Addresses	Addresses	
Lock Closure	Yes	No	Addresses	Addresses	Addresses

The technology alternatives and Lock Closure include an additional control point at BRLD. The TAEB includes nonstructural measures, an engineered channel, electric barrier, water jets, and a flushing lock. The electric barrier targets swimming modes of transport, and the water jets and flushing lock target floating modes of transport. Therefore, within the control point at BRLD, under the TAEB, two measures would address floating transport while one measure would address swimming transport. To a greater extent, the TAEB would provide redundancy for the swimming mode of transport with the CSSC-EB.

The TACN includes nonstructural measures, an engineered channel, complex noise, water jets, and a flushing lock. The complex noise targets swimming modes of transport, and the water jets and flushing lock target floating modes of transport. Therefore, within the control point at BRLD, under the TACN, two measures would address floating transport while one measure would address swimming transport. To a greater extent, the TACN would provide redundancy for the swimming mode of transport with the CSSC-EB.

The TACNEB includes nonstructural measures, an engineered channel, complex noise, an electric barrier, water jets, and a flushing lock. The complex noise and electric barrier would target swimming modes of transport, and the water jets and flushing lock would target floating modes of transport. Therefore, within the control point at BRLD, under the TACNEB, two measures would address floating transport and two measures would address swimming transport. To a greater extent, the TACNEB would provide redundancy for the swimming mode of transport with the CSSC-EB.

The LCA also provides two control points, lock closure at BRLD and the CSSC-EB. The Lock Closure alternative would address swimming, floating, and hitchhiking transport. The LCA in combination with the CSSC-EB provide two structural control points within the GLMRIS-BR Illinois Waterway Study

Area. The Lock Closure alternative would provide redundancy for the swimming mode of transport with the CSSC-EB.

Effectiveness

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. An effective plan is responsive to the identified needs and makes a significant contribution to the solution of some problem or to the realization of some opportunity. It also contributes to the attainment of planning objectives. The most effective alternatives make significant contributions to all of the planning objectives. Alternatives that make little or no contribution to the planning objectives can be rejected because they are relatively ineffective. Another factor that can affect the effectiveness of an alternative is whether substantial risk and uncertainty is associated with the alternative. If the functioning or success of an alternative is uncertain, or less certain than another alternative, its effectiveness may be compromised and should be discussed.

The alternative plans' effectiveness was evaluated using the following two criteria: probability of establishment and system performance robustness.

Probability of Establishment

Effectiveness of the alternative plans was evaluated by assessing system probability of establishment. This criterion was also used to evaluate the completeness of the alternative plans. Refer to the Probability of Establishment section under Completeness for a discussion of this criterion.

System Performance Robustness

The alternative plans' effectiveness was also evaluated by assessing system performance robustness. This criterion was also used to evaluate the completeness of the alternative plans. Refer to the System Performance Robustness section under Completeness for a discussion of this criterion.

Efficiency

Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment (see Water Resources Council 1983, Section VI.1.6.2[c][3]). An ecosystem restoration plan must represent a cost-effective means of addressing the restoration problem or opportunity. It must be determined that the alternative plan's outputs cannot be produced more cost-effectively by any other alternative plan.

Efficiency of the alternative plans was evaluated using CE/ICA.

CE/ICA

CE/ICA is a USACE-approved model that quantitatively compares the costs of the alternatives with the benefits of the alternatives to determine cost-effectiveness and best-buy plans. The benefits input into the CE/ICA software included the probability of no establishment for each alternative plan in comparison to the probability of no establishment for the NNFA. The costs input into the CE/ICA software were the implementation, OMRR&R, adaptive management, mitigation, LERRDs, and reduction in transportation rate savings. All costs were annualized over the 50-yr planning period of analysis. For a complete discussion of the CE/ICA that was performed, refer to Section 8.1.2, Cost-Effectiveness and Incremental Cost Analysis.

Figure 8-9 shows the cost of the alternative plans in comparison with the outputs achieved for Bighead and Silver Carp. The NNFA, NSA, TACN, TAEB, TACNEB, and LCA were designated as cost-effective alternatives, and the NNFA, NSA, TAEB, and LCA were also designated as best-buy plans. The TACNEB, although not a best-buy plan, is the only alternative that would provide redundancy within the BRLD control point by including two technologies (e.g., complex noise and electric barrier) that address swimming modes of ANS transport. In addition, complex noise may be operated when maintenance is required on the electric barrier, and/or during times when the electric barrier may need to be operated at less-than-optimal operating parameters. Some uncertainty is associated with the best-buy designation for the TAEB, because the cost-effectiveness analysis for the TAEB assumed that the electric barrier would operate continuously. However, as discussed in Section 8.1.5, Life Safety Risks, further safety evaluations in coordination with the USCG may preclude continuous operation of the barrier, which would impact the cost-effectiveness calculation for this alternative. The TACNEB includes complex noise, which would be used to deter fish during intermittent or altered operation of the electric barrier. The TACNEB was also estimated to have fewer impacts on navigation compared to the TAEB. Under the TACNEB, impacts on navigation (NED costs) were estimated to be $5.3 million less annually than if the TAEB were implemented. For more detailed information on navigation impacts, refer to Appendix D, Economics.

Figure 8-10 shows the cost of the alternative plans in comparison with the outputs achieved for *A. lacustre*. The NNFA, TACN, and LCA were designated as both cost-effective and best-buy alternative plans. The NSA, TACNEB, and TAEB were neither cost-effective nor best buys. It may not be appropriate to use CE/ICA to evaluate effectiveness of the alternative plans for *A. lacustre* because the Lock Closure alternative may be the only effective alternative at stopping this species' mode of transport (i.e., hull fouling).

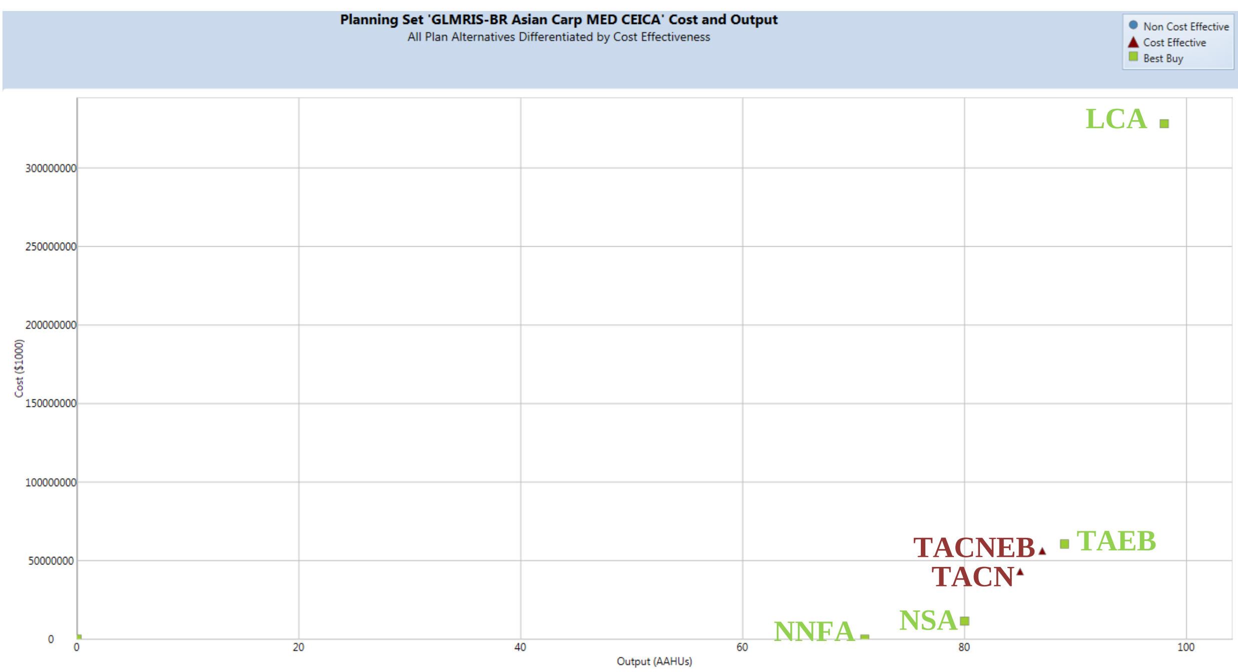

Figure 8-9 Cost and Output Results of Alternative Plans for Bighead and Silver Carp (Cost is in dollars and the output is the probability of no establishment [%].)

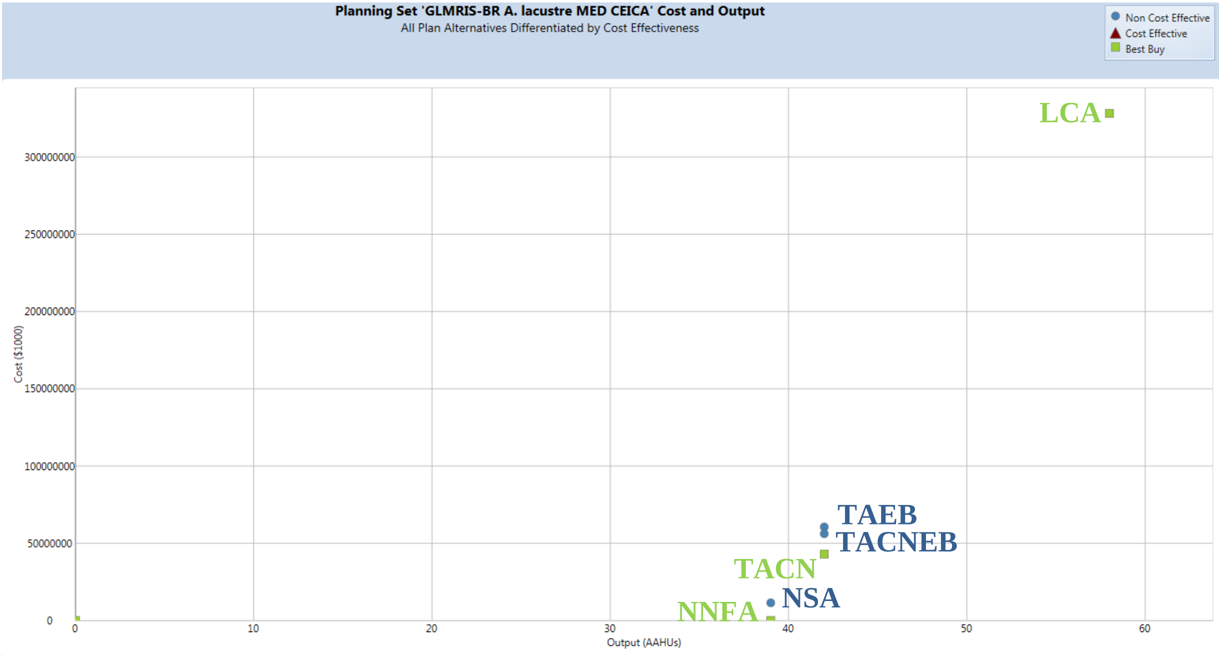

Figure 8-10 Cost and Output Results of Alternative Plans for *A. lacustre* (Cost is in dollars and the output is the probability of no establishment [%].)

8.1.5 Alternative Evaluation Matrix

The Alternative Evaluation Matrix (Figure 8-11) presents the evaluation criteria used in the selection process for the TSP. Criteria that are part of the Alternative Evaluation Matrix were discussed and analyzed in Chapter 6, Alternative Formulation, and Chapter 8, Comparison of Alternative Plans.

8.2 Selection of the National Ecosystem Restoration Plan

The criteria used to select the NER plan for recommendation from those that have been considered include all the evaluation criteria discussed above and in Chapter 6, Alternative Formulation. In addition, the potential impacts of the alternative plans (as discussed in Chapter 7, Impacts of Alternative Plans) are also part of the evaluation used to select an alternative plan. Selection of the NER plan required careful consideration to determine which plan meets planning objectives; is within planning constraints; and reasonably maximizes environmental benefits while passing tests of cost-effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

All costs associated with an alternative plan were considered, and tests of cost-effectiveness and incremental cost analyses were satisfied for the alternatives. The cost estimates were based on modeling results, assumptions made during formulation, level of engineering design, and current projects (e.g., CSSC-EB). Having established confidence in the estimated implementation costs, the remaining test of reasonableness is to assess the value of the resource to be protected in comparison with the cost to implement the alternative. The significance and value of the Great Lakes were discussed in Section 8.1.4, Significance of Ecosystem Outputs.

NOTE: All costs presented were estimated using the FY 2017 federal discount rate and price level.

[a] Evaluation criteria descriptions are located on the reverse side of this table.

[b] Composite expert values.

[c] System performance robustness.

[d] Ability to cycle in nonstructural controls: NS

[e] Ability to cycle in structural controls: S

[f] Number of structural control points:

One control point: CP

Two control points: CP CP

[g] Modes of transport:

Swimmers:

Floaters:

Hitchhikers:

[h] Assumed authorized for construction in FY 2021 and capability funding for planning, engineering design, and construction.

[i] "No Action" means no new federal or additional action, but current activities could continue.

[j] Permanent closure requires Congressional authorization.

GLMRIS – Brandon Road Alternative Evaluation Criteria[a]

Objective: Prevent the upstream transfer of aquatic nuisance species (ANS) from the Mississippi River Basin to the Great Lakes Basin through the Chicago Area Waterways in the vicinity of the Brandon Road Lock and Dam through the planning period of analysis.

	Alternative	Probability of Establishment for Silver and Bighead Carp in the Great Lakes[b] (Composite Expert Results)	Probability of Establishment for *A. lacustre* in the Great Lakes[b] (Composite Expert Results)	Relative Life Safety Risk	System Performance Robustness[c]: Ability to Cycle in Nonstructural[d]	Ability to Cycle in Structural[e]	Number of Structural Control Points[f]	Modes of Transport[g]	Project First Costs – Present Value: Construction Cost (CON) = Construction + PED + Con Mgmt. + Monitoring and Adaptive Management + Mitigation + LERRDS	Average Annual Costs: Construction Cost	Average Annual Costs: Nonstructural (NS) + OMRR&R	+ Costs of Impacts to Navigation (NAV) (NED)	= Total NED Costs (CON + NS + OMRR&R + NAV)	Anticipated Implementation Date[h]
	No New Federal Action (No Action)[i]	29% (22–36%)	61% (36–88%)	LOW	NS		CP		N/A	N/A	N/A	N/A	N/A	Ongoing
	Nonstructural Alternative	20% (15–26%)	61% (36–88%)	LOW	NS		CP		$600K (Mitigation: $0)	$20K	NS: $11.5M OMRR&R: $20K	N/A	$11.5M	2020: NS 2023: Construction Complete
Technology Alternatives	Electric Barrier	11% (8–14%)	58% (34–86%)	HIGH	NS	S	CP CP		$266.8M (Mitigation: $2.2M)	$10.1M	NS Measures: $11.3M OMRR&R: $7.8M	$31.4M	$60.6M	2020: NS 2025: Construction Complete
Technology Alternatives	Complex Noise	15% (11–19%)	58% (34–86%)	INTERMEDIATE	NS	S	CP CP		$113.9M (Mitigation: $2.2M)	$4.4M	NS Measures: $11.3M OMRR&R: $1.4M	$26.0M	$43.0M	2020: NS 2025: Construction Complete
Technology Alternatives	Complex Noise with Electric Barrier	13% (10–17%)	58% (34–86%)	HIGH	NS	S	CP CP		$275.3M (Mitigation: $2.2M)	$10.5M	NS Measures: $11.3M OMRR&R: $8.2M	$26.2M	$56.2M	2020: NS 2025: Construction Complete
	Lock Closure	2% (1–3%)	42% (17–78%)	LOW	NS		CP CP		$5.9M (Mitigation: $2.3M)	$200K	NS Measures: $9.2M OMRR&R: $20K	$318.7M	$328.2M	2020: NS + Lock Closed[j] 2023: Permanent Lock Closure Construction Complete

Figure 8-11 Alternative Evaluation Matrix

Probability of Establishment for Asian carp in the Great Lakes. This criterion estimates the probability of establishment for Asian carp within the Great Lakes for each alternative. The probability of establishment range is a composite based on results from the Asian carp expert elicitation. The GLMRIS-BR alternatives can impact Probability of arrival (P(arrival)) and Probability of passage (P(passage)). The mean value of the composite expert result is shown as well as the low and high ranges in parentheses.

Probability of Establishment for A. lacustre *in the Great Lakes.* This criterion estimates the probability of establishment for *A. lacustre* within the Great Lakes for each alternative. The probability of establishment range is a composite based on results from the *A. lacustre* expert elicitation. The GLMRIS-BR alternatives can impact P(arrival) and P(passage). The mean value of the composite expert result is shown as well as the low and high ranges in parentheses.

Relative Life-Safety Risks. This criterion represents the relative life-safety risk of navigators and facility operators associated with the alternatives. The qualitative risk assigned to each alternative is relative to the remaining alternatives. Low represents a low safety risk as compared to the other alternatives; high represents a high life-safety risk as compared to the other alternatives; and intermediate represents a safety risk between the alternatives ranked as low and high.

System Performance Robustness. This criterion has been evaluated as an alternative's ability to accomplish/address the following:

(5) *Ability to Cycle in Nonstructural Measures* – Ability to cycle in nonstructural measures refers to whether the alternative can cycle in new nonstructural measures.
(6) *Ability to Cycle in Structural Measures* – Ability to cycle in structural measures refers to whether the alternative can cycle in new structural measures.
(7) *Number of Structural Control Points* – Number of structural control points refers to the number of structural control points within the GLMRIS-BR Upper Illinois Waterway. The system currently has one structural control point, the CSSC Electric Dispersal Barriers. If a new structural control point is added at Brandon Road Lock and Dam, then the system would have two structural control points; this is also known as "defense in depth."
(8) *Modes of Transport* – Number of ANS modes of transport that are addressed by the alternative (modes of transport). This shows whether the alternative contains measure(s) that control the transfer of ANS that swim, float, and/or hitchhike. For example, if an alternative prevents swimmers and floaters, then the alternative addresses two modes of transport.

Project First Cost – Construction Cost. This criterion is the total estimated construction costs for an alternative. Construction costs include construction; lands, easements, rights-of-way, relocation, and disposal areas; preconstruction engineering and design (PED); construction management; performance monitoring and adaptive management; and mitigation. Although they are included in the total construction costs, the mitigation costs are noted in brackets. Mitigation costs are included for adverse effects on the connectivity of the Des Plaines River and the movement of native aquatic species due to the implementation of a technology alternative or Lock Closure. Mitigation costs also include the costs to mitigation for adverse and visual effects from the addition or modifications because of implementation of a Technology Alternative or Lock Closure. These would affect the original fabric of the dam and the new construction within the Brandon Road Lock and Dam Historic District boundaries. Neither the No Action Alternative nor the Nonstructural Alternative would require mitigation.

Average Annual Cost – Construction Cost. This criterion is the individual average annual costs for the construction project first cost.

Average Annual Costs – NS and OMRR&R Costs. This criterion is the individual average annual costs for nonstructural measures (NS) and Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R).

Average Annual Cost – Navigation Impacts (NED). This criterion is the estimated loss in average annual transportation cost savings for the alternative.

Average Annual Cost – Total NED Costs (Construction (CON) + Nonstructural Measures (NS) + OMRR&R + Navigation (NAV) Impacts). This criterion is total National Economic Development (NED) costs, which are the average annual costs of construction, nonstructural measures, OMRR&R, and navigation impacts.

Anticipated Implementation Date. This criterion is the expected calendar year when measures of an alternative would be implemented, assuming the alternative is authorized in FY 2021 and capability funding for pre-construction engineering design and construction.

8.2.1 NER Plan

The NER Plan and the TSP together are the alternative plan that reduces the risk of Mississippi River Basin ANS establishment in the GLB to the maximum extent possible while minimizing impacts on waterway uses and users. Selection of the TSP required careful consideration of the evaluation criteria for each alternative: (1) reduction in P(establishment) in the Great Lake Basin; (2) relative life safety risk; (3) system performance robustness; and (4) costs, which include construction, mitigation, OMRR&R, and navigation impacts (NED). The evaluation also included careful consideration of cost-effectiveness and incremental cost analyses, significance of the GLB ecosystem, acceptability, completeness, efficiency, and effectiveness.

Based on the results of the evaluation and comparison of the alternatives, the TSP is the Technology Alternative – Complex Noise with Electric Barrier, which includes the following measures: nonstructural measures, complex noise, water jets, an engineered channel, an electric barrier, a flushing lock, boat launches, and a mooring area. Assuming the project is authorized and USACE receives capability funding for preconstruction engineering and design, and construction activities, the project would be constructed in approximately 4 years. The nonstructural component of the plan would begin once funding is received. However, the structural components of the project would have to undergo safety testing and potentially a USCG-regulated navigation area rulemaking process prior to full operation. The TSP was selected because it was the alternative that prevented the transfer of ANS to the GLB to the maximum extent possible.

The TSP was chosen instead of the No New Federal Action and Nonstructural Alternatives because these alternatives did not meet the purpose and need to prevent, to the maximum extent possible, the movement of ANS (Bighead and Silver Carp) into the GLB through the CAWS.

This conclusion is supported by the following statements:

- For the No New Federal Action Alternative, a reduction in state and federal level of effort to control ANS is assumed because future actions are subject to the continuation of GLRI, the availability of future appropriations, and the budgetary allocations of other agencies.
- The CSSC electric barriers have a known flood bypass via the Des Plaines River, and USACE continues to evaluate and improve the efficacy of the barriers.
- The No New Federal Action and Nonstructural Alternatives cannot deter the continued upstream movement of Bighead and Silver Carp from the lower Illinois Waterway and Mississippi River. Instead, these alternatives are limited to monitoring and removal of Bighead and Silver Carp, public education and outreach, research and development of controls currently being used in the upper Illinois Waterway and CAWS, and integrated pest management. These alternatives do not deter the movement of fish.
- If Bighead and Silver Carp move past BRLD because no control point is present, installing control points upstream will be problematic due to the need for flood and navigation mitigation measures.

- The engineered channel increases the likelihood of detection using sonar and hydroacoustic monitoring gears and simplifies clearing of fish within the channel. The engineered channel also provides a platform to evaluate future technologies and potentially incorporate them.

The TSP was chosen over the Lock Closure Alternative because closing Brandon Road Lock would result in a discontinuation of the $318.7 million per year in transportation cost savings. Normally, fewer resources are required to move bulk commodities via waterways (waterborne transportation) than on land (i.e., via truck and rail). In these instances, the difference between the costs of moving commodities on land and the cost of moving them on a waterway is called "transportation cost savings." The NED benefits of navigation projects are the increases in transportation costs savings (increased efficiency of using the waterway to transport commodities). However, the navigation economic analysis completed in support of GLMRIS-BR found that several of the alternatives include measures that would *reduce* the efficiency of moving commodities on the waterway, consequently *increasing* transportation costs. Therefore, the GLMRIS-BR project alternatives are expected to result in navigation NED costs rather than NED benefits. In other words, there would be an overall reduction in transportation cost savings. Project alternatives that impose greater impacts on navigation are those that yield greater navigation NED costs.

The Lock Closure Alternative would cause businesses that currently ship goods through BRLD to shift to less efficient modes or routes, or go out of business. These mode shifts increase road and rail usage, with a related increase in the yearly average annual fatality, injury and property damage costs. Mode shifts of commodities from barge to rail and particularly by road increases the transportation related nonrenewable fuel usage and results in greater air emissions, including the emission of greenhouse gases and criteria pollutants. Although the Lock Closure Alternative would affect air quality in the region, it demonstrates conformity with the State Implementation Plan to maintain National Ambient Air Quality Standards. Although the Lock Closure Alternative was most effective in preventing Bighead and Silver Carp establishment in the GLB, it would have the greatest impact on navigation.

The TSP provides redundancy and robustness to the performance of the existing system and therefore better meets the project objective of preventing the risk to the maximum extent possible. The technology alternatives provide a physical deterrent to swimming and floating ANS, and a second ANS control point at BRLD. The TSP also includes an engineered channel that increases the effectiveness of existing structural and nonstructural measures for Asian carp and future ANS. The engineered channel also improves the plan's future adaptability by providing a platform to develop and test current and future technologies and possibly add these technologies in the future. The TSP minimizes impacts on waterway uses and users by maintaining the navigation mission at Brandon Road Lock while maximizing alternative effectiveness.

The TSP minimizes impacts on waterway uses and users by maintaining the navigation mission at Brandon Road Lock while maximizing alternative effectiveness. The nonstructural measures are important components of the TSP. The P(Establishment) model used for plan evaluation incorporated each expert's characterization of the probability of a small, medium, or large Asian carp population density developing in the Dresden Island Pool at specific time periods during the course of the 50-yr period of analysis. P(Establishment) model scenarios were run using these actual inputs provided by the experts as well as hypothetical scenarios that assumed either a large or a small population in Dresden Island Pool during the entire period of analysis (see Appendix C). The results of this scenario analysis indicated that the density of the population of Asian carp in the Dresden Island Pool has a significant effect on the P(Establishment) of Asian carp in the Great Lakes Basin, because Asian carp passage upstream of BRLD increases with the population size below BRLD. Therefore, the presence of a large population in the Dresden Island Pool through 2071 greatly reduces the efficacy of all of the technology alternatives in preventing Asian carp establishment in the GLB. Conversely, the efficacy of all of the technology alternatives is significantly enhanced if the Asian carp population density remains small through 2071. If the nonstructural measures that target Asian carp populations below BRLD are effective in keeping the currently small population density in Dresden Island Pool from increasing to medium or large, the efficacy of all of the technology alternatives would be significantly enhanced because the effectiveness of each alternative is the reduction in the probability of establishment estimates between the No New Federal Action and each alternative. The implementation of nonstructural measures is a shared responsibility that requires the support and participation of federal, state, and local agencies.

The TSP includes two swimmer controls: electric barrier and complex noise. The electric barrier is the most effective swimmer control currently available; however, the extent to which the electric barrier would impact navigation through Brandon Road Lock is uncertain. The TSP will be most effective if the electric dispersal barrier operates continuously at optimal parameters to deter fish. However, life safety must be considered, and the TSP will include life-safety considerations in its design in addition to fish deterrence. The measures will be tested to address site-specific operating considerations that cannot be addressed until after construction. Once the TSP is constructed, USACE and USCG will evaluate the operation of the electric barrier, complex noise, and water jets, all within an engineered channel, to assess safe operating parameters for each measure. The assessments will also include lock flushing. Life safety will be a primary consideration. Therefore, USACE expects it would initially operate the electric dispersal barrier only when vessels are not immediately downstream of the engineered channel, are not within the engineered channel, and are not locking through the lock. In lieu of operating the electric dispersal barrier during these times, complex noise will serve as the fish deterrent. Informed by the results of safety testing and continued coordination with USCG and the navigation community, USACE would work to maximize TSP effectiveness, which may include increasing the operating duration or continuously operating the electric dispersal barrier, while minimizing life-safety impacts.

The TSP was preferred over the Technology Alternative – Electric Barrier due to the uncertainty about whether the electric barrier would be operated continuously. The TSP was preferred over the Technology Alternative – Complex Noise Alternative because noise alone was ranked less effective in comparison to the TSP. Based on field demonstrations and other implemented projects, it is assumed complex noise will not interfere with navigation in the approach channel and could be operational prior to testing the electric barrier. The complex noise measure included in the TSP ensures a swimmer control is always operational when the electric barrier is turned off or operated at reduced power during vessel passage. The TSP control features will be operated to optimize effectiveness while minimizing safety impacts. A sensitivity analysis was conducted to assess the impacts on navigation if the electric dispersal barrier were to change operation from intermittent to continuous. If the electric dispersal barrier was to operate continuously, the impacts on navigation (NED costs) were estimated to increase from $26.2 million (intermittent operation) to $31.5 million (continuous operation). For more information regarding the sensitivity analysis, refer to Appendix D, Economics.

The TSP was selected because it meets the project objective by reducing the risk of MRB ANS establishment in the GLB to the maximum extent possible and provides for sustainable navigation. The TSP addresses two modes of ANS transport: swimming and floating, and creates a second structural control point in the GLMRIS-BR Illinois Waterway Study Area where swimming ANS would be deterred from upstream passage to the GLB. The TSP includes an engineered channel. The engineered channel would increase the effectiveness of the ANS control measures installed within and should also reduce the stray current impacts of the electric barrier. This feature provides a platform to test new controls and also, if appropriate, install future controls, as well.

The TSP is supported by the USFWS as noted in the draft Coordination Act Report, "The Service recognizes the need for the COE to follow established human safety guidelines when operating electric dispersal barriers for Asian carp deterrence. The Service requests that the Corps maximize the use of the electric barrier while balancing public safety factors (USFWS 2017)."

Chapter 9 Description of the Tentatively Selected Plan

9.1 Components of the Tentatively Selected Plan

The Technology Alternative – Complex Noise with Electric Barrier includes the following measures: (1) nonstructural activities, (2) complex noise, (3) water jets, (4) engineered channel, (5) electric barrier, (6) flushing lock, (7) boat launches, and (8) new mooring location (Table 9-1 and Figure 9-1).

9.2 Design and Implementation Considerations

As this project enters into the preconstruction engineering and design (PED) and implementation phases, more detailed analyses will be required. This section lays out (1) key assumptions that were made during the feasibility study and (2) associated additional studies that are needed during design to refine plans and reduce cost contingencies.

Physical Model of the Flushing Lock. A 3-D numerical model of the flushing lock was developed during the feasibility study; results determined that a flushing lock at BRLD is implementable. During PED, a physical model of the flushing lock would better define the required flushing time and potential navigation impacts.

Development of Complex Noise Operating Parameters. The following steps would need to be taken to further develop the complex noise feature: (1) map existing ambient sound conditions within the approach channel and lock under various scenarios; (2) establish audiogram for target ANS; (3) identify the target frequencies needed to elicit behavioral avoidance response in target ANS; (4) model the BRLD downstream approach channel to inform the design of the speaker array; (5) assess the time required to clear fish from the channel downstream of the BR Lock gate; and (6) assess the compatibility of complex noise with the other control features in this alternative. Additional research would be needed to determine when the complex noise should be turned off or changed in order to prevent habituation by fish species.

Table 9-1 Technology Alternative – Complex Noise with Electric Barrier Measures Included, Locations of Measures, and Modes of Transport Controlled by a Measure

Location	Measure	Controlled Modes of Transport
BRLD	Water jets	Floaters, small and stunned swimmers
	Flushing lock	Floaters
	Complex noise	Swimmers
	Electric barrier	Swimmers
	Engineered channel	Improves efficiency of swimmer and floater controls
	Boat launches	Supporting measure
Approximately 2 mi downstream of BRLD	Mooring area	Supporting measure
GLMRIS-BR Illinois Waterway Study Area	Nonstructural	Swimmers

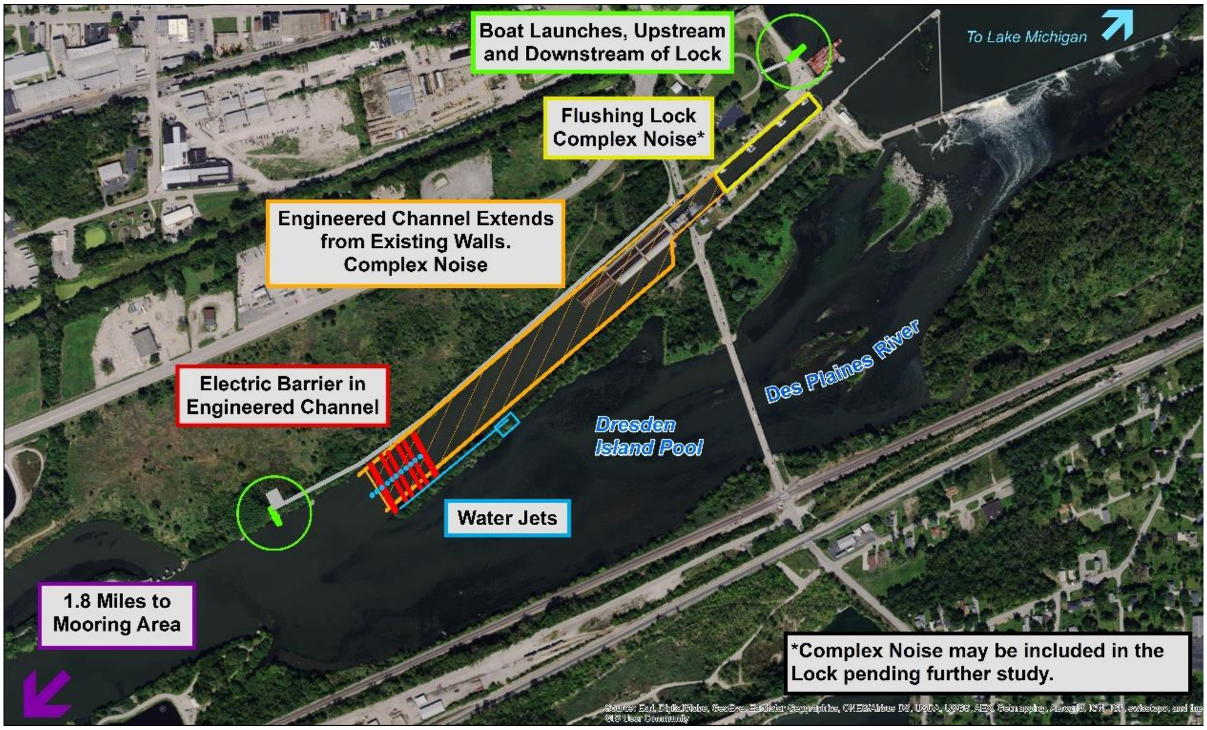

Figure 9-1 Aerial View of BRLD with Potential Layout of Technology Alternative – Complex Noise with Electric Barrier

Assessment of Potential Adjacent Land Use Impacts. At the time of this report, there has been limited analysis and no modeling for the proposed BR electric barrier. Assumptions about impacts have been based on an assessment of possible interference of neighboring land uses due to the electric barrier, impacts on infrastructure, and impacts identified at the CSSC-EB. For example, the BR Lift Bridge and the BR Lock could be impacted due to effects from ground current. Ground currents have the potential to accelerate corrosion of metallic structures on land in the vicinity of an electric barrier, such as piping, concrete reinforcing steel, and fence posts. The corrosion of the metal items is limited to the areas where the electrical potentials can be detected. To mitigate for any potential impacts on infrastructure resultant of operation of an electric barrier continuously at the BRLD, studies would likely need to be performed once it is functioning to map the presence of ground currents from the BR electric barrier on nearby infrastructure. Assumptions about potential impacts on adjacent property owners from stray current, as well as potential impacts on nearby infrastructure, would need to be further assessed during the PED and implementation phases. Refer to Section 7.1.10, Land Use, and Section 7.3.3, Infrastructure, for a more detailed discussion on the potential impacts on land use and nearby infrastructure, respectively.

Assessment of Potential Adjacent Waterway Use and User Impacts. At the time of this report, there has been limited analysis and no modeling for the proposed BR electric barrier. Assumptions about impacts have been based on an assessment of possible interference of upstream and downstream waterway use due to the electric barrier and impacts identified at the CSSC-EB. Assumptions about potential impacts on adjacent waterway uses and users (e.g., recreational fishermen, waterfowl hunters) from an elevated electric field would need to be further assessed during the PED and implementation phases. In addition, the potential impact on tow personnel and lock personnel would also need to be further assessed during the PED and implementation phases. The operation of the electric barrier could have increased injury or mortality potential to waterway users and waterway personnel within the GLMRIS-BR Site-Specific Study Area. Refer to Section 7.4.3, Navigation, and Section 7.4.4, Injury or

Mortality Potential, for a more detailed discussion on the potential impacts on waterway use and users, respectively.

Evaluation of ANS Design and Operating Considerations Due to Reversed Flow. Further analysis would need to be completed during the PED and implementation phases to assess the influence of flow reversal and to determine whether measures are required to address the return current that flows upstream toward the BR Lock during changes in dam and lock operations. Velocity data collected during the study and modelling confirm that frequent flow reversals in the BR Lock downstream approach channel occur. The majority of these reversals occur following lock empties. Additional simulations have shown that the operation of the BR Dam head gates, and the rapid increase in discharge associated with these gate operations, can also induce flow reversals in the approach channel.

Continued Development of Structural ANS Controls. For water jets, additional development includes but is not limited to their placement, orientation, number, and flow rates. For the electric barrier, research continues on ways to improve its efficacy and possible other designs.

Synergistic Operation of Control Technologies. Further analysis is needed during the PED and implementation phases to maximize effectiveness of the control point with the synergistic operation of the various control technologies included in the TSP.

USCG Safety Risk Assessment. The USCG has completed a preliminary risk assessment addressing marine safety and navigation safety due to an electric barrier, underwater speakers, water jets, and flushing lock in the vicinity of the BRLD (USCG 2016). Once constructed, USACE and USCG will conduct an evaluation of the operation of the electric dispersal barrier, complex noise, and water jets, all within an engineered channel, to assess safe operating parameters for each measure. Lock flushing will also be included in the assessments. This evaluation will be conducted to address site-specific operating considerations that cannot be addressed until after construction. Safety testing and rulemaking are expected to take approximately 19 months, which is inclusive of a 90-day public review (Tantillo 2017).

Electric Barrier Operation. The TSP will be most effective if the electric dispersal barrier operates continuously at optimal parameters to deter fish. However, life-safety must be considered, and the TSP will include life-safety considerations in its design, in addition to fish deterrence. As noted in the previous paragraph, USACE and USCG will evalate the measures to address site-specific operating considerations that cannot be addressed until after construction. Life-safety will be a primary factor of consideration. Therefore, USACE expects it would initially operate the electric dispersal barrier measure only when vessels are not immediately downstream of the engineered channel, are not within the engineered channel, and are not locking through the lock. In lieu of operating the electric dispersal barrier during these times, complex noise will serve as the fish deterrent. Informed by the results of safety testing and continued coordination with USCG and the navigation community, USACE would work to maximize TSP effectiveness, which may include increasing the operating duration or continuously operating the electric dispersal barrier, while minimizing life-safety impacts.

Characterization of the Site for the Operational Support Facilities (i.e., Tract 3 [Figure 7-2]). Under USACE policies, civil works projects should avoid locations with environmental conditions to the extent practicable (E.R. 1165-2-132). Further investigation of any environmental conditions associated with the sediment or adjacent land will be conducted, as more fully described in Appendix G, Phase I Environmental Site Assessment (HTRW). To the extent environmental conditions are verified, implementation may include consideration of alternative upland locations, proper disposal of all contaminated sediment and soils, best management practices for erosion and dust control, and any other appropriate measures.

Other environmental considerations that will be addressed during implementation include the following:

- Water quality, in regard to impacts on technology performance as well as impacts of technologies on water quality;
- Compliance with USACE climate change guidance;
- Compliance with USACE sustainability and green development construction guidance; and
- Best management practices for dredging contractors and in water construction.

9.3 Residual Risk

Some risks and uncertainties are inherent in many of the complex concepts discussed in the GLMRIS-BR Report. The costs and implementation schedule presented in Chapter 6, Alternative Formulation for the TSP are commensurate with the conceptual plans as presented in this report. At the level of detail presented in the GLMRIS-BR Report, some assumptions were made for the TSP. The cost and implementation schedule estimate assumes that the necessary funding to fully and efficiently complete the TSP will be provided annually, and the necessary real estate and necessary permits to implement the TSP can be acquired and obtained in a timely manner. These risks cannot be quantified at this time and could have impacts on the costs and implementation schedule of the TSP. For additional information on cost risks, refer to Appendix I, Cost Estimate.

One of the most important caveats of the analyses presented in this document is the study's statutorily derived focus on the aquatic pathway. The transport or dispersal of ANS outside of the aquatic pathway is considered a residual risk for the GLMRIS-BR effort.

In GLMRIS-BR, all risk assessments, proposed measures, and alternative plans are centered upon aquatic-based mechanisms through which ANS could arrive at and transfer through aquatic pathways. These include active movement (swimming or crawling), passive drift via currents, and vessel-mediated movement. Vessel movement was included in GLMRIS-BR to account for the significant existing use of the CAWS by commercial cargo, passenger, emergency services, government, and recreational navigation traffic. Any vessel that remains within the waterway as it moves between the basins via the CAWS is considered a relevant mode of potential transfer between the basins. This includes the transfer via ballast and bilge water, because of the interbasin movement of commercial cargo vessels via the CAWS, as well as hull fouling by organisms semipermanently attached to vessels below the waterline. However, transport by recreational or other types of smaller vessels on trailers or otherwise portaged over land from one basin to the other was considered outside the scope of this study.

There also is a risk that one or more currently identified ANS may transfer between the basins prior to implementation of the TSP, but the TSP is formulated to be effective at preventing the transfer of future ANS. For a discussion on the formulation of alternatives to address different modes of ANS transport, refer to Chapter 6, Alternative Formulation.

After the TSP has been implemented, there are still residual risks of adverse impacts due to ANS transfer and establishment. For example, although the implementation of the TSP would reduce the likelihood of ANS transferring through the CAWS and becoming established in the GLB, the potential for ANS establishment and the resulting consequences still exist. The potential GLB impacts discussed in Chapter 5, Consequences of ANS Establishment in the Great Lakes Basin, are applicable to the TSP. However, the TSP attempts to reduce the potential for these consequences actually occurring by reducing the likelihood the ANS will establish. Second, residual risk of transfer remains along the Great Lakes and Mississippi River Basin divide outside of the CAWS. For additional information on the remaining pathways, refer to *The GLMRIS Report, Chapter 2, Section 2.2.1, Focus Area 2* (USACE 2014a). Last, regardless of the implementation of the TSP, residual risk of interbasin transfer through non-aquatic pathways remains. The TSP addresses, to some level, non-aquatic pathways because each alternative includes nonstructural measures, such as public education and monitoring, that may deter but not completely address ANS transfer through non-aquatic pathways.

Methods of ANS transport and spread outside of the aquatic pathway can be grouped into three general categories: (1) transportation-related mechanisms, (2) living industry-related mechanisms, and (3) miscellaneous mechanisms. Some examples of transportation-related mechanisms are aircraft; overland transportation of recreational boats and other craft; vehicles; transportation/relocation of dredged material, topsoil, and fill; hikers, hunters, and anglers; travelers (including their luggage); and pets and plants. Living industry refers mainly to aquaculture, horticulture, and agriculture, as well as the aquarium trade, the use of live bait, and releases from aquariums or water gardens. Miscellaneous mechanisms represents a catch-all category for a variety of modes of movement including transport on or within other plants and animals, disposal of solid waste/garbage, land or water alterations, and natural spread. Human-mediated dispersal may transport certain ANS at greater distances, or in higher numbers, than those ANS could disperse naturally. Humans are also likely to be instrumental in the secondary spread of ANS following initial establishment.

The GLMRIS Report, Appendix C, Risk Assessment (USACE 2014a) identifies other pathways for the GLMRIS and GLMRIS-BR ANS of Concern to disperse, and presents a discussion of the most likely non-aquatic transfer methods. A review of applicable literature indicates that no matter what actions are pursued to prevent interbasin transfer of ANS via the aquatic pathway, there remains the risk for the species to be transferred by one or more of the non-aquatic transfer mechanisms. This residual risk is very important to consider when evaluating a long-term recommendation for prevention of ANS transfer; the risks and risk reduction methodology presented within this study do not consider those non-aquatic pathways. Recreational use, particularly in the vicinity of the CAWS, may be of more concern for interbasin transfer than the other non-aquatic transfer mechanisms because of the number of individuals that participate in hunting, fishing, boating, and other water sports in the vicinity, as well as the number of transfer mechanisms associated with recreation (e.g., equipment, clothing, vehicles). Interbasin transfer is also possible from private aquariums and water gardens, accidental and unregulated stocking, and the live food fish market.

There is uncertainty associated with the ability of the TSP to control ANS transfer through the CAWS. The TSP includes known technologies and engineering concepts; however, the combination of technologies and application of the technologies at a single control point would be implemented for the first time under the TSP. In addition, some of these concepts have not been applied to control the transfer of ANS. For example, the flushing lock uses an existing process engineering concept but has not been previously applied to control the transfer of floating ANS. In addition, while USACE currently operates an electric barrier (i.e., CSSC-EB), there are ongoing studies associated with improving its efficacy. The level of uncertainty associated with the TSP's reduction in probability of establishment is discussed in Chapter 6, Alternative Formulation.

9.4 Real Estate Considerations

The proposed project footprint includes privately owned lands under the operation of NRG Energy. The property has been identified as the location to temporarily stage construction materials and equipment; to dewater sediment; to temporarily store the blasted rock from the approach channel awaiting reuse; and to permanently house the ancillary buildings and other support features for the TSP. The property has an unclear site history, and past uses may have affected property conditions. Aerial photographs document that the land was excavated and later filled, although, to date, no records have been found to indicate the entity conducting the operations and the nature of the fill materials. USACE does have information that indicates it has historically disposed of dredged material on some portions of the site. A Phase II Environmental and Geotechnical Site Assessment will be conducted that will inform whether regulatory coordination is required, whether a response action is necessary, and whether site conditions have an impact on project design. For more information, see Appendix J, Real Estate Plan.

9.5 Operations and Maintenance Considerations

The OMRR&R costs for each of the alternative measures were accounted for separately from the construction cost estimates. The OMRR&R costs were estimated based on knowledge of existing systems and parametric costs as follows. Costs include salary costs of the operational staff for each measure; the staffing requirements are detailed below. Note in Table 9-2 that all costs are rounded to the nearest hundred thousand for significant digit consistency. In addition, this table shows only the consistent annual cost of OMRR&R. Occasional costs for significant maintenance and equipment replacement are detailed in Sections 9.5.1 through 9.5.9 and are included in the economic analysis (Appendix D, Economics). Separate costs were calculated for the continued Monitoring and Adaptive Management work and are covered in Section 9.7, Monitoring and Adaptive Management.

9.5.1 Electric Barrier

The OMRR&R estimates for the electric barrier measure were estimated using known costs from the CSSC-EB. It was estimated that $7 million would be required for annual O&M of the electric barrier, including staffing requirements. In addition, approximately $3.7 million was estimated for replacing the barrier electrodes every 25 years, and $12 million of upgrades to the electrical equipment of the barrier are estimated every 10 years. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.2 Mooring Area

The TSP includes a new mooring area installed to the south of the BR Lock. It was estimated that during the 50-year project period, maintenance dredging of the mooring area would need to occur once. The estimated one-time cost of maintenance dredging is $10 million, as the material will need to be dredged, treated, and disposed of in a landfill as in the initial dredging effort. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.3 Water Jets

The annual O&M cost for the water jets were estimated to be $500,000. In addition, pump replacement was estimated to occur every 15 years at a cost of $300,000. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.4 Complex Noise

The annual O&M cost for complex noise was estimated to be $500,000. In addition, speaker replacement was estimated to occur every 15 years at a cost of $300,000. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.5 Flushing Lock

The annual O&M cost for the flushing lock was estimated to be $300,000. Major rehabilitation, replacement, or repair costs are not anticipated for this measure. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.6 Engineered Channel

Normal OMRR&R costs for the engineered channel are assumed to include the cost of periodic inspections of the channel walls and floor, which are negligible for this estimating purpose. Major rehabilitation, replacement, or repair costs are not anticipated for this measure. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.7 Lock Closure

Normal O&M costs for lock closure are assumed to include inspection of the lock, which is negligible for this estimating purpose. Major rehabilitation, replacement, or repair costs are not anticipated for this measure. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.8 Boat Launches

The annual O&M costs for the two boat launches were estimated to be $20,000. This is to cover minor repairs, the addition of gravel, repairs to safety fencing and lighting, and similar items. Major rehabilitation, replacement, or repair costs are not anticipated for this measure. For a more detailed discussion, refer to Chapter 6, Alternative Formulation.

9.5.9 Staffing Requirements

In regard to staffing requirements for the TSP, it was estimated that 8 full-time employees would be needed to cover the operational needs. Staffing requirements are expected to have an estimated annual cost of $2 million. For a more detailed discussion, refer to Chapter 6, Alternative Formulation. This cost is included in the cost of the electric barrier measure.

9.6 Implementation and Sequencing

Implementation and construction assumptions were based on best-available information from Engineering. Implementation sequencing and construction were designed with the intent to minimize impacts on navigation activities. Construction features that would require temporary closure of the lock to navigation include the flushing lock, water jets, and the electric dispersal barrier. Navigation may be restricted during construction of the engineered channel because of (a portion of) the landside wall construction and channel bottom activities (e.g., excavation, installation of precast panels) to ensure safety. Additional engineering and economic analysis, safety testing, and coordination with navigation stakeholders and the USCG would be completed as the study continues and during the PED phase to better inform the construction schedule and associated navigation restrictions. If possible, construction activities will be scheduled to coincide with other scheduled waterway maintenance in order to minimize impacts on navigation.

Nonstructural Measures. Nonstructural measures do not require construction and could commence as soon as authorization of the project is received and funds are appropriated.

Engineered Channel. Construction of the engineered channel would occur first since it is the platform for the other technologies (e.g., water jets, electric barrier, and complex noise). Construction of the engineered channel guidewall is expected to require a 30-day navigation restriction during which the BR Lock would be in operation for only 12 hours per day (construction would occur during daylight hours). Construction of the walls and bottom of the engineered channel is expected to require 1-hr closures daily for 6 days per week during daylight (construction would occur every day but Sunday). These daily 1-hr closures are expected to occur over the course of 800 calendar days. Construction of the engineered channel includes preblast survey, excavation, and installation of lined walls and bottom of channel.

Water Jets. Construction of the water jets is expected to occur concurrently with construction of the engineered channel. Construction would include the water jet system (jets and pumping system) and associated pumphouse control buildings.

Complex Noise. Construction of the complex noise technology would require the placement of speakers potentially within the engineered channel and lock chamber. Construction of a building would also be required for housing of control equipment. Placement of the speakers underwater for the complex noise within the engineered channel is expected to require 8-hr closures, 5 days per week, for approximately 45 days.

Electric Barrier. Construction of the electric barrier would require two electrical substations, three-array electric barrier, backup power facility with two generators, grounding field, electrodes and parasitics, and a stop log feature. Construction of the electric barrier component within the engineered channel is expected to require 8-hr closures, 5 days per week, for approximately 22 days.

Flushing Lock. This construction would begin when the engineered channel was begun. Construction of the flushing lock would require dewatering of the lock, plugging of the existing ports and drilling of the new portholes. This feature is expected to require a 40-day lock closure.

Mooring Area. Construction of the new mooring area would require dredging of sediments and construction of the four new mooring cells. This measure could be implemented at any time during the construction process and would not require any waterway closures.

Boat Launches. Boat launches would be constructed as soon as possible to improve timely contingency response actions. This measure would not require any waterway closures.

The site for this invasive species control project is located at BRLD on the IWW. It is recommended that an Interagency Coordination Committee be established to provide active management recommendations to USACE pertaining to the operation and adaptive management of invasive species controls at the BRLD. The Interagency Committee will be established in coordination with the ACRCC, which oversees the monitoring and removal planning for Asian carp in the upper Illinois River and CAWS. It is recommended that the committee be cochaired by USACE and the USFWS. The USFWS will be representing the U.S. Department of the Interior (DOI) for this project. Members of the committee, in addition to USACE and USFWS, shall include other federal agencies with an interest in navigation and environmental aspects that may be affected by *management actions* at the Brandon Road Project. Additional federal agencies may include the USCG, EPA, and MARAD. It is recommended that in addition to the federal agencies involved, the Coordinating Committee include a minimum of two state members. Because of the project location, the State of Illinois would maintain a standing membership along with other states on a rotational 4-yr cycle. The committee organization structure is presented in Figure 9-2. The GLMRIS-BR Interagency Coordination Committee would also consider establishing a science subcommittee.

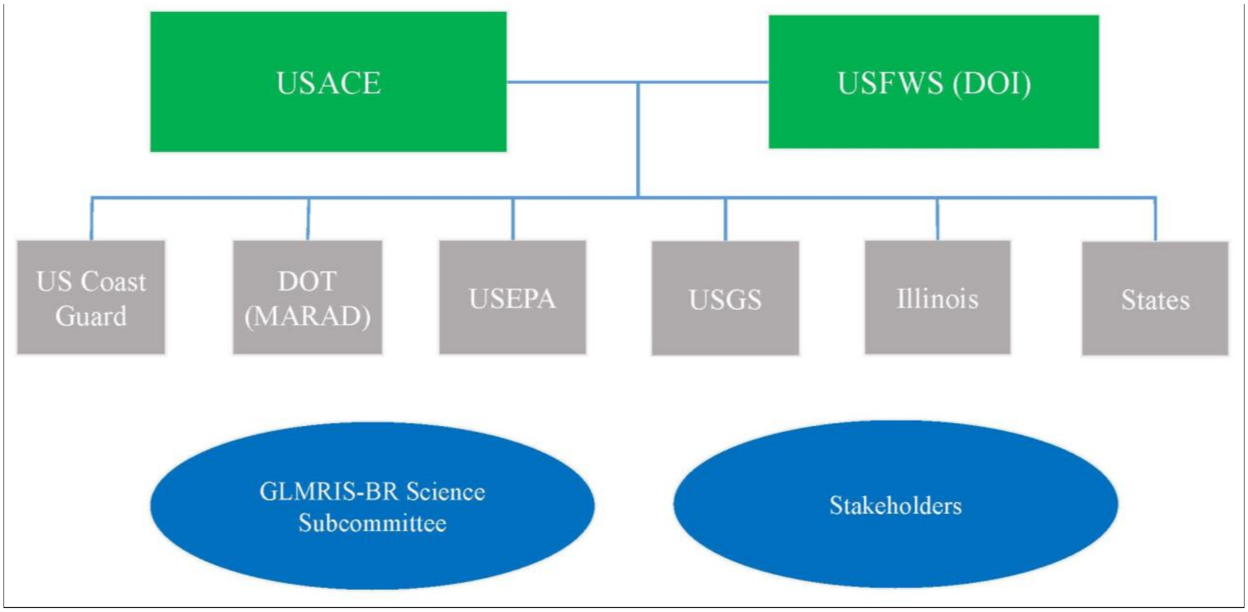

Figure 9-2 GLMRIS-BR Interagency Coordination Committee

The GLMRIS-BR Interagency Coordination Committee would meet a minimum of twice per year. The meetings will be advertised and scheduled at least 60 days in advance to allow stakeholders and the public to attend. Time will be allocated during each meeting to allow for stakeholder comments and questions. These comments will be taken into consideration by the committee in developing recommendations to USACE pertaining to operations and adaptive management.

9.7 Monitoring and Adaptive Management

Section 2039 of the WRDA of 2007, 33 USC §2330a, directs the Secretary of the Army to ensure, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration, that the recommended project include a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated August 31, 2009, also requires an adaptive management plan be developed for all ecosystem restoration projects. Within a period of 10 years from completion of construction of the project, monitoring shall be a cost-shared project cost. Monitoring for the success of the project is different from the monitoring that would be undertaken as part of the nonstructural measure component of the TSP. For the entire monitoring and adaptive management plan refer to Appendix L, Monitoring and Adaptive Management.

Monitoring allows for the determination of whether a project is performing as it was designed and as effective as it was thought to be. Adaptive management allows for the TSP to be modified in response to monitoring results to maximize its effectiveness and reduce its impact on waterway uses and users. Performance monitoring includes two types of monitoring: biological monitoring of the fish populations below BRLD and their response to the TSP, and monitoring of the measures to determine whether they are performing as they were designed (i.e., is the electric barrier producing the desired field strength in the water, are the speakers producing the desired characteristics of the complex noise in the water column, and so on). Performance monitoring and adaptive management have been estimated at 10% of the construction costs and will occur within 10 years of project implementation. The following are brief descriptions of activities that could occur as a result of project monitoring.

Electric Barrier. Based on the results of project monitoring, the equipment would be cleaned, repaired, and/or replaced as necessary to maintain power in the water. Results of the studies and observations are utilized to optimize the effectiveness of the electrical field while minimizing its impacts and to minimize/address stray current.

Flushing Lock. Based on the results of the physical model during design, the frequency and length of flushing would be set for normal lock operations. As the constructed feature operates, continued testing will allow lock operators to refine the procedures, using the flushing more or less often and lengthening or shortening the flushing time as necessary.

Complex Noise. The number and placement of speakers and decibel levels of noise would be determined during the detailed design phase of this project. As the installed project and its effect on ANS swimmers are monitored, additional speakers may be installed or the placement of the speakers changed. Continual testing of the effectiveness of various decibel levels would also inform and potentially change the operating parameters of the noise system.

Water Jets. Based on observation of ANS within the water jets and on continued testing by ERDC, operators may change the velocity of the jets, install additional jets, turn off some existing jets, or revise the length of time during which jets are turned on during barge passage.

Down-bound Tows. If ongoing studies find that modified vessel operations reduce fish entrainment, they would be explored during the adaptive management phase of the project in conjunction with USCG and the navigation community.

Much research, in particular for swimming ANS, continues. The development and testing of new and innovative barrier technologies through the collaborative research efforts of federal and state agencies, universities, nongovernmental organizations, and private industry has expanded the possibilities for controlling invasive species in the future.

The TSP includes an engineered channel that provides a platform to field-test future technologies in a navigation channel prior to full-scale deployment as well as the opportunity to replace or update planned features or add new ANS controls as control technologies become mature or other conditions change. Field-testing or implementation would be subject to required environmental analysis. Proposed modifications to the engineered channel by others, in order to test or add new technologies, would be subject to Section 408 (33 USC §408) analysis. To address the evolving nature of ANS control technologies, USACE recommends, as part of this report, that USACE be authorized to study and implement options and technologies that improve the efficacy of the ANS control measures at BRLD similar to the efficacy study authority associated with the CSSC-EB.

Because of the evolving nature of ANS control technologies, ongoing evaluation for available technologies and optimal operation techniques is advisable. Thus, the recommendation includes ongoing study and implementation of options and technologies that improve the efficacy of the ANS control measures at BRLD. This is similar to the CSSC-EB efficacy study (Section 3061(b)(1)(D) of WRDA 2007) and implementation authority in Section 1039(c) of the WRRDA of 2014, P.L. 113-121.

9.8 Implementation of Environmental Operating Principles

The formulation of all the alternatives considered for implementation was done in accordance with the Environmental Operating Principles, as follows.

Environmental Sustainability. The study was formulated to avoid and/or minimize adverse effects on critical, unique, and diverse fish and wildlife areas to the greatest extent practicable while keeping in mind the objective of the study, which is to prevent the upstream transfer of MRB ANS through the CAWS to the GLB. Periodic monitoring and annual OMRR&R requirements are included in the TSP to ensure deficiencies that may occur in project performance are addressed in a timely fashion to ensure the overall project is sustainable.

Proactively Consider Environmental Consequences. The study took into consideration the potential environmental consequences that could occur if Bighead Carp, Silver Carp, and *A. lacustre* were to become established in the GLB. These consequences are discussed in detail in Chapter 5, Consequence of ANS Establishment in the Great Lakes Basin.

Build and Share an Integrated Scientific, Economic, and Social Knowledge. The GLMRIS-BR Report used the best available information to identify ANS of Concern, develop measures and screen potential controls, define potential consequences of the alternative plans, and define the potential consequences if the ANS of Concern were to become established in the GLB. Coordination was undertaken with NOAA, USFWS, and the University of Michigan.

Respect the Views of Individuals and Groups Interested in USACE Activities. Throughout the feasibility phase, continual coordination with local stakeholders and interested agencies has occurred. Public scoping meetings were held (Chapter 10, Public Involvement) to ensure stakeholders had input on the project. In addition, a GLMRIS-BR newsletter is sent regularly to interested stakeholders, and a website is maintained to ensure stakeholders are aware of the progress and direction of the project. Multiple federal and state agencies have also provided valuable insight into the development and evaluation of the alternative plans, including USFWS, EPA, USGS, NOAA, USCG, Illinois DNR, MARAD, and AWO.

9.9 Compliance with USACE Campaign Plan

In assessing the environmental effects of the alternative plans, USACE implemented the following Campaign Plan goal as part of the Feasibility Study.

Transform Civil Works. USACE will focus its talents and energy on comprehensive, sustainable, and integrated solutions to the nation's water resources and related challenges by collaborating with stakeholders (internal, regional, states, local entities, other federal agencies), playing traditional or emerging roles (leadership, technical support, broker, data and knowledge provider), and evaluating the current and required portfolio of water resources infrastructure. This goal refers to not only developing and delivering comprehensive and lasting solutions and products but also ensuring that the deliverables are sustainable (long-lasting, integrated, and holistic) to respond to today's and future challenges.

Opportunities were sought to identify innovative measures to address the GLMRIS-BR study authority.

9.10 NEPA Compliance

The President's Council on Environmental Quality guides public participation opportunities with respect to Feasibility Reports and Environmental Impact Statements, Engineering Regulations, and procedures for implementing NEPA. The GLMRIS-BR project was determined to be in compliance with NEPA and all other appropriate statutes, executive orders, and memoranda (refer to Section 7.9, Compliance with Environmental Statutes). Coordination and compliance with this Feasibility Study included comprehensive public involvement, agency coordination, and review of and inclusion of compliance with applicable federal statutes according to the USACE E.R. 1105-2-1000, Planning Guidance Notebook. USACE policy is to ensure that adverse impacts on significant resources have been avoided or minimized to the extent practicable and that remaining, unavoidable impacts have been compensated for to the extent justified.

The USACE assessment of the alternative impacts reveals that impacts are expected to be minor overall. However, the Illinois DNR has observed significant ecological recovery of the Des Plaines River in recent decades, such as improved aquatic habitat, increased species richness partly driven by recolonization of fish species from downstream population sources, and reestablishment of mussel beds downstream of the BRLD. The Illinois DNR and USFWS recognize that technologies proposed for use in the recommended BRLD alternative would limit native fish passage and mussel recolonization into the Des Plaines River through BRLD, therefore hindering the continued recovery of the Des Plaines River system.

Among the structural alternatives for impeding the upstream dispersal of Asian carp, the USACE GLMRIS-BR Project has identified a TSP that incorporates the use of an engineered channel, electric barrier, complex noise, water jets, and a flushing lock as the most efficient and effective means of preventing Asian carp access to the GLB while still allowing for barge traffic.

To address the potential impacts of the TSP, the following list of mitigation measures has been proposed. This list should not be considered all-inclusive, and needs may change over time.

- Stocking of sport and nongame native fishes to meet management goals over the life of the project (Draft Des Plaines River management plan outlines strategy and priorities).

- Stocking of or translocation of mussel species and host species to meet management goals over the life of the project (Draft Des Plaines River management plan outlines strategy and priorities).

- Enhancement of aquatic habitat to support and increase fish/mussel populations of the Des Plaines River.
  - Enhancement of dam removal projects in select basins.
  - Enhancement or creation of key habitat features identified in the Draft Des Plaines River management plan to maintain and meet Des Plaines River management goals (e.g., vegetation [water willow] establishment, rock bar creation, and other physical habitat improvements).
  - Water quality, landscape level educational outreach to reduce nonpoint-source pollution (e.g., EPA Low Impact Development, incorporating green infrastructure).
  - Mitigation of select point-source pollution activities, if opportunities present themselves.

- Improvement of ongoing ANS surveillance, monitoring, and surveys both below BRLD and within the Des Plaines River.

- Continuation and/or enhancement of ongoing harvesting of Asian carp in the upper IWW.

- Assisted fish migration planning for select priority species (e.g., American Eel) passage.

- Support of sport fish enhancement in the Des Plaines River and elsewhere.
- Support of nongame fish enhancement in the Des Plaines River.
- Support of mussel enhancement, use, and recolonization of the Des Plaines River.
- Establishment of monitoring protocols and resources to assess status, movement, and habitat use of select fish species in the lower Des Plaines watershed (species and strategies are identified in current Draft Illinois DNR Des Plaines River management plan)
- Support of stakeholder outreach and education to further promote appropriate management of aquatic resources for which mitigation actions are needed, and to support current Illinois DNR management plans (e.g., engage with "Friends of groups" to meet the variety of water user needs under an altered Des Plaines River with BRLD modifications).
- Support of appropriate outreach and education to prevent overland or unintentional transport of ANS through or around additional control measures at BRLD (e.g., signage, community involvement, area school curriculum, and the like).

The USFWS, in coordination with Illinois DNR and USACE, will develop a mitigation plan to fully evaluate these mitigation measures as reasonable and prudent options to mitigate for the loss of native fish passage and maintenance of those populations in the Des Plaines River at or upstream of BRLD.

9.11 Milestone Schedule and Procedures

The current schedule for completing the feasibility report is as follows:

Agency decision milestone	June 2018
Internal Progress Review	February 2019
State and agency review begins	February 2019
Chief's report milestone	August 2019

Upon completion, the Report of the Chief of Engineers will be reviewed by the Office of the Assistant Secretary of the Army (Civil Works) ([OASA(CW]) and the Office of Management and Budget (OMB). Once the OASA(CW) has reviewed and processed the report and OMB has provided clearance, the report will be transmitted to Congress for authorization in a future WRDA. If funds are made available by Congress, PED can begin. In addition, the report will be reviewed by the OASA(CW) and the OMB for potential inclusion in future administration budget requests.

9.12 Implementation Responsibilities

At this time a non-federal sponsor(s) has not been identified for implementation of a GLRMIS-BR Project. The GLMRIS authority authorizes completion of study activities at full federal expense. Throughout the completion of the GLMRIS Report (USACE 2014a), the PDT engaged with a wide variety of stakeholders and plans to continue doing so during the GLMRIS-BR Feasibility Study with a goal of identifying a non-federal sponsor.

Involvement of a non-federal sponsor(s) willing to cost-share an alternative plan is required by USACE policy in order to recommend authorization of a project; see E.R. 1105-2-100 at 4-3. Under current law, non-federal sponsors are required to pay for 35% of environmental protection and restoration projects implemented by USACE, and such projects may not be implemented until a non-federal sponsor enters into an agreement and assumes obligations on a variety of matters including cost-sharing, real estate acquisition, and OMRR&R activities; see 33 USC §2213(c)(7), (j). Thus, implementation of the TSP could not proceed unless a non-federal sponsor is identified according to Section 210 of the WRDA of 1996, 33 USC § 2213(c)(7).

Following authorization for construction of a project, the sponsor enters into a Project Partnership Agreement (PPA) to define the responsibilities of each party. The sponsor must normally agree to the following:

1. Provide without cost to the United States all lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) necessary for the construction and subsequent maintenance of the project.

2. Provide without cost to the United States all necessary alterations of buildings, utilities, highways, bridges, sewers, and related and special facilities.

3. Hold and save the United States free from damages due to the construction and subsequent maintenance of the project, except damages due to the fault or negligence of the United States or its contractors.

4. Maintain and operate the project after completion without cost to the United States.

5. Prevent future encroachment, which might interfere with proper functioning of the project.

6. Assume responsibility for all costs in excess of applicable federal cost limitations.

7. If the value of the sponsor's contribution above does not equal or exceed 35% of the project cost, provide a cash contribution to make the sponsor's total contribution equal to 35%.

9.12.1 Federal Agencies

The TSP includes nonstructural measures that are important to the alternative's long-term effectiveness. Currently, many of these nonstructural measures are being carried out by USACE, EPA, USFWS, Illinois DNR, and USGS. These activities are currently funded by agency base budgets and supplemented by GLRI funds. When projecting the FWOP condition, the Asian carp-monitoring and -controlling efforts were assumed to be a shared responsibility and dependent on the aforementioned agencies. It is anticipated that other federal agencies will carry out the nonstructural measure component of the TSP to the extent of their authorities and funding. If, at any time during the project duration, the other federal agencies are unable to implement sufficient nonstructural measures, then the measures may need to be implemented under the project authority. The estimated project costs are described in the following section.

9.12.2 Total Project Costs

Total project costs include costs for study, design, implementation, contingencies, construction management, engineering during construction, and project management. Note the costs in Tables 9-2 and 9-3 are rounded to the nearest hundred thousand for significant digit consistency, except for the for Nonstructural Measure and OMRR&R costs. Costs for design and management are estimated based on a percentage of estimated implementation costs and contingencies. These costs will be revised prior to the execution of a PPA, and actual costs for these activities will be used to remedy final cost sharing responsibilities during project close-out.

Cost Apportionment

The study has been conducted with 100% federal financing in accordance with Section 3061(d) of WRDA 2007, which states that the study would be conducted "at Federal expense." As such, the feasibility study will not be cost-shared 50/50 between the federal and non-federal sponsor as typically required by E.R. 1105-2-100, Paragraph F-1.b. Reimbursement of feasibility study costs will not be sought from the non-federal sponsor during execution of the PED agreement.

According to Section 210 of the WRDA of 1996, 33 USC §2213(c)(7), the non-federal share of the implementation costs for ecosystem restoration/protection projects will be 35% of the project. The non-federal share includes PED, implementation, construction management, engineering during construction (EDC), and project management costs. The non-federal sponsor must provide 100% of the LERRDs and OMRR&R. The value of LERRDs shall be included in the non-federal 35% share.

Table 9-2 Summary of NER Estimated Project First Costs

Item	Estimated Total Cost[a]
01 Lands and Damages[b] LERRDs	$200,000
06 Fish and Wildlife Facilities Structural[c]	$223,900,000
30 Planning, Engineering, and Design[d]	$37,000,000
31 Construction Management[e]	$14,300,000
Total Implementation Cost	$275,400,000

[a] All costs presented at a 2016 price level and discounted using the FY17 Federal Discount Rate (FDR) of 2.875%.
[b] LERRDS subject to change pending results of Phase II Environmental Site Assessment.
[c] Structural costs are cost-shared 65% federal and 35% non-federal.
[d] Planning, engineering, and design are 17% of construction costs. Begins 2 years prior to construction and occurs over the 2 years until construction begins. 50% of PED costs allocated to PED year 1, and 50% allocated to PED year 2. Cost-shared 65% federal and 35% non-federal.
[e] Construction management is 5.5% of construction costs and occurs at same time as construction; cost-shared 65% federal and 35% non-federal.

Table 9-3 Cost Apportionment of NER

Contributor	Estimated Project First Costs[a]
NER Plan USACE (65%) Non-federal (35%)	 $179,000,000 $96,400,000
Total Federal Contribution	$179,000,000
Total Non-federal Contribution	$96,400,000
Cash	$96,200,000
LERRDs	$200,000
Total Implementation Cost	$275,400,000
Nonstructural Measures (Average Annual Cost)[b]	
Federal USACE Other federal agencies	 $130,000 $11,110,000
Non-federal	$70,000
OMRR&R (Average Annual Cost)[c] USACE Non-federal	 $260,000 $7,950,000

[a] All costs presented at a 2016 price level and discounted using the FY17 Federal Discount Rate (FDR) of 2.875%.

[b] For nonstructural measures costs, USACE's portion (e.g., monitoring) pertains to monitoring of the control point. That yearly estimate will be cost-shared 65% federal and 35% non-federal.

[c] OMRR&R costs are 100% federal for the flushing lock and 100% non-federal for the remaining alternative features.

The estimated project first costs for the National Ecosystem Restoration (NER) are summarized in Table 9-2. A breakdown of federal and non-federal contributions to the estimated project first cost for the NER is provided in Table 9-3.

Financial Capability of Non-federal Sponsor

Once a non-federal sponsor has been identified, they will need to certify in accordance with the CECW-PC Memorandum dated June 12, 2007, the non-federal sponsor's Self-Certification of Financial Capability, that they are aware of the financial obligations of the non-federal sponsor and have the financial capability to satisfy obligations for the project.

Chapter 10 Public Involvement*

10.1 GLMRIS Public Meetings

At the initiation of the GLMRIS effort, the GLMRIS PDT scoped the study to include the development of a recommended plan and an associated EIS under the NEPA. As part of that effort, a Notice of Intent (NOI) to prepare the GLMRIS Draft EIS was first published in the *Federal Register* on November 16, 2010, and a subsequent notice on February 14, 2011, announced additional NEPA public scoping meetings. The NOIs invited interested members of the public to provide comments on the scope and objectives of the EIS, including identification of issues and alternatives that should be considered in the EIS analysis.

Public scoping meetings were held to solicit comments on the GLMRIS project from the public at 12 locations within the GLB and MRB. These meetings occurred between December 2010 and March 2011. Dates and locations of the public scoping meetings are listed in Table 10-1. During the scoping period, the public was provided with several methods for submitting comments or suggestions, including via an online comment form on the project website, through standard mail, or in person at the public meetings, either by testifying or submitting written comments. The public scoping comment period started with the publication of the first NOI November 16, 2010, and ended March 31, 2011.

Table 10-1 Locations and Dates for GLMRIS Public Scoping Meetings

City	Date	Location
Chicago, Illinois	December 15, 2010	University of Chicago, Gleacher Center
Buffalo, New York	January 11, 2011	Buffalo Conference Center, Hyatt Regency
Cleveland, Ohio	January 13, 2011	Great Lakes Science Center
Minneapolis, Minnesota	January 20, 2011	University of Minnesota, McNamara Alumni Center
Green Bay, Wisconsin	January 25, 2011	NE Wisconsin Technical College, Center for Business & Industry
Traverse City, Michigan	January 27, 2011	Northwestern Michigan College, Hagerty Conference Center
Cincinnati, Ohio	February 1, 2011	University of Cincinnati, Tangeman Center
St. Louis, Missouri	February 8, 2011	Great Lakes River Museum, Alton, Illinois
Vicksburg, Mississippi	February 10, 2011	Vicksburg Convention Center
Milwaukee, Wisconsin	February 15, 2011	O'Donnell Park Complex, Miller Room
New Orleans, Louisiana	February 17, 2011	Port of New Orleans Administration Building
Ann Arbor, Michigan	March 18, 2011	Eagle Crest Conference Center, Ypsilanti, Michigan

Public comments were gathered and displayed on the GLMRIS project website, glmris.anl.gov. A report summarizing the NEPA scoping effort, titled *Great Lakes and Mississippi River Interbasin Study Environmental Impact Statement Scoping Summary Report* (USACE 2011c), is also available online.

The GLMRIS Report (USACE 2014a) was submitted to Congress on January 6, 2014, including the Senate Committee on Environment and Public Works, the House Committee on Transportation and Infrastructure, and the Senate and House Committees on Appropriations. A briefing for members of Congress and their staffs was held on January 6, 2014, by conference call, and a follow-up question-and-answer session was held in Washington, D.C., on January 8, 2014.

USACE invited the public to comment on the alternatives presented in the GLMRIS Report via an online comment form on the project website, through standard mail, or in person at the public meetings, either by testifying or submitting written comments. The public comment period began January 6, 2014, with the release of the GLMRIS Report and ended March 31, 2014. In January and February 2014, the USACE held 11 public meetings at key locations within the study area. Dates and locations of the public meetings are listed in Table 10-2.

Public comments were gathered and displayed on the GLMRIS project website, glmris.anl.gov. A report summarizing the public review effort, titled *Great Lakes and Mississippi River Interbasin Study GLMRIS Report Public Comment Summary* (USACE 2014c), is also available online.

Table 10-2 Locations and Dates for GLMRIS Public Review Meetings

City	Date	Location
Chicago, Illinois	January 9, 2014	University of Chicago, Gleacher Center
Milwaukee, Wisconsin	January 13, 2014	Milwaukee Area Technical College
Cleveland, Ohio	January 16, 2014	Cleveland Public Library
Ann Arbor, Michigan	January 21, 2014	University of Michigan League
Traverse City, Michigan	January 23, 2014	Northwestern Michigan College, Hagerty Conference Center
Erie, Pennsylvania	January 24, 2014	Erie County Library
Twin Cities, Minnesota	January 27, 2014	Refuge Headquarters and Bloomington Education & Visitor Center
St. Louis, Missouri	January 30, 2014	National Great Lakes Rivers Museum, Alton, Illinois
New Orleans, Louisiana	January 31, 2014	USACE-MVN District Assembly Room A
Northwest Indiana	February 11, 2014	Northwest Indiana Planning Commission Auditorium, Portage, Indiana
Buffalo, New York	February 13, 2014	Buffalo Central Library Auditorium

10.2 Brandon Road Scoping Meetings

An NOI to prepare a Draft EIS to evaluate the impacts of a range of potential structural and nonstructural ANS controls near the BRLD was initially published in the *Federal Register* on November 20, 2014, and a subsequent notice on January 5, 2015, announced an additional public meeting in New Orleans and extended the comment period. The NOIs invited interested members of the public to provide comments on the scope of the Draft EIS, including identification of issues and alternatives (ANS control technologies) that should be considered in the EIS analysis.

Public scoping meetings were held to solicit comments on the GLMRIS-BR from the public at three locations with the GLB and MRB. These meetings occurred between December 2014 and January 2015. Dates and locations of the public scoping meetings are listed in Table 10-3. During the scoping period, the public was provided with several methods for submitting comments or suggestions, including via an online comment form on the project website, through standard mail, or in person at the public meetings, either by testifying or submitting written comments. The public scoping comment period started with the publication of the first NOI November 20, 2014, and ended January 30, 2015.

Public comments were gathered and displayed on the GLMRIS-BR project website, glmris.anl.gov/Brandon-rd/. A report summarizing the NEPA scoping effort, titled *GLMRIS–Brandon Road EIS Scoping Summary Report* (USACE 2015e), is also available online.

10.3 Mooring Location Scoping

In 2016, USACE acknowledged that mooring cells may be required to facilitate navigational traffic if an alternative with an electric barrier were implemented at BRLD. The BR Lock chamber is 600 ft (182 m) in length, and navigation tows longer than the lock must split apart to pass through the lock. Currently, tows split along upper and lower guidewalls adjacent to the BR Lock chamber. If an alternative with an electric barrier were to be implemented, tows moving upstream toward Lake Michigan may cut farther downstream in a mooring area due to the changed conditions in the approach channel.. The proposed mooring location would be downstream of BRLD between IWW RM 276 and 285. The proposed mooring location would potentially need to be dredged to provide adequate depth for tows. Dredge material would be moved to a temporary placement site for dewatering on the right descending bank, downstream of BRLD between IWW RM 285.1 and 285.5.

An Investigation of the Submerged Historic Properties in the Upper Mississippi River and Illinois Waterway, dated October 1997 (Contract Number DACW25-93-D-0-012, Order No. 27), and The Historic Properties Management Plan for the Illinois Waterway System, Rock Island District, Corps of Engineers, Volumes I and II, dated February 1999 (Contract Number DACW25-93-D-0014, Order No. 0021), are two reports that focus on historic properties potentially affected by this project and were reviewed for information on the proposed mooring location. It is the opinion of USACE that no known

Table 10-3 Locations and Dates for GLMRIS-BR Public Scoping Meetings

City	Date	Location
Lemont, Illinois	December 6, 2014	Argonne National Laboratory, Building 240
Chicago, Illinois	December 9, 2014	University of Chicago, Gleacher Center
New Orleans, Louisiana	January 8, 2015	USACE New Orleans District Office

historic shipwrecks are located within this reach of the Des Plaines River in the IWW. The proposed temporary dredged material placement site, Tract 3 (Figure 10-1), has been previously coordinated with the Illinois SHPO. Refer to Section 4.5.1, Cultural and Historic Resources, GLMRIS-BR Illinois Waterway Study Area, for a detailed discussion of this prior coordination.

More than 230 interested and consulting parties from a Distribution List were contacted via letter dated August 29, 2016 (Appendix K Coordination). Interested and consulting parties were given 30 days to provide comments on the mooring location scoping letter. A total of 16 response letters were received (Appendix K Coordination). Letters received were primarily from the navigation industry and expressed the following concerns:

- Several navigation stakeholders are opposed to the implementation of an electric barrier in the BR Lock approach channel, citing safety concerns for crew members; increased congestion, delay times, and cost to shippers because of new restrictions on tow configurations; higher fuel consumption and air emissions in the local region if waterway traffic is diverted to land routes; and impacts on the regional and national economies; as well as other concerns.

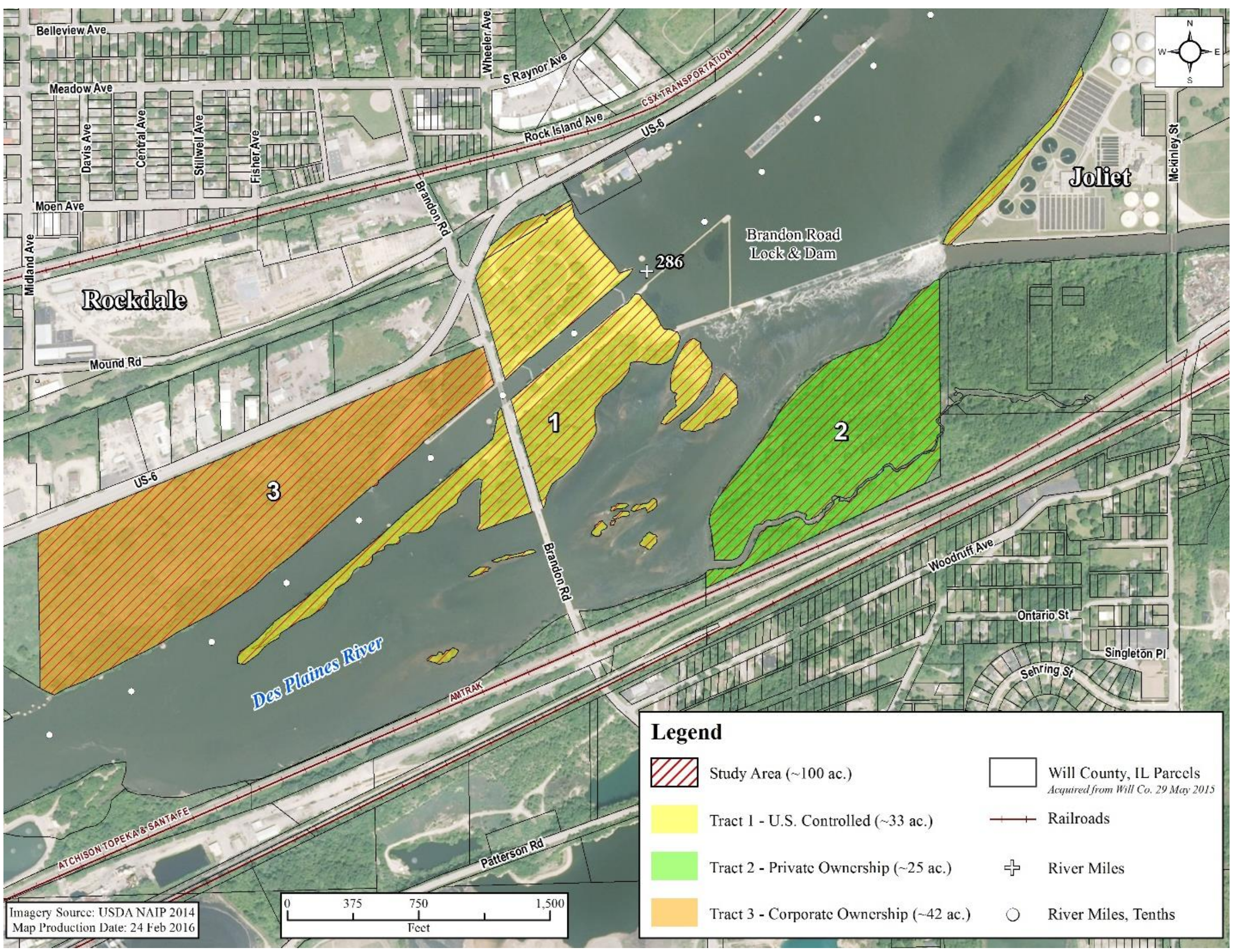

Figure 10-1 Parcels within the Vicinity of the GLMRIS-BR Site-Specific Study Area

- Several navigation stakeholders are concerned that the proposed mooring location would not be sufficient to alleviate the congestion, delay times, and associated costs imposed by implementation of an alternative with an electric barrier at BRLD.

10.4 State Coordination on Consequence Assessment

To better understand the labor and monetary expenditures associated with Bighead and Silver Carp establishment, questionnaires were sent to and interviews were conducted with the state environmental agencies of Wisconsin, Ohio, New York, Pennsylvania, Indiana, and Minnesota, as well as the Government of Canada and the Province of Ontario. Information was requested on whether the states had developed management plans for existing Bighead and Silver Carp populations in their states and whether they had response plans if Bighead and Silver Carp were to establish in the GLB. They were also asked to describe the contents of these plans and estimate the associated costs. For a summary of the information collected, refer to Section 5.3.8 New Increased Bighead and Silver Carp Management Expenditures in U.S. and Canada.

10.5 Navigation Safety Workshop

On August 8, 2016, a Navigation Safety Workshop was hosted at the Will County, Illinois, Office Building. Participants included professionals within the navigation industry and representatives of multiple agencies. The workshop was organized to discuss the GLMRIS-BR alternatives, specifically those with the electric barrier measure. In light of safety issues associated with navigation in the vicinity of the CSSC electric barrier and USCG regulation of the waterway in the vicinity of these electric barriers, input was sought about the safety and operational concerns related to navigating through a continuous electric barrier in the approach channel downstream of BRLD.

The discussion centered around the proximity of the electric barrier and the importance of having crew members on the head of the vessel to help the captain navigate into the approach channel and lock. Additional topics included the navigation impact of the construction of the technology alternatives and the proposed location of a new mooring location. Questions were also answered relating to the locations of the electric barrier included in two of the technology alternatives.

The gathered information helped support the qualitative discussion of impacts, particularly those that may affect the safety of navigation personnel. The workshop was intended to obtain the navigation communities' concerns about operations and safety concerns related to navigating through an electric barrier in the downstream approach channel of the BR Lock.

10.6 Brandon Road Public Meetings on the Draft EIS

This section will be furnished after the public meetings are held during the review of the Draft EIS.

10.7 Distribution List for Draft Report/EIS

This section will be furnished after the draft report is released for public review.

10.8 Public Comments on the Draft EIS

This section will be furnished after the public input generated from the review is analyzed.

10.9 Interagency Coordination

USACE initiated coordination and consultation with USFWS, under the FWCA, in 2015 (which is also the date of the Scope of Work). As part of this coordination and consultation for the GLMRIS-BR feasibility study, the USFWS hosted two meetings with interested state fish and wildlife agencies in September 2015 and January 2016. In addition, two Planning Aid Letters (PALs) were provided by USFWS to USACE on October 30, 2015, and March 31, 2016. A Draft FWCA Report was provided to USACE September 16, 2016, and a Final FWCA Report is expected in January 2017.

10.10 Internet and Social Media

The identification and engagement of nongovernmental and community stakeholders who are interested in the GLMRIS and the GLMRIS-BR effort are critical aspects of the overall study effort. In addition to the NEPA scoping effort, the GLMRIS-BR PDT continued to actively organize and participate in stakeholder meetings in an effort to promote coordination among agency groups, as well as among the public, nongovernmental organizations, and other project stakeholders. USACE primarily engaged and communicated with stakeholders via a strong online and social media presence. The GLMRIS-BR PDT established a dedicated website, glmris.anl.gov/Brandon-rd/, to capture study activities and inform stakeholders, and cultivated a regular presence on social media sites including Facebook (GLMRIS–Government Organization) and Twitter (@GLMRIS).

10.11 Established Stakeholder Groups

10.11.1 Asian Carp Regional Coordinating Committee

Because of heightened concern about Asian carp in the Great Lakes, the ACRCC, comprising U.S. and Canadian federal, state, provincial, and local agencies (Table 10-4), was formed in 2009. Members of the ACRCC work collaboratively to bring their particular authorities and knowledge together to reduce the threat of Asian carp establishment in the Great Lakes.

ACRCC develops the Asian Carp Control Strategy Framework to document actions already undertaken and to identify potential courses of action to be implemented in both the near and short term. Through the framework, the ACRCC coordinates the planning and execution of projects for its members to prevent the introduction and establishment of Asian carp populations in the Great Lakes. ACRCC provides oversight and coordination of multijurisdictional short- and long-term prevention activities. The primary objectives of the ACRCC include the following efforts:

- Promote collection of biological information on Asian carp, their impacts, and preferred habitats to better understand the species and their biological and ecological requirements.

- Identify additional research, technology, and data needs to effectively inform and support Asian carp management strategies.

- Support the development of technologies and methods that will result in the control and management of Asian carp and in the transferability of these new tools for use in the control of other invasive species, where possible.

Table 10-4 Federal, State, and Local Agencies and Other Private Stakeholder Entities That Are Part of ACRCC

Federal		
Council on Environmental Quality	U.S. Coast Guard	U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service	U.S. Geological Survey	National Oceanic and Atmospheric Administration
U.S. Department of Transportation	U.S. Environmental Protection Agency	
State		
Illinois Department of Natural Resources	Illinois Environmental Protection Agency	Indiana Department of Natural Resources
Michigan Department of Natural Resources	Michigan Department of Environmental Quality	Minnesota Department of Natural Resources
New York Department of Environmental Conservation	Ohio Department of Natural Resources	Pennsylvania Department of Environmental Protection
Pennsylvania Fish & Boat Commission	Wisconsin Department of Natural Resources	
Local		
City of Chicago	Metropolitan Water Reclamation District of Greater Chicago	
Binational		
Great Lakes Fishery Commission		
Canada		
Fisheries and Oceans Canada	Ontario Ministry of Natural Resources	Quebec's Ministry of Sustainable Development, Environment, Wildlife and Parks

- Encourage the exchange of information among member agencies and stakeholders, and seek opportunities to transfer technologies developed as part of the framework to other areas of the United States and Canada. Work under this objective by ACRCC fulfills the coordination and notification requirements of the United States–Canada GLWQA.

- Develop the comprehensive framework (completed), and annually coordinate the development of potential projects for inclusion in the framework.

- Coordinate implementation and evaluation of the effectiveness of collaborative Asian carp assessment, prevention, and control measures, as described in this framework.

The framework is designed to establish the need for participating agencies to act urgently to apply full authorities, capabilities, and resources to prevent Asian carp from becoming established in the

Great Lakes; to integrate and unify the impending actions of the participating agencies; and to facilitate cooperation by additional agencies. It also serves to identify lead agencies for particular actions. The most recent framework is available on the ACRCC website, http://www.asiancarp.us.

10.11.2 Monitoring and Response Workgroup

The Monitoring and Response Workgroup (MRWG) was established by ACRCC and is co-led by the Illinois DNR and GLFC. Guided by the ACRCC Framework, the MRWG was assigned the task of developing and implementing a Monitoring and Response Plan for Asian carp that were present or could gain access to the CAWS. The Monitoring and Response Plan has been released annually since the establishment of the MRWG in 2010. In addition, the MRWG releases annually an interim summary report document that contains preliminary results and analysis of actions completed for each project described in the Monitoring and Response Plan. The most recent Monitoring and Response Plan, as well as the most recent Interim Summary Report, is available on the ACRCC website, http://www.asiancarp.us.

10.11.3 CAWS Advisory Committee

The CAWS Advisory Committee is a multistakeholder advisory committee comprising 41 agencies and organizations (Table 10-5). The committee is assigned the task of identifying short-term and long-term mechanisms in the CAWS for preventing the transfer of aquatic invasive species (especially Asian carp) between the Great Lakes and the Mississippi River. Objectives of the CAWS Advisory Committee are as follows:

- Participate in the evaluation, refinement, and improvement of long-term solutions, such as those presented in the GLMRIS and *Restoring the Natural Divide* reports, to stop the interbasin transfer of invasive species while maintaining or improving water quality, transportation, recreational uses, and flood protection, and to develop an implementation strategy for those solutions determined to be viable; and

- Encourage and participate in the development of partnerships for multijurisdictional and cross-sector cost-sharing.

10.11.4 The Great Lakes and St. Lawrence Cities Initiative

The Great Lakes and St. Lawrence Cities Initiative is a binational coalition of more than 110 U.S. and Canadian mayors and local officials working to advance the protection and restoration of the Great Lakes and St. Lawrence River. The Cities Initiative and local officials integrate environmental, economic, and social agendas and sustain a resource that represents approximately 20% of the world's surface freshwater supply, provides drinking water for 40 million people, and is the foundation upon which a strong regional economy is based. Members of the Cities Initiative work together and with other levels of government and stakeholders to improve infrastructure, programs, and services and increase investments that protect and restore this globally significant freshwater resource. The Cities Initiative works with mayors and municipal staffs to protect and preserve the Great Lakes and St. Lawrence region at the local, regional, and basin-wide levels.

10.11.5 Great Lakes Fishery Commission

The 1954 Convention on Great Lakes Fisheries, which created the GLFC, was created from a strong need to work together across borders not only to combat sea lampreys but also to promote science and establish working relationships among the players. The commission consists of four Canadian commissioners

Table 10-5 Agencies and Organizations of the CAWS Advisory Committee

CAWS Advisory Committee		
Alliance for the Great Lakes	Illinois Farm Bureau	Northwest Indiana Forum
American Waterways Operators	Illinois International Port District	Northwestern Indiana Regional Planning Commission
Chemical Industry Council of Illinois	Illinois River Carriers Association	Ontario Federation of Anglers and Hunters
Chicago Metropolitan Agency for Planning	Lake Erie Charter Boat Association	Passenger Vessel Association & Wendella Sightseeing
Council of Great Lakes Industries	Metropolitan Mayors Caucus	Prairie Rivers Network
Environmental Law and Policy Center	Metropolitan Planning Council	Save the Dunes
Friends of the Chicago River	Metropolitan Water Reclamation District of Greater Chicago	Sierra Club–Illinois Chapter
General Iron Industries, Inc.	Mississippi Interstate Cooperative Resource Association	Illinois Department of Transportation
Great Lakes and St. Lawrence Cities Initiative	Mid-West Truckers Association	Illinois Environmental Protection Agency
Great Lakes Commission	National Wildlife Federation	Indiana Department of Transportation
Great Lakes Panel on Aquatic Nuisance Species	Natural Resources Defense Council	U.S. Army Corps of Engineers
Great Lakes Sport Fishing Council	The Nature Conservancy	U.S. Department of Transportation
Healing Our Waters–Great Lakes Coalition	Northeast Ohio Mayors & City Managers Association	White House Council on Environmental Quality
Illinois Chamber of Commerce		

appointed by the Privy Council and four U.S. commissioners (plus one alternate) appointed by the President. The commissioners are supported by a secretariat, located in Ann Arbor, Michigan. The convention charges the commission with five major duties:

- Develop a binational research program aimed at sustaining Great Lakes fish stocks;
- Coordinate or conduct research consistent with that program;
- Recommend measures to governments that protect and improve the fishery;
- Formulate and implement a comprehensive sea lamprey control program; and
- Publish or authorize publication of scientific and other information critical to sustaining the fishery.

The convention also includes a clause mandating the commission to establish “working arrangements” among governments to ensure multijurisdictional fishery management. The commission thus became a focal point for cooperative Great Lakes fishery management, although it was designed specifically to not supersede existing state or provincial management authority.

The commission formulates its program based on advice from several research and management committees, comprising scientists, fishery managers, and academic experts. In addition, the commission receives advice from the Committee of Advisors, made up of citizens from Canada and the United States. Sea lamprey control is implemented in partnership with USFWS, Fisheries and Oceans Canada, and USACE. Research is conducted in cooperation with the USGS; state, provincial, and tribal authorities; and universities.

Since 1954, the GLFC has ensured an ongoing, robust working relationship between Canada and the United States for the benefit of the fishery and the millions of citizens who depend on the resource for food, subsistence, recreation, and income.

10.11.6 Mississippi Interstate Cooperative Resource Association

The Mississippi Interstate Cooperative Resource Association (MICRA) is an organization of 28 state natural resource departments organized in 1991 as a partnership to improve management of interjurisdictional fish and other aquatic resources in the MRB. The MICRA states have identified more than 90 interjurisdictional rivers within the MRB. Interjurisdictional fisheries and other aquatic resources of the MRB are cooperatively managed by regional partnerships developed around multiple subbasins. These partnerships work together through MICRA to achieve cooperative management of aquatic resources throughout the MRB.

MICRA's mission is to improve the conservation, management, development, and utilization of interjurisdictional fishery resources (both recreational and commercial) in the MRB through improved coordination and communication among the responsible management entities. MICRA has the following goals:

- Develop a formal framework and secure funding for basin-wide networking and coordinating mechanisms that complement existing and emerging administrative entities;
- Develop public information and education programs to disseminate information that supports fishery resource management in the MRB;
- Develop an information management program based on standardized methods for collecting and reporting fishery resource data, basin-wide;
- Determine and document the socioeconomic value of fishery resources and related recreation;
- Improve communication and coordination among entities responsible for fisheries resource management in the MRB;
- Periodically identify and prioritize issues of concern in the MRB for coordinated research that supports cooperative resource management;
- Identify and coordinate fishery management programs to address species and habitat concerns from an ecosystem perspective;
- Develop compatible regulations and policies for fishery management to achieve interstate consensus on allocation of fishery resources;

- Develop protocols, policies, and regulations for disease control, introduction of exotics, maintenance of genetic integrity, and maintenance and enhancement of indigenous species; and

- Preserve, protect, and restore fishery habitats basin-wide.

Chapter 11 Recommendation

The District Commander has considered all the significant aspects of this study, including the environmental, social, and economic effects; the engineering feasibility; and the comments received from other resource agencies and the public, and has determined that the Technology Alternative – Complex Noise with Electric Barrier presented in this report is in the overall public interest and a justified expenditure of federal funds. The project includes construction of a structural control point and annual nonstructural measures. The Project First Cost for construction of the structural control point is estimated to be $275,300,000 inclusive of associated investigation, environmental, engineering and design, construction, supervision and administration, and contingency costs. The average annual cost for nonstructural measures is estimated to be $11,300,000 per year. The recommended project includes the continuing evaluation and implementation of options and technologies that improve the efficacy of the ANS control measures implemented at BRLD. This process would be similar to the CSSC-EB efficacy study [Section 3061(b)(1)(D) of WRDA 2007] and implementation authority in Section 1039(c) of the WRRDA of 2014, Public Law 113-121.

Federal implementation of the recommended project would be subject to the existing statutory requirements regarding nonfederal sponsor responsibilities, including but not limited to the following:

a. Provide 35% of total project costs as further specified below:

    1. Provide 35% of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

    2. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material – all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

    3. Provide, during construction, any additional funds necessary to make its total contribution equal to 35% of total project costs;

b. Shall not use funds from other federal programs, including any nonfederal contribution required as a matching share therefore, to meet any of the nonfederal obligations for the project unless the federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments), such as any new developments on project lands, easements, and rights-of-way or the addition of facilities that might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project’s proper function;

d. Shall not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

e. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 USC §§4601–4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons or applicable benefits, policies, and procedures in connection with said act;

f. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the Federal Government;

g. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the nonfederal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

h. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

i. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 yr after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR §33.20;

j. Comply with all applicable federal and state laws and regulations, including, but not limited to Title VI of the Civil Rights Act of 1964, Public Law 88-352 (42 USC §2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 USC §6102); the Rehabilitation Act of 1973, as amended (29 USC §794), and Army Regulation 600-7 issued pursuant thereto; and all applicable federal labor standards requirements including, but not limited to, 40 USC §§3141–3148 and 40 USC §3701–3708 (revising, codifying, and enacting without substantial change the provisions of the Davis-Bacon Act [formerly 40 USC §276a, et seq.]), the Contract Work Hours and Safety Standards Act (formerly 40 USC §327, et seq.), and the Copeland Anti-Kickback Act (formerly 40 USC §276c, et seq.);

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 95-510, as amended

(42 USC §§9601–9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the nonfederal sponsor with prior specific written direction, in which case the nonfederal sponsor shall perform such investigations in accordance with such written direction;

l. Assume, as between the Federal Government and the nonfederal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

m. Agree, as between the Federal Government and the nonfederal sponsor, that the nonfederal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 USC §1962d-5b), and Section 103(j) of the WRDA of 1986, Public Law 99-662, as amended (33 USC §2213[j]), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each nonfederal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The recommendation contained herein reflects the information available at this time, 2016 price levels, and current USACE policies governing the formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program, nor the perspective of higher levels of review within the Executive Branch. Consequently, the recommendation may be modified before being transmitted to the Congress as proposals for authorization and/or implementation funding.

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Chapter 13 PDT Members and Report Preparers

Table 13-1 List of Report Preparers

Name	Discipline/Expertise	Organization	Role
Dena Abou	Economics	USACE	Feasibility/EIS Preparation
Jason Appel	Real Estate	USACE	Feasibility/EIS Preparation
Nick Barkowski	Biology/Planning	USACE	Feasibility/EIS Preparation
Ken Barr	Environmental/Cultural	USACE	Feasibility/EIS Preparation; Reviewer
John Behrens	Mechanical Engineer	USACE	Engineering Documents
Mellie Billingsley	Office of Counsel	USACE	Feasibility/EIS Preparation; Reviewer
Chris Bouquot	Economics	USACE	Navigation Analysis
Kirsten Brown	Project Management	USACE	Feasibility/EIS Preparation
Mark Cornish	Biology/Planning	USACE	Feasibility/EIS Preparation; Reviewer
Susanne Davis	Plan Formulation	USACE	Feasibility/EIS Preparation; Reviewer
Ronald Deiss	Cultural Resources	USACE	Feasibility/EIS Preparation
Michelle Dojutrek	Planning	USACE	Feasibility Preparation/Feasibility
Kelly Granberg	Environmental	USACE	Feasibility/EIS Preparation
Justin Griffeth	Engineering	USACE	Feasibility/EIS Preparation
Allen Hammack	Research	USACE-ERDC	Feasibility/EIS Preparation
Jeff Heath	Programs Management	USACE	Feasibility Preparation
Shawna Herleth-King	Biology/Planning	USACE	Feasibility/EIS Preparation
Kathryn Herzog	Biology/Planning	USACE	Feasibility/EIS Preparation
Craig Hess	Operations	USACE	Feasibility/EIS Preparation
Toby Hunemuller	Hydrology and Hydraulics	USACE	Feasibility/EIS Preparation
Fred Joers	Engineering	USACE	Feasibility/EIS Preparation
Perry Jones III	Operations	USACE	Technical Assistance
Felicia Kirksey	Project Management	USACE	Feasibility/EIS Preparation
Amy Kryston	Engineering	USACE	Feasibility/EIS Preparation
Zach Langel	Engineering	USACE	Engineering Documents
Andrew Leichty	Project Management	USACE	Feasibility Preparation
Erin Maloney	Hydrology and Hydraulics	USACE	Feasibility/EIS Preparation
Jennifer Miller	Environmental/HTRW	USACE	Feasibility/EIS Preparation
Julie Millhollin	Project Management	USACE	Feasibility/EIS Preparation
Rana Mishra	Cost	USACE	Engineering Documents

Table 13-1 (Cont.)

Name	Discipline/Expertise	Organization	Role
Marshall Plumley	Plan Formulation	USACE	Feasibility/EIS Preparation; Reviewer
Johnna Potthoff	Plan Formulation	USACE	Feasibility/EIS Preparation
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Chapter 14 Acronyms

ac	acre(s)
AC	alternating current
ACHP	Advisory Council on Historic Preservation
ACRCC	Asian Carp Regional Coordinating Committee
ANS	Aquatic Nuisance Species
ANSTF	Aquatic Nuisance Species Task Force
APE	Area of Potential Effect
APHIS	Animal and Plant Health Inspection Service
Argonne	Argonne National Laboratory
ASA	American Sportfishing Association
AWO	American Waterway Operators
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
BR	Brandon Road
BRLD	Brandon Road Lock and Dam
°C	degree(s) Celsius
CAA	Clean Air Act
Cal-Sag	Calumet-Saganashkee
CAWS	Chicago Area Waterway System
CDF	Cumulative Distribution Functions
CE/ICA	Cost-Effectiveness and Incremental Cost Analysis
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
cm	centimeter(s)
cms	cubic meter per second
CND	Canadian National Dollar
CO	carbon monoxide
CO_2	carbon dioxide
CORA	Chippewa Ottawa Resource Authority
CPUE	catch per unit effort
CSO	combined sewer overflow
CSSC	Chicago Sanitary and Ship Canal
CSSC-EB	Chicago Sanitary and Ship Canal Electric Barriers
CTA	Chicago Transportation Authority
CUP	Chicago Underflow Plan
CWA	Clean Water Act
DC	direct current
DEM	Department of Environmental Management
DIDSON	dual frequency identification sonar
DNR	Department of Natural Resources
DO	dissolved oxygen
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DOS	U.S. Department of State
DOT	U.S. Department of Transportation
DOW	Division of Wildlife

E.O.	Executive Order
E.R.	Engineering Regulation
EA	Environmental Assessment
EB	Electric Barrier
EDC	Engineering during Construction
eDNA	environmental deoxyribonucleic acid
EIS	Environmental Impact Statement
EOP	environmental operating principles
EPA	U.S. Environmental Protection Agency
ERDC	U.S. Army Engineer Research and Development Center
°F	degree(s) Fahrenheit
FERC	Federal Energy Regulatory Commission
FRA	Federal Railroad Administration
FS	Feasibility Study
ft	foot (feet)
FTE	full-time equivalent
ft/s	feet per second
FWCA	Fish and Wildlife Coordination Act
FWCAR	Fish and Wildlife Coordination Act Report
FWOP	Future without Project
FWP	Future with Project
FY	Fiscal Year
GHG	greenhouse gas
GHz	gigahertz
GIS	geographic information system
GLB	Great Lakes Basin
GLC	Great Lakes Commission
GLERL	Great Lakes Environmental Research Laboratory
GLFC	Great Lakes Fishery Commission
GLFER	Great Lakes Fishery and Ecosystem Restoration
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GLMRIS-BR	Great Lakes and Mississippi River Interbasin Study – Brandon Road
GLNS	Great Lakes Navigation System
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
GRTS	Grants Reporting and Tracking System (EPA)
ha	hectare(s)
HAER	Historic American Engineering Record
HQUSACE	Headquarters of the U.S. Army Corps of Engineers
HTRW	hazardous, toxic, and radioactive waste
hr	hour(s)
Hz	hertz
I&M	Illinois and Michigan
IBA	important bird area
IBM	individual based models
IEPA	Illinois Environmental Protection Agency
IGLD	International Great Lakes Database
IHPA	Illinois Historic Preservation Agency
IJC	Illinois Joint Commission
in.	inch(es)
INHS	Illinois Natural History Survey

IPM	integrated pest management
ISAC	Invasive Species Advisory Committee
IJC	Illinois Joint Commission
in.	inch(es)
INHS	Illinois Natural History Survey
IRN	Illinois River Basin
ISAC	Invasive Species Advisory Committee
ISLT	Invasive Species Leadership Team
$IWFS_O$	in-water field strength
IWW	Illinois Waterway
kg	kilogram(s)
km	kilometer(s)
km^2	square Kilometer(s)
$KMnO_4$	potassium permanganate
L	liter(s)
lb.	pound(s)
LCA	Lock Closure Alternative
LD	Lock and Dam
LERRD	lands, easements, rights-of-way, relocations, and disposal areas
LPMS	Lock Performance Monitoring System
m	meter(s)
MAP-21	Moving Ahead for Progress in the 21st Century Act
MARAD	Maritime Administration
mg	milligram(s)
MHz	megahertz
mi	mile(s)
mi^2	square mile(s)
MICRA	Mississippi Interstate Cooperative Resources Association
mm	millimeter(s)
mm Hg	millimeters of mercury (standard atmospheric pressure)
MOU	Memorandum of Understanding
MRB	Mississippi River Basin
MRP	Monitoring and Response Plan
MRWG	Monitoring and Response Workgroup
ms	millisecond(s)
MSC	Major Subordinate Command
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NAAQS	National Ambient Air Quality Standards
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NAWQA	National Water-quality Assessment
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NGO	nongovernmental organizations
NHPA	National Historic Preservation Act
NIH	Northern Illinois Hydropower
NIM	navigation investment model
NISA	National Invasive Species Act
NISC	National Invasive Species Council
NLCD	national land cover data
NNFA	No New Federal Action

NO_2	nitrogen dioxide
NOI	notice of intent
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrous oxides
NOAA-GLERL	National Oceanic and Atmospheric Administration-Great Lakes Environmental Research Laboratory
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	*National Register of Historic Places*
NSA	Nonstructural Alternative
O&M	operation and maintenance
OASA(CW)	Office of the Assistant Secretary of the Army (Civil Works)
OEC	Ohio-Erie Canal
OFAH	Ontario Federation of Anglers and Hunters
OMB	Office of Management and Budget
OMRR&R	operation, maintenance, repair, rehabilitation, and replacement
OASA(CW)	Office of the Assistant Secretary of the Army (Civil Works)
P(Arrival)	probability of arrival
P(Colonization)	probability of colonization
P(Establishment)	probability of establishment
P(Passage)	probability of passage
P(Pathology)	probability of pathology
P(Spread)	probability of spread
P.L.	Public Law
PAL	Planning Aid Letter
Pb	lead
PAL	Planning Aid Letter
P.L.	Public Law
PCB	polychlorinated biphenyl
PDT	Project Delivery Team
PED	preconstruction engineering and design
$PM_{2.5}$	particles 2.5 micrometers (μm) in diameter
PM_{10}	particles 10 micrometers (μm) in diameter
PPA	Project Partnership Agreement
ppb	parts per billion
ppm	parts per million
PSI	pollution standard index
R&D	research and development
RDC	Research and Development Center
RECONS	Civil Works Regional Economic System
RED	Regional Economic Development
RM	river mile
RNA	regulated navigation area
RRA	resource rich area
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SMART	specific, measurable, attainable, risk informed, and timely
SME	subject matter expert
SO_2	sulfur dioxide
TACN	Technology Alternative – Complex Noise
TACNEB	Technology Alternative – Complex Noise with Electric Barrier

TAEB	Technology Alternative – Electric Barrier
TARP	Tunnel and Reservoir Plan
TDS	total dissolved solids
TMDL	total maximum daily load
TNC	The Nature Conservancy
TSP	Tentatively Selected Plan
TSS	total suspended solids
$\mu g/m^3$	microgram(s) per cubic meter
µm	micrometer(s)
UAA	use attainability analysis
UPS	uninterruptable power supply
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	volt(s)
VFD	variable frequency srive
VHS	viral hemorrhagic septicemia
V/in.	volts per inch
WAM	waterway analysis model
WPS	Wilmette Pumping Station
WQS	water quality standards
WRDA	Water Resources Development Act
WRP	Water Reclamation Plan
WRRDA	Water Resources Reform and Development Act
YOY	young-of-year

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