The GLMRIS Report

Great Lakes and Mississippi River Interbasin Study

USACE
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GLMRIS Report Executive Summary

The Great Lakes and Mississippi River Interbasin Study (GLMRIS) Report presents a comprehensive range of options and technologies available to prevent the interbasin transfer of aquatic nuisance species (ANS) between the Great Lakes and Mississippi River through aquatic pathways. The United States Corps of Engineers (USACE) pursued a structured study process to identify ANS of Concern, and then formulated and analyzed a suite of options and technologies to prevent transfer between the two basins, specifically within the Chicago Area Waterway System (CAWS) (Figure ES.1). The alternatives presented do not address ANS transfer via non-aquatic pathways. Nor do the alternatives address ANS transfer from beyond the study area boundaries, i.e., transfer via Canada, the St. Lawrence Seaway, or the Gulf of Mexico.

In recent years, successful invasions of ANS have severely impacted the economic and environmental resources of the Great Lakes and Mississippi River basins. Aquatic nuisance species threaten native plants and animals, reduce biodiversity, harm important terrestrial and aquatic ecosystems, degrade water quality, transport diseases, and result in economic, political, and social impacts. For these reasons, invasive species are of national and global concern. ANS populations span geographic and jurisdictional boundaries; thus, efforts to manage invasive species must be coordinated across watershed and jurisdictional boundaries. According to the National Invasive Species Council's 2008 Management Plan, the best defense against aquatic nuisance species is prevention, stemming the tide of new introductions.

Study Authority

GLMRIS was authorized by Section 3061(d) of the Water Resources Development Act of 2007 (WRDA 2007), Public Law 110-114. Specifically, the statute authorizes the Secretary of the Army (Secretary), 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 Great Lakes and the Mississippi River basins. This authority differs from a traditional USACE feasibility study authorization in that it directs the identification and assessment of a range of available options and technologies, rather than requiring the recommendation of a single plan.

In March 2009, Headquarters of USACE (HQUSACE) issued implementing guidance for Section 3061 of WRDA 2007. The implementation guidance directed that the study would include an analysis of the impacts associated with the implementation of any alternative plans on existing uses and users of the CAWS and an assessment of the need to mitigate for any such impacts.

In July 2012, the GLMRIS authority was modified by Section 1538 of the Moving Ahead for Progress in the 21st Century Act (MAP-21), Public Law 112-141. MAP-21 directs the Secretary to expedite the completion of the report for the study, and, if the Secretary determines a project is justified, to proceed directly to Preconstruction Engineering and Design (PED). MAP-21 also directs the Secretary to focus the report on the CAWS, and to include an analysis of hydrologic separation as a means to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River basins.

Figure ES.1 Focus Area 1: GLMRIS Report Chicago Area Waterway System (CAWS)

USACE had originally scoped the GLMRIS effort to result in a recommended plan and an associated Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA), 42 U.S.C.§ 4321 et seq., for completion in late 2015. Although not required by the study authority, the Secretary retains the discretion under the study authority to recommend a specific alternative. The enactment of MAP-21 compelled reevaluation of the breadth of the study, given the compressed timeline. As a result, USACE determined that sufficient time was not available to complete the detailed analyses, reviews, and coordination needed for selecting a recommended plan and completing an EIS. This Report does not include a NEPA analysis, because "planning and technical studies which do not contain recommendations for authorization or funding for construction, but may recommend further study" are categorically excluded from NEPA documentation requirements. See 33 C.F.R.§ 230.9 (d). NEPA compliance documentation, along with other additional detailed analyses and requirements, would need to be completed prior to USACE implementing a specific plan.

Per the MAP-21 authority, the GLMRIS Report focuses on the five direct connections of the CAWS between the Great Lakes and the Mississippi River basins. USACE evaluated all potential aquatic pathways between the Great Lakes and Mississippi River basins, and then divided them into two focus areas. Focus Area 1 consists of the aquatic pathways within the CAWS, which are the only continuous aquatic connections between the basins. Focus Area 2 includes all of the other potential aquatic pathways between the basins. A summary of current activities in Focus Area 2 can be found in Appendix N of the GLMRIS Report and on the GLMRIS website (http://glmris.anl.gov).

Description of the CAWS

The CAWS is a complex, multipurpose waterway that has many uses and users that developed to accommodate the needs of the City of Chicago as its population grew and economy expanded. Uses and users of the CAWS include, but are not limited to, stormwater management, effluent conveyance, water supply and discharge, emergency response vessels, commercial navigation, recreational boating, sport fishing, and power generation. The CAWS is operated by the *Metropolitan Water Reclamation District of Greater Chicago* (MWRD) primarily to accommodate stormwater and effluent conveyance and the USACE for the purpose of commercial and recreational navigation. A change in waterway conditions resulting from the implementation of a given alternative may require significant adaptation on the part of users of the CAWS and extensive change of system operations. Major users that rely upon the current configuration or conditions of the CAWS may face significant challenges in updating their infrastructure and management practices in order to meet new requirements.

What Is in the GLMRIS Report?

The GLMRIS Report presents "a range of options and technologies available" to prevent the transfer of ANS through aquatic pathways between the basins. The GLMRIS Report focuses on the aquatic connections between the Great Lakes and Mississippi River basins that are located within the CAWS. This report includes general information on effectiveness, impacts, and costs for each type of alternative that should be considered by a decision-maker.

The following objectives formed the basis for development of the GLMRIS Report alternatives:

GLMRIS Report Objectives

1. **Prevent Aquatic Nuisance Species Transfer** – Study the range of options and technologies available to prevent, by reducing the risk to the maximum extent possible, additional ANS transfer through the CAWS and other aquatic pathways between the Mississippi River and Great Lakes basins. 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.

2. **User and Resource Mitigation** – Address the need to mitigate impacts on significant natural resources and existing waterway uses and users as identified in GLMRIS Implementation Guidance, such as, commercial navigation, recreational navigation, stormwater management, and recreation.

The GLMRIS Report includes the following features and analyses:

- Study Goals, Objectives, Opportunities, and Constraints.
- Inventory of Baseline and forecast of Future Conditions for the Detailed Study Area.
- Baseline and Future without Project (FWOP) Conditions detailed assessment.
- Risk Assessment of ANS of Concern to support formulation of alternatives.
- Screening Criteria and Screened ANS Controls based on ANS of Concern for the CAWS.
- General description of range of alternatives, including the No New Federal Action Alternative.
- Location map(s) for each alternative.
- Conceptual design for each alternative and mitigation requirements.
- Cost estimate and Cost Risks Analyses for each alternative.
- General regulatory requirements and potential regulatory issues.
- Evaluation of alternatives.
- Status of Focus Area 2 studies.

What Is Not in the GLMRIS Report?

Although MAP-21 allows the Secretary to proceed to PED, if a plan is determined to be justified, additional technical investigation, policy evaluation, NEPA analysis, site-specific detailed design, and public and state/agency reviews would need to be accomplished prior to the recommendation of a specific alternative. The alternatives presented in the GLMRIS Report do not address ANS transfer via non-aquatic pathways, nor do they address ANS transfer beyond the study area boundaries, such as transfer via Canada, the St. Lawrence Seaway, or the Gulf of Mexico.

Specifically, the GLMRIS Report does not include:

- Site Specific Investigations and Analyses;
- Site Specific Designs;
- Detailed Drawings, Quantities, and Cost Estimates;
- Detailed evaluations of impacts and with-project mitigation requirements;
- Optimized designs for controls and any mitigation features;
- A Recommended Plan;

- Independent External Peer Review Report;
- USACE Planning Model Certification; and
- Completed NEPA compliance documentation.

GLMRIS Report Findings

The transfer of ANS between basins could result in significant environmental, economic, political, and social consequences. In recent years, successful invasions of ANS have severely impacted the economic and environmental resources of the Great Lakes and Mississippi River basins.

Each alternative is feasible and designed to meet the objectives stated in the Report. Each alternative presents a different strategy to prevent ANS transfer between the Great Lakes and Mississippi River basins through the CAWS aquatic pathways. This Report includes general information on effectiveness, impacts, and costs for each type of alternative that should be considered by a decision-maker.

GLMRIS is a unique study for USACE. While it focuses on a significant water resource issue, the geographic scope and complexity of this study are much greater than traditional studies. As a result, some elements of traditional water resources planning processes were incorporated into GLMRIS, but GLMRIS also includes the use of innovative planning methods, including the use of qualitative risk methods and SMART Planning tools and techniques that facilitated progress on the study. Further, because of the level of public interest, GLMRIS has included the release of interim products that represent portions of the baseline analyses completed for the study, as well as a very high level of stakeholder engagement. The GLMRIS Team included subject matter experts from across USACE and a fully integrated Agency Technical Review Team.

Through the planning process, the GLMRIS Team developed four strategies for preventing ANS transfer: Nonstructural; Technologies; Hydrologic Separation; and Combination of Technologies and Hydrologic Separation. From these strategies, a total of eight alternatives are presented in the GLMRIS Report, as briefly described below:

Alternative Plan 1: No New Federal Action – Sustained Activities

The No New Federal Action – Sustained Activities Alternative essentially describes the current and future actions of federal, state, and local agencies in combating ANS and serves as a comparison point for the remaining alternatives. This alternative assumes that all ongoing efforts supported by federal agencies discussed for the baseline and future-without-project conditions continue through the project planning horizon, which currently includes telemetry and eDNA for Asian carp and Research and Development of ANS Controls. For the purposes of this analysis and based on input from state and local agencies, it was assumed that ongoing state and local support for monitoring and response directed at Asian carp would continue for at least the next decade. This alternative also assumes the continued operation of the existing Electric Dispersal Barriers (Barrier IIA and Barrier IIB), construction and operation of new Permanent Electric Barrier I, and associated monitoring and response actions by USACE and others to support electric barrier operations. This alternative also assumes all other ANS education, outreach, monitoring, and prevention activities currently supported will continue.

Alternative Plan 2: Nonstructural

Nonstructural measures are ANS Controls that do not require implementation of structural features. The Nonstructural Alternative evaluated measures that: (1) may be implemented relatively quickly; (2) pose little or no risk to human health or safety; (3) would not require the construction of any type of infrastructure; (4) could act to stop or slow the arrival at and passage of at least some ANS; and (5) have been or are being currently implemented for other ANS elsewhere in North America, which would ensure the measure is consistent with U.S. laws and regulations.

This alternative contemplates activities that are not traditionally performed by USACE. To achieve the risk reduction produced by this alternative may require that these measures be implemented by other stakeholder groups such as other federal agencies, state agencies, local municipalities, and non-governmental organizations (NGOs). Nonstructural control technologies most effectively reduce risk of establishment for fish and plant ANS. All nonstructural measures identified are effective Best Management Practices capable of complementing other ANS Controls.

Examples of nonstructural control measures include removal (e.g., netting), chemical control (e.g., use of herbicides), controlled waterway use (e.g., inspection and cleaning of watercraft before or after entry to a water body), and educational programs.

Nonstructural measures have been included as part of each proposed structural alternative discussed below. This facilitates opportunities to enhance structural measures with targeted nonstructural measures. For example, in the alternatives that contain a CAWS Buffer Zone, nonstructural measures could be deployed in a rapid response action in the Buffer Zone, should they be necessary. Further, nonstructural alternatives could be implemented quickly, while remaining elements of a primarily structural plan were being designed and constructed.

Alternative Plan 3: Mid-System Control Technologies without a Buffer Zone

This strategy focused on maintaining the current operations of the CAWS with a minimal number of control points. This alternative includes nonstructural measures and two single point ANS Control technologies located at Stickney (IL) and Alsip (IL). These technologies reduce the risk of transfer of ANS between basins in both directions. Additionally, the nonstructural measures discussed above would also be implemented as part of this alternative.

At both Stickney (IL) and Alsip (IL), a new GLMRIS Lock would be constructed on the Chicago Sanitary and Ship Canal (CSSC) and the Cal-Sag Channel, respectively. A GLMRIS Lock is an ANS Control system that includes a lock chamber, approach channels, electric barriers, and an ANS Treatment Plant. The lock chamber is specifically designed to allow for controlled directional flushing. The approach channels built on either side of the lock would include electric barriers to prevent fish from entering the lock chamber. An ANS Treatment Plant would provide ANS treated water for lockages to ensure ANS not affected by the electric barriers would not transfer during lockages. These locks would remain closed at all times unless a vessel needed to cross to the other side. Additionally, if there were a power failure with the electric barriers or another maintenance concern, the locks would remain closed to prevent passage of ANS. In addition, the normal flow of the CAWS would be diverted from the channel on the lake side of the new locks, through ANS Treatment Plants at each location, and then discharged back to the river side of the new locks.

There would be significant impacts to Flood Risk Management under this alternative that would require construction of three stormwater reservoirs, conveyance tunnels, and associated infrastructure.

Alternative Plan 4: Control Technology Alternative with a Buffer Zone

This strategy focused on maintaining the current operations of the CAWS by analyzing the system and then creating a Buffer Zone within the CAWS. This Buffer Zone is the segment of the waterway located between the lakefront and downstream controls points. The water within this zone would be composed of discharge from ANS Treatment Plants, treated Water Reclamation Plant (WRP) effluent, precipitation, and stormwater. The Buffer Zone provides for redundancy in control points in the system and serves as a zone where an ANS response action could occur, if necessary. The presence of a Buffer Zone allows for greater freedom in the selection of ANS Controls. Since transfer is managed at two points, the control technology at each point only needs to be effective in a single direction. Additionally, the nonstructural measures discussed above would be implemented as part of this alternative.

This alternative creates an ANS-free Buffer Zone by installing ANS Control measures along all five aquatic connections between the CAWS and Lake Michigan and by installing ANS Control measures at the single downstream point of the CAWS at Brandon Road (IL). This is achieved by modifying or replacing the existing structures at Wilmette (IL), Chicago (IL), T.J. O'Brien (IL), and Brandon Road (IL) and by constructing physical barriers along the uncontrolled pathways of the Grand Calumet River and Little Calumet River at Stateline (IL/IN) and Hammond (IN). Specifically, GLMRIS Locks with their associated features including directionally flushing lock chambers, approach channels, electric barriers, and ANS treatment plants will be installed at Chicago, T.J. O'Brien, and Brandon Road. Screened sluice gates are also included at Wilmette, T.J. O'Brien, and Chicago.

This alternative would allow for the operation of the CAWS to remain relatively unchanged and is not anticipated to significantly impact CAWS uses and users.

Alternative Plan 5: Lakefront Hydrologic Separation

This strategy focused on preventing the mixing of untreated surface waters between the Great Lakes and Mississippi River basins through hydrologic separation. Additionally, this alternative minimizes water quality impacts to Lake Michigan. This alternative includes four physical barriers located at Wilmette (IL), Chicago (IL), Calumet City (IL), and Hammond (IN). Additionally, the nonstructural measures discussed above would also be implemented as part of this alternative.

There would be significant induced flooding, impacts to the water quality of the CAWS, and impacts to commercial and recreational navigation under this alternative. Additional flood risks would be mitigated by construction of two stormwater reservoirs, conveyance tunnels, and pertinent features. Impacts to water quality of the CAWS would be mitigated by construction of ANS Treatment Plants to provide ANS treated water to the CAWS. Impacts to commercial navigation would not be mitigated because CAWS operators indicated they would not be likely to use a multi-modal facility. Additionally, a multi-modal facility owned by CenterPoint Properties currently operates in Joliet, Illinois. Impacts to recreation navigation may be mitigated by construction of lake side boat storage.

Alternative Plan 6: Mid-System Hydrologic Separation

This strategy focused on preventing the mixing of untreated surface waters between the Great Lakes and Mississippi River basins through hydrologic separation. Additionally, this alternative minimizes induced flooding impacts to the Chicago area. This alternative has two physical barriers located at Stickney (IL) and Alsip (IL). Additionally, the nonstructural measures discussed above would also be implemented as part of this alternative.

There would be significant impacts to the water quality of the CAWS, to the water quality of Lake Michigan, and to commercial and recreational navigation under this alternative. Impacts to the water quality of the CAWS and Lake Michigan would be mitigated by construction of three stormwater reservoirs, conveyance tunnels and pertinent features, sediment remediation within the CAWS, and by re-routing Water Reclamation Plant effluent to the river side of the hydrologic separation. Impacts to commercial navigation would not be mitigated because CAWS operators indicated they would not be likely to use a multi-modal facility. Additionally, a multi-modal facility owned by CenterPoint Properties currently operates in Joliet, Illinois.

Alternative Plan 7: Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone

This alternative combines both technologies and hydrologic separation strategies to minimize impacts to existing CAWS uses and users. This alternative includes three physical barriers located at Stickney (IL), Stateline (IL/IN), and Hammond (IN) that will hydrologically separate four of the five aquatic pathways between the CAWS and Lake Michigan. Along the remaining aquatic pathway, a Buffer Zone would be established by the construction of ANS Control measures at T.J. O'Brien (IL) and Brandon Road (IL). Screened sluice gates are also included at T.J. O'Brien. Additionally, the nonstructural measures described above would be implemented as part of this alternative.

The ANS Controls at T.J. O'Brien and Brandon Road include GLMRIS Locks with their associated features including directionally flushing lock chambers, approach channels, electric barriers, and ANS Treatment Plants.

There would be significant impacts to the water quality of the CAWS, the water quality of Lake Michigan, and commercial and recreational navigation under this alternative. Impacts to the water quality of the CAWS and Lake Michigan would be mitigated by construction of three stormwater reservoirs, conveyance tunnels and pertinent features, sediment remediation, and by construction of tunnels to re-route Water Reclamation Plant effluent to the riverside of the hydrologic separation.

Alternative Plan 8: Mid-System Separation CSSC Open Control Technologies with a Buffer Zone

This alternative combines both technologies and hydrologic separation strategies to minimize impacts to existing CAWS uses and users. This alternative includes a physical barrier located at Alsip (IL) hydrologically separating three of the five aquatic pathways between the CAWS and Lake Michigan. Along the two remaining aquatic pathways, a Buffer Zone would be established by installing ANS Control measures at Wilmette (IL), Chicago (IL), and Brandon Road (IL). Additionally, the nonstructural measures described above would be implemented as part of this alternative.

The ANS Controls at Chicago and Brandon Road include GLMRIS Locks with their associated features including directionally flushing lock chambers, approach channels, electric barriers, and ANS Treatment Plants. Screened sluice gates are also included at Wilmette and Chicago.

There would be significant impacts to the water quality of the CAWS, the water quality of Lake Michigan, and commercial and recreational navigation under this alternative. Impacts to the water quality of the CAWS and Lake Michigan would be mitigated by construction of two stormwater reservoirs, conveyance tunnels and pertinent features, sediment remediation, and by construction of tunnels to re-route existing Water Reclamation Plant effluent to the riverside of the hydrologic separation.

Alternative Adaptive Management

Adaptive Management is a decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. For the GLMRIS Alternatives, two components to adaptive management were identified. First, is the ANS Control measure working as intended? Second, if the measure is not working as intended, how easy is it to change, reverse, or adapt the measure to function more effectively?

Study evaluation processes were consistent across all alternatives. Staged implementation and associated incremental risk reduction were not specifically considered by the GLMRIS Team for the GLMRIS Report, but could be beneficial in future analyses. For some alternatives, there are common plan elements which could provide flexibility during implementation to modify the original alternative to another alternative under certain circumstances. For example, the Technology with an ANS Buffer Zone could be staged for the implementation of ANS Control measures at Brandon Road (IL) as the first system control point. Implementation of these ANS Control measures at Brandon Road (IL) could evolve from the Technology with ANS Buffer Zone Alternative into the Mid-System Separation CSSC Open Alternative or the Mid-System Cal-Sag Open Alternative. It is anticipated that the early implementation of the Technology with an ANS Buffer Zone measures at Brandon Road (IL) would allow for the timely evaluation of the implementability and efficacy of the measures in this plan, allowing minimal deviation from achievement of its ANS risk reduction in either the total implementation of this alternative or the evolution into either of the two identified hybrid alternatives.

Risk and Uncertainty

Some risks and uncertainties are inherent in many of the complex concepts discussed in the GLMRIS Report. The costs and implementation schedules presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. At the level of detail presented in the GLMRIS Report, some assumptions were made for all the alternatives to reach this comparable level of detail. Each cost and implementation schedule estimate assumes that: the necessary funding to fully efficiently complete the alternative will be provided annually; and the necessary Real Estate and necessary permits to implement the alternative can be acquired and obtained in a timely manner. These risks cannot be quantified at this time and could have impacts upon the costs and implementation schedules for each alternative in the GLMRIS Report. For additional information on cost risks, refer to Appendix K; for additional information on implementation schedule risks, refer to section 3.4 of the GLMRIS Report.

There also is a risk that one or more presently identified ANS may transfer between the basins prior to alternative implementation, but these alternatives may be effective at preventing the transfer of future ANS. For a full discussion, refer to Section 4.2 of the GLMRIS Report and Appendix C.

After alternative implementation, there are still residual risks of adverse impacts due to ANS transfer and establishment for each GLMRIS Alternative. First, a "Low" risk rating does not indicate that "No" risk remains, but instead indicates that a Low level of risk remains after alternative implementation. For instance, after implementation of the Lakefront Hydrologic Separation Alternative the tubenose goby received a "Low" risk rating because the physical barriers are constrained by the storm size they were designed to withhold. For additional information, refer to Appendix C. Second, residual risk of transfer remains along the Great Lakes and Mississippi River basin divide outside of the CAWS. For additional information, refer to Appendix N. Lastly, regardless of the implementation of any alternative, residual risk of interbasin transfer through non-aquatic pathways remains. The GLMRIS Alternatives address, 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. For additional detail on non-aquatic pathways, refer to Appendix A.

There is uncertainty associated with the ability of each alternative to control ANS transfer through the CAWs, and this uncertainty is discussed as part of the alternative risk assessments. The alternatives presented in this report include measures or technologies, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies incorporated into the alternatives are known, the combination of technologies and application of the technologies in some instances are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. The level of uncertainty associated with an alternative's rated risk reduction for each High and Medium ANS is discussed in detail in the project risk assessments found in Appendix C.

GLMRIS Alternatives Evaluation Criteria

The following table outlines the criteria that could be utilized by decision-makers to evaluate the GLMRIS Alternatives. Descriptions of the evaluation criteria and associated metrics can be found on the back of the table.

The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. The funding stream for an alternative is assumed to be sufficient to support annual progress to meet corresponding implementation timelines. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

Table ES.1 GLMRIS Evaluation Criteria Summary

GLMRIS Alternatives	GLMRIS Alternatives Evaluation Criteria†		Effects of GLMRIS Alternatives										
	Effectiveness at Preventing Interbasin Transfer (at time of implementation)	Implementation (years)	Negative CAWS Environmental Impacts	Negative Water Quality Impacts (CAWS)	Negative Water Quality Impacts (Lake Michigan)	Water Quality Mitigation Measures Cost[4]	FRM (net change in EEAD – an annual impact)	FRM Mitigation Measures Cost[4]	Commercial Cargo Cost Impacts (annual cost)	Non-Cargo Navigation Impacts	Complexity of Regulatory Compliance	Cost of the ANS Control and Mitigation Measures[4]	Nonstructural & OMRR&R Costs (annual)[4]
No New Federal Action – Sustained Activities	★	The No New Federal Action – Sustained Activities Alternative assumes that any currently funded ANS prevention actions are maintained to include the operation of the existing electric barrier in Romeoville, IL. All alternatives below are actions in addition to the No New Federal Action – Sustained Activities Alternative. For complete details on this alternative, please review Section 3.8.											
Nonstructural Control Technologies	★★	0	L	L	L	N/A	$0	N/A	Likely minimal[3]	L	L	$–[5]	$68 M
Mid-System Control Technologies without a Buffer Zone – Flow Bypass[2]	★★★	25	M	L	L	N/A	$1.1 M	$9,100 M	$0.75 M	L	M	$15,500 M	$210 M
Technology Alternative with a Buffer Zone[2]	★★★	10	H	L	L	$1,600 M	$0.6 M	$2,000 M	$0.50 M	M	M	$7,800 M	$220 M
Lakefront Hydrologic Separation[2]	★★★★	25	H	M	Improves[1]	$500 M	$66.0 M	$14,500 M	$210 M	H	H	$18,300 M	$160 M
Mid-System Hydrologic Separation[2]	★★★★	25	L	H	H	$12,900 M	$1.1 M	$24 M	$250 M	M	H	$15,500 M	$140 M
Hybrid – Mid-System Separation Cal-Sag Open[2]	★★★	25	H	M	M	$8,300 M	$28.1 M	$1,900 M	$7.30 M	M	H	$15,100 M	$180 M
Hybrid – Mid-System Separation CSSC Open[2]	★★★	25	M	H	M	$4,300 M	($26.4 M)	$145 M	$8.80 M	M	H	$8,300 M	$160 M

† Evaluation Criteria Descriptions are located on the reverse side of this table.

1 Under the Lakefront Hydrologic Separation Alternative, stormwater and CSOs would no longer be able to backflow to Lake Michigan, likely reducing beach closures and contaminant loading to Lake Michigan.

2 This alternative includes the nonstructural measures identified in the Nonstructural Alternative.

3 A quantified evaluation of the impacts of the Nonstructural Alternative was unable to be completed. Based on professional judgment, the impacts are believed to be likely minimal.

4 The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. The funding stream for an alternative is assumed to be sufficient to support annual progress to meet corresponding implementation timelines. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

5 Estimated initial costs for the Nonstructural Alternative are assumed negligible and sufficiently captured by the estimate for the annual OMRR&R Costs.

Effectiveness at Preventing Interbasin Transfer. This criterion qualitatively assesses the alternative's effectiveness at preventing ANS transfer based on the number of High and Medium risk ANS of Concern whose risk of establishment can be reduced from High or Medium to Low. This criterion is also influenced by the comparative levels of uncertainty associated with the ANS Control measures proposed in each alternative. Plans are given a "star" [*] rating; with four "stars" being the most effective.

Implementation. This criterion is the total number of years it will take for the alternative to fully realize projected risk reduction benefits.

Negative CAWS Environmental Impacts. This criterion qualitatively evaluates the negative effects of an alternative on the existing environment limited to the footprint area of the alternative's construction and the alternative's impact on the connectivity of the habitats in the CAWS.

CAWS Ecosystem Mitigation Measures Costs. This criterion presents the estimated costs to mitigate some of the negative environmental impacts of an alternative.

Water Quality Impacts (CAWS). This qualitative rating is based upon the output of the CAWS DUFLOW model. DUFLOW simulates the water quality (WQ) in the CAWS under baseline, future without project, and future with project conditions. DUFLOW simulation results are used to generate a CAWS Water Quality Index for each project alternative based on the percent increase in Days Out of Regulatory Compliance for three indicator constituents (Fecal Coliform, Dissolved Oxygen, and Chloride). A detailed discussion of these analyses can be found in Appendix F – Water Quality Analyses.

Water Quality Impacts (Lake Michigan). This qualitative rating is based upon the output of the CAWS DUFLOW and Lake Michigan FVCOM models. DUFLOW calculates the loads of pollutants discharged to Lake Michigan for the baseline, future without project, and future with project conditions. DUFLOW simulation results are used to generate a Lake Michigan Water Quality Index for each project alternative, based on the mass of pollutant loads to Lake Michigan for six indicator constituents (Biochemical Oxygen Demand, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Chloride, and Fecal Coliform). A detailed discussion of these water quality analyses can be found in Appendix F – Water Quality Analyses.

Water Quality Mitigation Measures Costs. This criterion presents the estimated costs to mitigate the Water Quality Impacts to both the CAWS and Lake Michigan of an alternative. Further detailed discussion of the mitigation measures can be found in Appendix F – Water Quality, and the associated cost analyses are described in more detail in Appendix K.

Flood Risk Management (FRM). This criterion displays the FRM impacts as the equivalent expected annual damages (EEAD) associated with implementing each GLMRIS Alternative plan. In the without-project conditions, damages are expected to occur to various structures. However, the implementation of a GLMRIS plan will either increase the total damages in the Chicago area (represented as positive values in this column) or decrease total damages in the Chicago area (negative value). Specifically, the values presented represent the difference (i.e., net change) between the without-project condition (EEAD of $231.241 million) and the with-project conditions. Positive values represent induced damages in the Chicago area. Negative values represent a reduction in overall damages in the Chicago area. Values show the unmitigated impacts. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix D – Economic Analyses.

FRM Mitigation Measures Costs. This criterion presents the estimated costs to mitigate the FRM impacts of an alternative. Further detailed discussion of the mitigation measures can be found in Appendices E, and J, and the associated cost analyses are described in more detail in Appendix K.

Commercial Cargo Cost Impacts. Normally, it is cheaper to move bulk commodities via waterways (waterborne transportation) than it is on land (i.e., via truck and rail). The difference between the costs of moving commodities on land and the cost of moving them on a waterway is called "transportation cost savings." This criterion displays the losses in transportation cost savings if a GLMRIS Alternative is implemented. Several of the GLMRIS Alternative plans include measures that would decrease the efficiency of moving goods on the waterway, so the cost of shipping these goods via waterways increases. Therefore, there are fewer savings associated with moving the goods via water versus land. The greater the losses in transportation cost savings, the greater the cargo navigation impacts. A more detailed discussion of these analyses can be found in Appendix D – Economic Analyses.

Non-Cargo Navigation Impacts. This criterion, based on professional judgment, qualitatively states the impact of an alternative on non-cargo navigation in the CAWS, to include recreational navigation. The alternatives will be given a ranking of "High," "Medium," or "Low." A more detailed discussion of these analyses can be found in Appendix D – Economic Analyses.

Complexity of Regulatory Compliance. This criterion qualitatively states the level of regulation that the alternative will be subject to and incorporates the complexity of the associated compliance with those regulations. The alternatives will be given a ranking of "High," "Medium," "Low," or "None." "High" means a high level of difficulty achieving regulatory compliance would be associated with the alternative. All alternatives will be fully compliant with applicable regulations.

Cost of the Alternative (ANS Controls and Mitigation). This criterion is a parametric cost estimate of each alternative. The cost estimate will include the cost of construction of the alternative measures, including any mitigation that would be required as part of the alternative. Cost estimates underwent an abbreviated risk analysis to determine an appropriate contingency percentage to be included in the cost. These estimates include costs for all work necessary to implement an alternative, although some of these costs may be borne by entities other than USACE. Cost estimates do not include final quantities. The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. The funding stream for an alternative is assumed to be sufficient to support annual progress to meet corresponding implementation timelines. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Nonstructural & OMRR&R Costs. This criterion is an estimate of the nonstructural measures and the annual operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Chapter 1 Overview

The United States Army Corps of Engineers (USACE), in consultation with other federal agencies, Native American tribes, state agencies, local governments, and nongovernmental organizations, is conducting the Great Lakes & Mississippi River Interbasin Study (GLMRIS). In accordance with the study authorization, USACE has evaluated a range of options and technologies, including hydrologic separation, that are intended to prevent aquatic nuisance species (ANS) transfer between the Great Lakes and Mississippi River basins via aquatic pathways. Located entirely within the United States, the GLMRIS study area includes the Great Lakes (GL) and Mississippi River (MR) basins.

GLMRIS was conducted as an Ecosystem Restoration Study. USACE Policy on Ecosystem Restoration includes both restoration and protection of natural resources and should include proactive engineering measures. "Protection" may be the primary purpose of an ecosystem project if the subject area is a high quality native ecosystem that is likely to be significantly degraded by man or nature in the reasonably foreseeable future and degradation of current quality can be substantially reduced through implementation of proactive engineering measures. The GLMRIS Report includes the development of options and technologies to prevent the interbasin transfer of aquatic nuisance species that would, if implemented, protect the environmental, economic, and political/social resources of the Great Lakes and the Mississippi River basins.

In recent years, successful invasions of aquatic nuisance species (ANS) have severely impacted the economic and environmental resources of the Great Lakes and Mississippi River Basins. Aquatic nuisance species threaten native plants and animals, reduce biodiversity, harm important terrestrial and aquatic ecosystems, degrade water quality, transport diseases, and result in economic, political, and social impacts. For these reasons, invasive species are of national and global concern. ANS populations span geographic and jurisdictional boundaries; thus, efforts to manage invasive species must be coordinated across watershed and jurisdictional boundaries. According to the National Invasive Species Council's (NISC) 2008 Management Plan, the best defense against aquatic nuisance species is prevention, stemming the tide of new introductions.

Recent ANS invasions to the Great Lakes and Mississippi River Basins include zebra mussels, quagga mussels, Eurasian ruffe, and Asian carps. 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, in the navigable waters of the Eastern United States, and in the Mississippi River Basin. Zebra mussels have inflicted tremendous damage to native ecosystems and to facilities using water, like power plants and municipal water suppliers. Hundreds of millions of dollars have been spent by water users, to control and eradicate zebra mussels. And, as zebra mussel populations in an area increase, native mussels decrease — a strong indication that zebra mussels are the cause. These invasive mussels can clog water intake and delivery pipes and dam intake gates. They adhere to boats, pilings, and most hard and some soft substrates. The mussels negatively impact water delivery systems, fire protection, and irrigation systems and require costly removal maintenance. The U.S. Fish and Wildlife Service (USFWS) has developed a Zebra Mussel/Quagga Mussel Action Plan to address the continued movement of these aquatic nuisance species into the Western United States. The spread of quagga and zebra mussels across the West brings the potential to extend devastating impacts into a geographic area already challenged with severe water-related problems (http://www.fws.gov/fisheries/ans/).

1.1 GLMRIS Report Roadmap

GLMRIS is a unique study for USACE. While it focuses on a significant water resource issue, the geographic scope and complexity of this study is much greater than traditional studies. As a result, some elements of traditional water resources planning processes were incorporated into GLMRIS, but GLMRIS also includes the use of innovative planning methods, including the use of qualitative risk methods, and "SMART Planning" tools and techniques that facilitated progress on the study. Further, because of the level of public interest, GLMRIS has included the release of Interim Products that represent portions of the baseline analyses completed for the study, as well as a very high level of stakeholder engagement. The GLMRIS Team included subject matter experts from across USACE and a fully integrated Agency Technical Review Team (ATR Team).

The study process for GLMRIS was developed in a stepwise fashion taking into account study authority, additional legislative direction, USACE policy, and agency implementation guidance. Scoping of the study considered the geographic extent of the study area — i.e., the Mississippi River and Great Lakes basins, as well as the need for more detailed analyses in specific portions of these large watersheds. The scoping process included the problem, as broadly identified in the study authority, opportunities to affect the problem, as well as physical, legal, and policy constraints. The scoping process included both internal and external scoping exercises designed to help USACE map out the study approach. USACE evaluated the range of options and technologies available, to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins in a manner that would protect or preserve environmental resources, rather than in a manner that restores impacted environmental resources back to pre-impact condition.

Another key consideration was how to characterize the existing environmental, social-political, economic, and physical resources for a study conducted at such a large geographic scale. Evaluation of the affected environment was developed in some detail for the resources within the Chicago Area Waterway System (CAWS). A number of economic analyses were completed as part of the inventory and forecasting to include fisheries and their dependent industries. The information developed as part of inventory and forecasting will be used to assess impacts of project alternatives, rather than to place a value on the resources to be protected. Economic methods that provide a value for large natural resources, such as the Great Lakes, are not part of USACE study processes, but provide an assessment of economic parameters that could change in the future. Economic and related analyses also provide a means to evaluate the potential impacts of alternatives on existing uses and users of the waterways. For some uses and users, an economic evaluation was the most appropriate means of categorizing impacts. For other uses and users, more qualitative methods, including risk assessments, were considered the best available tools to utilize. The proposed study process, including individual analyses, was documented in a Project Management Plan (PMP). The PMP is available on the GLMRIS website at glmris.anl.gov.

Twelve (12) scoping meetings were conducted at key locations in the Great Lakes and Mississippi River basins. The scoping processes further informed the study problem, opportunities, and constraints. A summary of the study scoping process is available at glmris.anl.gov.

The following paragraphs include a general description of the key elements of GLMRIS. More detailed discussions on key study elements and the initial steps in the USACE Planning Process are set forth later in this chapter.

Step One of GLMRIS focused on the first step of the USACE Planning Process as defined in Water Resource Council report known as the "Principles and Guidelines" (WRC 1983): problem identification. This step includes development of the study goal, understanding of the problems and opportunities that could be addressed by a civil works projects, and those factors that could limit or constrain the analysis.

Problem. The problem, as broadly defined in the study authority (Section 3061(d), Water Resources Development Act of 2007 (WRDA 2007)), is the transfer of aquatic nuisance species between the Great Lakes and Mississippi River basins. In order to determine which species the study should focus on, USACE developed a preliminary literature-based assessment of possible aquatic nuisance species. Initially more than 250 species were identified that were present in one basin and had the potential to invade the other basin, become established, and negatively impact the receiving basin. The initial list of species was reduced from more than 250 to 35, based on additional research, including confirmation that some of the species were already present in both basins. The species list and the process used to develop the list was reviewed by technical experts within USACE and other resource agencies including U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS).

To further refine the list of ANS, a risk-based approach was utilized. The GLMRIS Risk Assessment methodology was modeled after a methodology used by the National ANS Task Force and the U.S. Department of Agriculture's (USDA's) APHIS program was incorporated into the problem identification process. The Risk Assessment was conducted in consultation with the USDA-APHIS and USACE subject matter experts. The model considered both probability and consequences in the development of a risk rating for each of the 35 species. The analysis was conducted for four time steps: baseline (T_0); ten years after baseline (T_{10}); twenty-five years after baseline (T_{25}); and fifty years after baseline (T_{50}). The result of this qualitative analysis was a probability of establishment for each of the 35 species. The results were characterized as High, Medium, or Low probabilities of establishment for each species for the four time steps. Thirteen species were identified as having a High or Medium probability of establishment. These thirteen species were the focus of the next major steps in the Planning Process and plan formulation, which included the identification of aquatic nuisance species control technologies, and the formulation of alternatives.

Opportunity. The opportunities afforded for the study were informed by the authority and study problem. For GLMRIS, that opportunity is, in a broad sense, protection of the environmental and economic resources of the Mississippi River and Great Lakes basins from the impacts of ANS. From a basin perspective, the study included an assessment of the significance of the resources. The assessment identified both the technical and institutional significance of the resources of the Great Lakes and Mississippi River basins. Study opportunities were further refined based on both internal and external scoping efforts.

Constraints. The internal and external scoping process for GLMRIS also helped to define the constraints that would bound the universe of potential solutions to address the identified problem. Constraints identified were tied to the study authority, to the political-social boundaries of the basins, and to the resources of the two basins. The constraints were further refined based on additional analysis.

Step Two of GLMRIS focused on the second step of the Planning Process: inventory of resources and forecast of future without project conditions. As part of this stage of the study process, the GLMRIS Team developed and released of a number of Interim Products to the public. The Interim Products are detailed in Section 1.6.2 and are available on the project website glmris.anl.gov.

Inventory and Forecast. From the basin-wide perspective to the more Detailed Study Area (CAWS), additional analyses were needed to fully understand the current state of the environmental, physical, economic, social, and political resources, as well as forecast impacts to those resources and uses and users of the CAWS through the period of analysis for both with and without project conditions. These uses and users include commercial and recreational navigation, stormwater conveyance and flood risk management, wastewater treatment plant effluent conveyance, industrial uses (withdrawal and discharge), and hydropower.

Very detailed analyses of existing economic, environmental and physical resources in the Chicago Area Waterways Study areas were scoped and completed for the CAWS portion of the GLMRIS Detailed Study Area. The CAWS contains five direct connections between the Mississippi River and the Great Lakes basins. These analyses included:

- Environmental resources, including threatened and endangered species (T&E species) and cultural and historic resources for baseline and future conditions;

- Hydrologic and hydraulic modeling (H&H modeling) of the CAWS and connected areas for baseline and future conditions;

- Water quality modeling for the CAWS and near shore and southern Lake Michigan for baseline and future conditions;

- Economic analyses of commercial and recreational navigation; commercial, recreational, and tribal fishing for the Great Lakes, Mississippi, and upper Ohio River basins; regional economics; and flood risk analysis of commercial and residential properties within the 500-year floodplain of the CAWS; and

- Assessment for current uses and users of the CAWS.

Because it was anticipated that project alternatives could significantly modify the uses of the CAWS, models and other tools were developed to consider the effects of alternatives on the CAWS and on the uses and users of the CAWS. The tools identified impacts as well as providing a means, in some cases, of evaluating the effectiveness of mitigation. For example, H&H modeling for baseline and future conditions was used to quantify impacts to river stages of various alternatives and the need and magnitude of mitigation to address those river stage impacts. Further, H&H modeling was able to quantify the impacts on connected areas, including commercial, industrial, and residential basements from changed conditions in the waterway. Damage assessments were informed by output from the H&H modeling for substantial portions of the CAWS.

Various methods were utilized to quantitatively describe and assess the value of economic activities and resources that could be impacted in future with and without project conditions. Basin level assessments, such as fishing related activities, were conducted to identify possible negative impacts of ANS transfer and establishment. CAWS level assessments, such as navigation, flood risk management, water supply (including industrial use and discharges), and hydropower, were conducted to identify possible negative impacts of implementation of GLMRIS Report alternatives. When possible, the potential impacts to resources were quantified, but were otherwise qualitatively described.

Step Three of GLMRIS follows the third step of the Planning Process: Plan Formulation*.* Plan Formulation was initiated with the development of the research-based ANS Controls Paper. The paper, released as an Interim Product in March 2012, documented all potential technologies that could be applied to prevent the transfer of ANS between the Mississippi River and Great Lakes basins. These measures were used as building blocks by the GLMRIS Team to develop alternative plans.

The GLMRIS Report was carefully organized to present the significant amount of completed analyses in a logical, stepwise fashion. The Main Report includes three chapters focusing on the Planning Process. Appendices include documentation of detailed analysis. Chapter 1 of the GLMRIS Report focuses on the study goal, problems, opportunities, objectives, and constraints for study. The chapter also includes limited discussion on prior studies, scoping, and stakeholder engagement in the study process. Chapter 1 includes discussion on both Focus Area 1 (CAWS) and Focus Area 2 (Other Pathways). Following

Chapter 1, the GLMRIS Report discusses only Focus Area 1, the CAWS. Additional information about Focus Area 2 and the study results may be found in Appendix N – Focus Area and on the GLMRIS project website, glmris.anl.gov.

Chapter 2 of the GLMRIS Report introduces the Risk Assessment process, the identification of the “High” and “Medium” risk ANS, and the formulation process utilized to develop alternative plans. Also in Chapter 2, uses and users of the CAWS that could be impacted by GLMRIS Alternatives are identified. The implementation of a plan to prevent ANS transfer is likely to impact one or more of the other uses and users of the CAWS.

Chapter 3 of the GLMRIS Report presents a range of eight alternatives comprised of options and technologies that can address the transfer of ANS between the Great Lakes and Mississippi River basins. Each alternative description includes: the ANS Controls used to reduce the risk of ANS transfer; impacts to the CAWS uses and users; mitigation measures to minimize the impacts to uses and users; the risk reduction effected by the alternative; the anticipated cost of the alternative; and the estimated time to implement the alternative.

Chapter 4 of the GLMRIS Report presents fifteen evaluation criteria for the eight GLMRIS Alternatives that could be used to compare the alternatives and is consistent with Step 4 of the Planning Process. A tradeoff analysis was not completed, and no alternative has been identified as the tentatively selected plan, nor is any preference or overall ranking of the alternatives shown in Chapter 4.

Steps 5 and 6 of the Planning Process, Comparing Alternative Plans and Selecting a Plan, are not part of the GLMRIS Report. Consistent with the study authorization set forth in Section 3061 of WRDA 2007, the GLMRIS Report presents “a range of options and technologies available” to prevent the transfer of ANS between the basins, and does not select a recommended plan. Because it does not contain a recommendation, the report does not include National Environmental Policy Act (NEPA) compliance documentation. The Moving Ahead for Progress in the 21st Century Act (MAP-21) legislation does allow the Secretary of the Army to proceed to project preconstruction engineering and design (PED) if a project is deemed to be justified, and steps five and six of the Planning Process and the associated NEPA compliance documentation would need to be completed as part of the selection of a specific plan.

1.2 Report Intent

The intent of this GLMRIS Report is to present a range of options and technologies, summarized in a series of alternatives, to prevent the transfer of ANS between the Great Lakes and Mississippi River basins through aquatic pathways. This report does not include a recommended plan, but does include potential effects of the developed alternatives on aquatic and riparian environments, cultural and archaeological resources, and social and economic resources.

1.2.1 Goal

The overarching goal of this study is to develop a range of options and technologies to protect the Great Lakes and Mississippi River aquatic ecosystems from ANS that could transfer via aquatic pathways connecting the Great Lakes and Mississippi River basins.

The technical and institutional significance of the Great Lakes and Mississippi River basins and documented impacts associated with historical interbasin ANS transfer through other aquatic pathways including the CAWS, combined with future risk of transfer through the CAWS and other aquatic pathways, provide the need and purpose for GLMRIS. Several species transferred from the GL to the MR basin through the CAWS, including the zebra mussel, white perch, and round goby. Two Asian carp species, imported to the United States, have caused significant environmental impacts within the Mississippi River basin, including the Illinois River and Illinois Waterway, and pose a threat to the GL basin. Numerous other ANS, in addition to fish and mussels, may also use the CAWS as a dispersal pathway. The significance of the resources, the observed adverse impacts resulting from past transfer of ANS, and the potential for future ANS transfer support the goal to protect the Great Lakes and Mississippi River ecosystems.

1.3 Study Authority

The Great Lakes and Mississippi River Interbasin Study was authorized in Section 3061(d) of WRDA 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 feasibility study authorizations in that it directs the identification and assessment of a range of available options and technologies, and it does not require the recommendation of any one option. It also authorizes completion of study activities at full federal expense.

1.3.1 Implementation Guidance

In March 2009, the HQUSACE issued implementing guidance for Section 3061 of WRDA 2007. The implementation guidance directed:

> The feasibility study authorized by Section 3061(d) shall provide a thorough and comprehensive analysis of the options and technologies that could be applied to prevent the inter-basin transfer of aquatic nuisance species between the Great Lakes and Mississippi River through aquatic pathways. The impacts associated with the implementation of any of the final alternative plans shall include an impact analysis on all current uses of the CSSC. The analysis shall address the need to mitigate or provide alternative facilities or measures for the other users including commercial navigation, recreational navigation, storm water management and recreation. The study will be at 100% Federal expense and will be budgeted in accordance with the annual budget EC [Engineer Circular]. The study shall be conducted in consultation with appropriate Federal, state, local and nongovernmental entities. No work may be initiated on this study until funds are specifically appropriated by Congress for the study.

This implementing guidance was influential in the drafting of the Project Management Plan, the scoping of study activities, and the development of a robust stakeholder engagement strategy, which are discussed later in this chapter.

1.4 Intervening Legislation

In July 2012, the GLMRIS authority was modified by Section 1538 of Public Law 112-141 of the Moving Ahead for Progress in the 21st Century Act (MAP-21). MAP-21 directs the Secretary of the Army (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 PED.

USACE has compiled this document, the Great Lakes & Mississippi River Interbasin Study Report (GLMRIS Report), per the statute enacted by the MAP-21 legislation. 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).

1.4.1 Implementing Guidance

In August 2012, the HQUSACE issued implementing guidance for Section 1538 of MAP-21. The implementation guidance directed:

> Originally enacted in Section 3061(d) of WRDA 2007, the GLMRIS study authority requires the Secretary, in consultation with other entities, to fund at full federal expense a feasibility study of the range of options and technologies available to prevent aquatic nuisance species from spreading between the Great Lakes and the Mississippi River Basins. Section 3061(d) differs from a traditional Corps feasibility study authority in several ways. First it directs the study to be conducted at full federal expense, in contrast to cost sharing requirements generally mandated for Corps studies of water resources development projects by Section 105 of WRDA 1986. Second, Section 3061(d) does not require participation by a non-federal sponsor in the study, instead

> directing USACE to perform the study 'in consultation with appropriate federal, state, local, and nongovernmental entities.' This also contrasts with the traditional feasibility study process of the Corps, which requires a binding agreement with a non-federal interest at the earliest stages of a study. Finally, Section 306l(d) uses a different description for the GLMRIS effort than that found in a traditional feasibility study authorization. Section 306l(d) requires a 'feasibility study of the range of options and technologies available' to prevent aquatic nuisance species from spreading between the Mississippi River Basins and the Great Lakes, rather than targeting a Corps recommended solution to traditional water resources problem. These distinctive aspects of the GLMRIS authority require a different study from that normally undertaken by USACE, but still allow the agency considerable discretion in fulfilling the study's mandate.
>
> Section 1538 adds several requirements to GLMRIS, including a completion deadline and additional reporting and content requirements, but largely retains GLMRIS's original scope as well as its lack of study cost sharing or any requirement of a non-federal study sponsor. Section 1538 also continues to leave to the Secretary's discretion whether to identify a GLMRIS project for possible implementation, by stating that only if the Corps determines a project to be justified, will that project be required to proceed directly into PED. In short, Section 1538 does not direct specific changes to the GLMRIS study's scope or process, focusing instead on directing the Corps to quickly complete the study and include if at all possible a determination of whether any GLMRIS project is justified. This has allowed and will continue to allow USACE, in complying with the GLMRIS authority's requirements, to adopt a number of useful aspects of its traditional feasibility study process including the goal of finding a non-federal interest to partner with USACE in implementing a project if authorized by Congress.

This implementing guidance also provided direction on the drafting of the 90-day report required by the MAP-21 legislation:

> USACE has determined that the GLMRIS study as currently planned by the district cannot be accomplished by the deadline imposed by the MAP-21 Act. That plan called for completion of the Focus Area I (CAWS) portion of the study in 2015 and completion of the Focus Area II (Other Pathways) portion of the study in 2018. Over the past two years, aggressive consideration of the plan has not resulted in effective ways to maintain all elements of the plan while accelerating the completion date. As described above, the 90-day report will explain what elements of the plan will be used for the report required by Section 1538. This explanation will include detail regarding how that will impact the ultimate product.

1.4.2 90-Day Report

In October 2012, USACE submitted the 90-Day Report outlining the milestones to be met prior to the completion of the 18-month GLMRIS Report and the funding necessary to complete those milestones. In its approach to considering how to satisfy the requirements set forth in the MAP-21, USACE took into account the deadline established by the MAP-21, the funds anticipated in fiscal year 2013, and the original GLMRIS study schedule, including necessary technical work, design and evaluation, environmental compliance analysis, required reviews, and stakeholder involvement. While the Corps had scoped the GLMRIS effort to result in a recommended plan and an associated EIS that would be completed in late 2015, the passage of the MAP-21 legislation compelled the reevaluation of the breadth of the study on a compressed timeline. As a result, even with additional funds, USACE determined that sufficient time was not available to complete the detailed analyses, reviews, and coordination needed for a recommended plan and EIS. For this reason, additional funding was not requested toward the completion of the GLMRIS Report under the expedited timeline.

As previously noted, this Report does not include an EA or EIS under NEPA, because "planning and technical studies which do not contain recommendations for authorization or funding for construction, but may recommend further study" are categorically excluded from NEPA documentation requirements. See

33 C.F.R. 230.9 (d). Although an EA is not required, the GLMRIS 90-day report initially indicated that USACE planned to use an EA format in this Report to simply "assist agency planning and decision-making," 40 C.F.R. 1501.3(b). However, as this report was further developed, USACE determined that the clarity of communication was better served by integrating the discussion of environmental impacts studied to date throughout the report, rather than placing them in a separate EA format. As discussed in Section 1.8.3, NEPA compliance documentation would need to be completed before USACE could make any recommendation for a specific alternative under GLMRIS.

1.4.3 GLMRIS Report

Due to the requirements enacted by Section 1538 of MAP-21, the GLMRIS Team refocused study efforts toward meeting the 18-month deadline. The requirements contained in MAP-21 cut approximately 20 months from the study schedule, thereby impacting the scope and breadth of analysis that could be completed. The analysis presented in this report will provide Congress and other stakeholders with an analysis of potential alternatives, and other information that may be informative for decision-makers. It does not contain sufficient analysis to develop a recommended plan, nor have other critical analyses been completed and documented in this report. The GLMRIS Report focuses on methods to prevent the transfer of aquatic nuisance species between the Great Lakes and Mississippi River basins, including hydrological separation as required by MAP-21. The analyses concentrate on the specifically named watersheds in MAP-21 associated with the Chicago Area Waterway System (CAWS). Therefore the majority of this report will concentrate on efforts in Focus Area 1, providing a summary of the efforts to date from Focus Area 2 in Appendix N – Focus Area 2.

1.5 Underlying Study Principles

The USACE Planning Process follows the six-step process defined in the principles and guidelines set forth in WRC (1983). This process is a structured approach to problem solving which provides a rational framework for sound decision-making. The six steps are:

Step 1 – Identifying Problems and Opportunities
Step 2 – Inventorying and Forecasting Conditions
Step 3 – Formulating Alternative Plans
Step 4 – Evaluating Alternative Plans
Step 5 – Comparing Alternative Plans
Step 6 – Selecting a Plan

USACE decision-making is generally based on the accomplishment and documentation of all of these steps. Steps 5and 6 of the Planning Process, Comparing Alternative Plans and Selecting a Plan, are not included in the GLMRIS Report. Consistent with the study authorization set forth in Section 3061 of WRDA 2007, the GLMRIS Report presents "a range of options and technologies available" to prevent the transfer of ANS between the basins, and does not select a recommended plan. The MAP-21 legislation does allow the Secretary to proceed to PED if a project is deemed to be justified, and Steps 5 and 6 of the Planning Process would need to be completed as part of the selection of a specific plan.

It is important to stress the iterative nature of the Planning Process. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. The six steps, though presented and discussed in a sequential manner for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete, and acceptable plans.

Another critical underlying study principle is the incorporation of risk into the conduct of the study. As noted in USACE Planning Guidance Notebook (ER1105-2-100) and in USACE (2006):

> "Planners shall characterize, to the extent possible, the different degrees of risk and uncertainty inherent in water resources planning and to describe them clearly so decisions can be based on the best available information. Risk-based analysis is defined as an approach to evaluation and decision making that explicitly, and to the extent practical, analytically incorporates considerations of risk and uncertainty." (ER1105-2-100)
>
> "Risk and uncertainty are intrinsic in water resources planning and design." (USACE 2006)

This approach provides the study team with methods to capture and quantify the extent of risk and uncertainty for some planning and design components. Examples include uncertainty with parameters used for numerical modeling including stream gage data, rainfall data, soil parameters, and other material-based parameters. Numerical modeling methods include methodology to account for uncertainty related to input parameters. Another area of uncertainty is project design and cost estimates. In order to address cost-related risk and uncertainty, USACE conducts a Cost-Schedule Risk Assessment (CSRA). The CSRA results in documentation of the design and cost related risk and uncertainty and provides a methodology to set appropriate contingencies for the cost estimates.

USACE also utilizes qualitative risk assessments for some water resources studies. Recently, USACE adopted a risk-based approach to decision-making as part of the Planning Modernization Program. For GLMRIS, a qualitative risk process was used to assess risks associated with ANS, as well as determine the level of risk for various project alternatives. The approaches employed are consistent with risk assessment tools employed by the National ANS Task Force and the USDA. More discussion on the ANS Risk Assessment is contained in Chapter 2.

1.5.1 Problems

1. **Impact from Aquatic Nuisance Species** – ANS cause significant environmental, economic, and social/political impacts within the MR and GL basins.

The need for action to remove, contain, and prevent non-native species from impairing native ecosystems and healthy economies was made extensively apparent as long ago as the 1950s, but with much more notoriety over the past 20 years. As discussed in the ANS White Paper, intentional and accidental species introductions are often associated with declines in native species richness and an overall decrease in biological diversity. Many consider the negative effects posed by invasive species to be of national and global significance, with these effects further compounded by habitat loss, impairments to natural processes, and commercial species depletion. In many instances, the addition of one aggressive non-native species can displace several native species that share similar ecological traits. It is estimated that over 50,000 non-native species may have been introduced to the United States, which 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*) (Pimentel, et al. 2005). Approximately 10 percent of all introduced species studied become established, and only 10 percent of established species are considered invasive (Groves 1991). This approximation, known as the tens rule, implies that approximately 1 percent of all introduced species will become invasive (Jeschke and Strayer 2005; Pyšek and Richardson 2006).

The introduction of ANS has had dramatic effects on natural resources and economies, with continued degradation of natural places such as the Chesapeake Bay and the Florida Everglades, as well as the Great Lakes and Upper Mississippi River basins. Pimental et al. (2005) estimated that invasive species cost the

United States more than $120 billion in damages every year. Additionally, when non-native species are introduced to complex ecosystems in which they did not evolve, their populations can grow rapidly, inducing further dispersal to other suitable areas.

The impacts of ANS are well documented for resources with specific emphasis on adverse effects. Environmental impacts include interspecies competition for space and resources, food chain disruption, and physical and chemical alteration of habitats. Economic impacts consist of commercial and recreational costs or lost time incurred due to changes created by ANS. These include costs necessary to manage the effects of an established species or lost time following regulations to ensure these species are not further spread. Social impacts include those associated with recreation losses, time losses, aesthetic degradation, and public services (drinking water, food production). Public opinion regarding the species impacts versus costs to address those impacts may also influence the management of ANS, and can even determine whether a particular species is considered a nuisance species.

2. **Transfer of ANS through Aquatic Pathways** – Currently, the CAWS and other aquatic pathways along the MR and GL basin divide provide opportunity for ANS to transfer and cause environmental, economic, and social/political impacts within the invaded basin.

GLMRIS defines pathways as determined by the Pathways Work Team, which is a partnership between the Aquatic Nuisance Species Task Force (ANSTF) and the National Invasive Species Council (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 natural pathways and man-made 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 Chicago Sanitary and Ship Canal, and the Calumet-Sag Channel.

Currently, GLMRIS is evaluating a subset of ANS poised to transfer via aquatic pathways from one basin to the other. These species are identified in the *Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study* (http://glmris.anl.gov/documents/docs/Non-Native_Species.pdf) and were assessed in the *Risks of Adverse Impacts from the Movement through the CAWS and Establishment of Aquatic Nuisance Species between the Great Lakes and Mississippi River Basins*. The five (5) CAWS pathways provide a complete year-round aquatic connection between the two basins that could allow the interbasin transfer for all 35 of the ANS of Concern.

3. **Transfer of ANS through Non-Aquatic Pathways** – Non-aquatic pathways between the MR and GL basins provide a means for ANS to transfer and cause significant environmental, economic, and social/political impacts in the invaded basin.

Transfer of ANS is not limited to aquatic pathways. While impacts of non-aquatic transfer may be similar to aquatic transfer, effects may be realized at differing rates and magnitudes, depending on the transfer points and mechanisms. The GLMRIS authority includes provisions that direct the study to focus on ANS transfer via aquatic pathways, but the report acknowledges non-aquatic pathways for completeness.

4. **Impacts of New Aquatic Nuisance Species** – Aquatic pathways into the GL and MR basins along their unshared boundaries provide a means for new ANS to be introduced and cause significant environmental, economic, and social/political impacts.

Shared boundaries are those basins or watersheds that border the Great Lakes and Mississippi River basins, such as the Mobile Basin would be to the lower Mississippi River or the Atlantic Slope watersheds would be to the Ohio River basin. Species introduced to these basins outside of the study area also possess the potential for transfer into either the GL or MR basin. Historically, this was the primary means of introduction of ANS into the Great Lakes basin (i.e., the Welland Canal, transoceanic shipping). In the event of a new ANS introduction, additional risk characterization could be performed to evaluate the probability of establishment for this newly identified species, and whether additional measures would need to be implemented to address the new ANS.

1.5.2 Opportunities

1. **Control of Aquatic Nuisance Species** – Control ANS spread between the GL and MR basins to avoid environmental, economic, and social/political impacts from ANS on the basins.

USACE interprets the language in Section 3061(d) of WRDA 2007, which directs the Secretary of the Army to study options and technologies to "prevent" the spread of ANS between the GL and MR basins, as an opportunity to prevent or reduce the risk of ANS interbasin transfer to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution. While many agencies have taken and will continue to take action to prevent the spread of aquatic nuisance species, there are no large-scale actions currently planned by others that will reduce the risk of interbasin transfer for a suite of problematic species. Opportunity exists for this study to investigate options and technologies that target ANS species or groups of species poised to transfer via the aquatic pathways connecting the Great Lakes and Mississippi River basins.

2. **Control ANS Transfer through Aquatic Pathways** – Protect the GL and MR basins from the significant environmental, economic, and social/political impacts of ANS by controlling the transfer of ANS through the Chicago Area Waterway System and other aquatic pathways along the MR and GL basin divide.

The divide separating the GL and MR basins spans nearly 1,500 miles that is breached by the permanent CAWS connection and a number of smaller viable aquatic pathways. The scope of the GLMRIS authority includes only the study of options and technologies available to prevent the spread of ANS **via aquatic pathways** between the MR and GL basins. Opportunity exists for this nontraditional study to investigate and to assess effective methods for dispersal prevention (risk reduction to the maximum extent possible) for ANS species that may transfer via the aquatic pathways.

3. **Control ANS Transfer through Non-Aquatic Pathways –** Protect the GL and MR basins from significant environmental, economic, and social/political impacts by controlling ANS transfer through non-aquatic pathways between the MR and GL basins.

Although non-aquatic pathways are beyond the GLMRIS study scope, recognizing that these pathways exist and pose a threat for interbasin transfer is critical to successful ANS transfer prevention and management. In order to minimize or eliminate ANS transfer in a whole systems context, these non-aquatic pathways require the attention of federal, state, and local governments, as well as public education, support, and involvement via avenues other than GLMRIS.

4. **Control New Aquatic Nuisance Species –** Protect the GL and MR basins from significant environmental, economic, and social/political impacts by controlling ANS transfer through aquatic pathways into the GL and MR basins along their unshared boundaries.

Although outside the scope of the GLMRIS study authority, monitoring and effective management of ANS in basins adjacent to the study area, along with efforts to control introduction via aquatic pathways, may provide an opportunity to minimize environmental and economic impacts to the MR and GL basins. Identification of new species with the potential for introduction from outside the MR and GL basins would require planning and cooperation between governments and the public to prevent or minimize the impacts of new ANS transfer. The global nature of modern commerce and travel will continue to encourage ANS transfer, making education and public outreach more important at an international level.

1.6 The GLMRIS Report Objectives

Study objectives are statements that describe the desired results of the Planning Process by identifying the problems and realizing the opportunities associated with the study purpose and need. These objectives were used for the development and evaluation of alternative plans. Objectives must be clearly defined and provide information on the effect desired, the subject of the objective (what will be changed by accomplishing the objective), the location where the expected result will occur, the timing of the effect (when would the effect occur), and the duration of the effect.

As the GLMRIS authority is specifically focused on preventing ANS transfer via aquatic pathways, objectives are quite limited and are specifically directed at two of the four problem/opportunity statements, presented in Section 1.3: (1) Aquatic Nuisance Species and (2) Aquatic Pathways. Problem/opportunity statements (3) Non-Aquatic Pathways and (4) New Aquatic Nuisance Species are considered as part of the ANS risk assessment methodology, but are not specific objective of GLMRIS.

1. **Prevent Aquatic Nuisance Species Transfer** – Study the range of options and technologies available to prevent, by reducing the risk to the maximum extent possible, additional ANS transfer through the CAWS and other aquatic pathways between the MR and GL basins. 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.

The ultimate effect desired for this objective is the prevention of the transfer and subsequent establishment of new ANS to the Great Lakes and Mississippi River basins through aquatic pathways. USACE defines prevention as the reduction of risk to the maximum extent possible, because it may not technologically feasible to achieve an absolute solution. The risks and subsequent effects of ANS colonization of these habitat acres were assessed throughout the Great Lakes and Mississippi River basins. Measures developed to meet this objective need to result in the protection of aquatic resources including habitats and associated environmental, economic, and social resources. Effectiveness of plans developed from ANS control measures can be evaluated through a qualitative risk assessment.

2. **User and Resource Mitigation** – Address the need to mitigate impacts on significant natural resources and existing waterway uses and users as identified in GLMRIS Implementation Guidance such as commercial navigation, recreational navigation, stormwater management, and recreation.

The analysis shall address the need to mitigate the impacts of potential options and technologies on natural resources (such as water quality and ecosystems) and existing waterway uses and users (including commercial navigation, recreational navigation, and stormwater management). Technologies considered may be nonselective, meaning that there is no way to ensure that their implementation as a control for ANS transfer does not have potential for detrimental impacts to nontarget species. The array of alternative plans shall include an impact analysis associated with plan implementation on all current uses of the CAWS to the extent possible. The level and breadth of the impact analysis is not a NEPA analysis.

1.7 Federal Objective

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, executive orders, and other federal planning requirements and policies. USACE decisions regarding invasive species prevention, control, and management are guided by Executive Order 13112, Invasive Species; Executive Order 13340, Protection and Restoration of the Great Lakes; and the USACE Invasive Species Policy.

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

- Invasive Species (E.O. 13112)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C.§ 4701 et seq.)
- National Invasive Species Act of 1996 (16 U.S.C.§ 4701 et seq.)
- Lacey Act, as amended (18 U.S.C.§ 42)
- Agricultural Risk Protection Act of 2000 (7 U.S.C.§ 7712)
- Endangered Species Act of 1973, as amended (16 U.S.C.§ 1531 et seq.)
- Fish and Wildlife Coordination Act, as amended (16 U.S.C.§ 661)
- Migratory Bird Treaty Act of 1918, as amended (16 U.S.C.§ 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 U.S.C.§ 1251 et seq.)
- Safe Drinking Water Act of 1986 as amended (42 U.S.C.§ 300f)
- National Environmental Policy Act of 1969 (42 U.S.C.§ 4321 et seq.)
- Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C.§ 6901, et seq.)
- Comprehensive Environmental Response, Compensation and Liability Act, as amended (42 U.S.C.§ 9601)
- Coastal Zone Management Act, as amended (16 U.S.C.§ 1451–1466)
- Clean Air Act, as amended (42 U.S.C.§ 7401 et seq.)
- Protection and Restoration of 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 U.S.C.§ 1271 et seq.)
- Federal Water Project Recreation Act, as amended (16 U.S.C.§ 460L-12)

Executive Order 13112, Invasive Species – This executive order 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 National Environmental Policy Act of 1969, as amended (42 U.S.C.§ 4321 et seq.), Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 U.S.C.§ 4701 et seq.), Lacey Act, as amended (18 U.S.C.§ 42), Federal Plant Pest Act (7 U.S.C.§ 150aa et seq.), Federal Noxious Weed Act of 1974, as amended (7 U.S.C.§ 2801 et seq.), Endangered Species Act of 1973, as amended (16 U.S.C.§ 1531 et seq.), and other pertinent statutes.

Executive Order (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 (2001 Plan), served as a comprehensive "blueprint" for federal action on invasive species, as well as NISC's primary coordination 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 (2008 Plan) 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, critical support for efforts such as research, data and information management, education and outreach, and international cooperation elements were included in the plan. The 2008 Plan identified prevention as the first line of defense, and calls for preventing the introduction and establishment of invasive species to reduce their impact on the environment, the economy, and health of the United States.

Executive Order 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 caused 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, Protection and Restoration of the Great Lakes – 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 executive order. USACE has been a major participant in these activities. The executive order established the Great Lakes Interagency Task Force, composed of Secretaries from the Departments of State, Army, Agriculture, Commerce, Housing and Urban Development, Homeland Security, Interior, Transportation, the Administrator of the U.S. Environmental Protection Agency (EPA), and the Chairman of the Council on Environmental Quality. The Task Force worked with the governors of the eight Great Lakes states, mayors, and tribal leaders to establish the Great Lakes Regional Collaboration. This partnership of federal, state, tribal, and local governments was officially formed in December 2004 at a ceremony in Chicago. The initial goal of the collaboration was to develop a strategy for the protection and restoration of the Great Lakes within 1 year (http://www.glrc.us). The collaboration developed the strategy by using teams consisting of 1,500 stakeholders for the following eight priority issues identified by the Great Lakes governors and mayors of which those in bold pertain to this study:

1. Toxic contaminants
2. Non-point source pollution
3. **Coastal health**
4. **Habitat/species**
5. Contaminated sediments/AOCs
6. Indicators/information
7. Sustainable development
8. **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 Executive Order 13112. In executing USACE missions, districts are faced with numerous and diverse issues concerning invasive species. These problems occur on Corps managed and/or administered lands and waters, lands, and waters being proposed for Federal Civil Works projects, and Corps lands utilized for out grants and permits. This policy is applicable to the entire spectrum of Civil Works programs and projects and meets 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 research and development. Specific USACE objectives to achieve the intent of the national invasive species management plan (HQUSACE, March 2009) as it pertains to GLMRIS include:

Leadership and Coordination Goal: Work strategically, using all Corps scientific, management, and partnership resources in unison to manage invasive species.

- Partner/coordinate with local, state, and federal agencies and non-governmental organization (NGOs) to manage invasive species at the project, regional, and national levels; examples include the Cooperative Weed Management Areas; Aquatic Nuisance Species Task Force; Federal Interagency Committee on the Management of Noxious and Exotic Weeds; and the 100th Meridian Initiative.

Prevention Goal: Prevent introduction and establishment of invasive species to reduce their impact on the environment, economy, and health of the United States.

- Identify pathways by which invasive species could potentially invade Corps-managed projects.
- Take steps to intercept 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 introduced unintentionally.
- Develop a communication plan to share information about invasive species infestations on Corps projects.

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 Corps-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.
- Develop a program for coordinating rapid response to incipient invasions on Corps projects.

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 priority of invasive species control projects at local, regional, and ecosystem-based 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 $130M per year (Table 1.1), with the majority of those costs allocated for ANS Control and Management.

1.8 Constraints and Limiting Factors

Constraints or limiting factors include issues that restrict the Planning Process or implementation of features. Constraints that need to be considered are legal, policy, and resource constraints, as well as environmental factors. Legal and policy constraints are those defined by law and Corps policy and guidance. Resource constraints are those associated with limits on knowledge, expertise, experience, ability, data, information, money, and time. Environmental constraints are those that may adversely impact significant natural resources. The following constraints are specifically applicable to the study effort:

Table 1.1 USACE Invasive Species Costs

Strategic Goal	FY 2012 Actual Expenditures	FY 2013 Estimated	FY 2014 President's Budget
Prevention Totals	$16,749,079	$22,511,054	$8,477,825
Early Detection & Rapid Response Totals	$7,855,293	$8,397,343	$9,225,489
Control and Management Totals	$87,101,418	$66,785,775	$89,515,363
Research Totals	$3,676,000	$4,648,000	$690,000
Restoration Totals	$15,363,875	$26,828,950	$19,653,975
Education & Public Affairs Totals	$2,879,213	$2,611,424	$2,796,070
International Cooperation Totals	$1,261,000	$1,356,000	$1,505,000
Cumulative Total	**$134,886,478**	**$133,138,546**	**$131,833,722**

1.8.1 Legal and Policy Constraints

- Study Authorization is limited to examining options and technologies that are available to prevent the transfer between the Great Lakes and Mississippi River basins through aquatic pathways. 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 authority. In addition, the spread of ANS by attachment to nonaquatic animals, such as transport by migratory waterfowl, is also outside of the scope of this study.

- Prevention of ANS transfer between the GL and MR basins through aquatic pathways includes the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution although that is the desired end state.

- Shared Boundaries are recognized in terms of potential ANS transfer between the United States and Canada and between the Great Lakes basin and the Atlantic Slope drainage and between the Mississippi River and the Gulf of Mexico. However, it is not within the study authority to address ANS issues between international boundaries or beyond the interface of the Great Lakes and Mississippi River basins. Despite this constraint, a commensurate level of involvement, coordination, and communication was pursued during the study scoping process, and in follow on public and stakeholders coordination outside of the Detailed Study Area, which includes other state and bi-national agencies.

- Law and Policies must be complied with if applicable. These include but are not limited to applicable statutes, regulations, treaties, court decrees, executive orders, and USACE policies. Regulatory requirements will be considered in the development of alternative plans, including mitigation features. Detailed assumptions regarding requirements relating to project features are discussed in Section 2.5.

1.8.2 Resourcing Constraints

- Project Schedule and Resourcing limitations may preclude acquiring and/or analyzing certain data sets for planning level designs, costs, or benefits. Analyses for the GLMRIS Report were scaled to meet the MAP-21 schedule requirements. USACE had initially scoped GLMRIS to include the development of a recommended plan and associated NEPA compliance documentation. However, after the MAP-21 legislation was enacted, USACE determined that the time required to complete a recommended plan and associated NEPA compliance documentation would exceed the 18-month report timeframe in the MAP-21 Act. As a result, the GLMRIS Report does not include a recommendation, but instead presents a range of options and technologies available to prevent the transfer of ANS between the Great Lakes and Mississippi River basins. The GLMRIS Report also documents additional analyses that would be needed prior to the identification of a recommended plan for implementation. Additionally, the Agencies and Stakeholders collaboration and contribution of resources and information may be limited in time and funding to provide necessary data and support.

1.8.3 Environmental Constraints

- Induced Flooding. The alternatives should avoid or minimize potential changes to hydraulic and hydrologic regimes. Small changes in flood stages can have significant effects within the study area due to flat topography. Identified measures must ensure that implementation would not result in adverse effects to properties, facilities, or the environment. Project features that would induce flooding will require consideration of additional measures to mitigate for flood impacts.

- Water Quality Degradation. The alternatives should avoid or minimize potential adverse effects on water quality of natural bodies of water such as Lake Michigan, the Illinois River, and the Des Plaines River. Any measure or alternative plans that would cause noncompliance with state water quality standards may require mitigation measures.

1.8.4 Social Constraints

- Use Change for Waterway Users. The alternatives should avoid or minimize potential changes to the infrastructure and operating parameters of the CAWS in terms of navigation, recreation, and water uses.

1.9 Remaining Requirements

The 90-day report identified milestones to be met prior to the completion of this report and the funding necessary to complete them. It included an inventory of additional analyses and legal and policy requirements that would not be addressed in the GLMRIS Report. The 90-day report noted that the following additional analyses would need to be completed after January 2014, but prior to recommending a specific alternative:

- Site-specific investigations and analyses;
- Site-specific designs;
- Detailed drawings, quantities, and cost estimates;
- Detailed evaluations of impacts and with-project mitigation requirements;
- Optimized designs for controls and any mitigation features;
- A recommended plan;
- Independent external peer review report;
- USACE Planning model certification; and
- Completed NEPA compliance documentation.

Upon completion of analyses to date for the GLMRIS Report, this list remains an accurate synopsis of the remaining requirements needed prior to the recommendation of a specific alternative.

Involvement of a non-federal sponsor(s) willing to cost share a plan is required by USACE policy in order to recommend authorization of a project. See Engineer Regulation 1105-2-100 at 4-3. Under current law, non-federal sponsors are required to pay for 35% of environmental 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 operation and maintenance activities. See 33 U.S.C.§ 2213(c)(7), (j). Thus implementation of a GLMRIS Alternative could not proceed unless a non-federal sponsor is identified, or the statutory authorization for implementation of a GLMRIS Alternative specifically changes these requirements.

1.10 Next Steps

Absent further direction and pending the availability of funding, the engagement of stakeholders will be a critical next step to try to identify and build consensus toward a collaborative path forward for GLMRIS. The completion of additional detailed investigations into one or more of the conceptual alternatives presented in this document would refine current assumptions and allow the team to fill gaps in critical datasets. Future study efforts to recommend a specific alternative would include state, agency, and public review/comment, as well as completion of statutory requirements including Model Certification and Independent External Peer Review. Portions of alternatives that do not fall within USACE mission areas may be referred to other entities for their consideration.

1.11 Study Area Description

The GLMRIS study area includes the Great Lakes and Mississippi River basins within the United States with attention given to bordering watersheds (Figure 1.1). Potential aquatic pathways between the basins exist along the boundary between the two watersheds, indicated by the red/white dashed line. This interface is the primary concentration of the study. USACE has defined a Detailed Study Area to include the regions where the largest economic, environmental and social impacts of project alternatives are anticipated. The Detailed Study Area consists of the Upper Mississippi and Ohio River basins (shown in Green) and the Great Lakes basin (shown in Brown). Future ANS may transfer beyond the Detailed Study Area, as was observed by the spread of the zebra mussel from the Great Lakes to the Mississippi River basin; therefore, the General Study Area encompasses the lower Mississippi River basin and tributaries (shown in grey).

Figure 1.1 GLMRIS Study Area

Not included within the study area are locations where watersheds direct flow to a basin other than the Mississippi River or Great Lakes basins (e.g., Hudson River, Delaware River, Susquehanna River, Chesapeake Bay, or Souris-Red-Rainy River basins). The Great Lakes and Mississippi River basins also have open surface water pathways to the Atlantic Ocean via the Gulf of Mexico, which are used for international commercial navigation, among other uses. For example, on the Great Lakes side are the Saint Lawrence Seaway and Erie Canal, and on the Mississippi River basin side are the Port of New Orleans and the Lock and Dam facilities on the Mississippi and Ohio Rivers upstream of their confluence. Evaluation of alternatives to prevent ANS transfer through those aquatic pathways is outside the scope of GLMRIS.

1.12 Project Management Plan

In accordance with the Study Authority and Implementation Guidance, study efforts were initiated upon receipt of Congressional Appropriations in June 2009. USACE established a study team to begin drafting a Project Management Plan (PMP), which defines project requirements, identifies expected outcomes, and guides project execution and decision-making authority. Primary uses of the PMP include the facilitation of communication among project participants, the delegation of project study team responsibilities, the definition of assumptions, and the documentation of the processes toward establishing a baseline plan for the scope of the study. The PMP exists as a "living" document that can be adjusted, as necessary and with the appropriate approval process, as a project evolves.

The PMP defines the project study area, as described above, and further details the operational management of GLMRIS activities into two Focus Areas. As the watershed boundary between the Great Lakes and Mississippi River basins covers a geographically large expanse, it was determined early in the study development process that overall programmatic management of study efforts would be conducted by the Great Lakes and Ohio River Division, located in Cincinnati, OH. As USACE studies are usually managed at the local District level, the PMP established that the Chicago District would concentrate resources on the CAWS — designated as Focus Area 1 — while the remainder of the watershed boundary, Focus Area 2, would be studied under the direction of the Buffalo (NY) District. This division of resources enhanced the ability to accelerate efforts on the respective tracks of study, but necessitated close coordination between the study teams.

1.12.1 Focus Area 1: Chicago Area Waterway System

For the GLMRIS Report, the Chicago Area Waterway System (Figure 1.2) consists of approximately 128 miles of waterways in the Chicago Metropolitan area used for conveyance of stormwater runoff and municipal wastewater effluent, commercial and recreational 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 result in a limited habitat for aquatic biota. Homogenous silty sediments that restrict macroinvertebrate and fish populations are deposited throughout much of the CAWS due to the unnatural stream flow dynamics (MWRD 2008). Water quality is also impaired throughout the system and fails to support many of the designated uses for the waterways (IEPA 2012).

The CAWS contains five aquatic pathways between the Great Lakes and Mississippi River basins. As shown in Figure 1.2, each of these pathways has a single connection point to the Great Lakes basin: (1) Wilmette Pumping Station, (2) Chicago River Controlling Works (CRCW), (3) Calumet Harbor, (4) Indiana Harbor and Canal, and (5) Burns Small Boat Harbor. All five pathways share a common connection point with the Mississippi River basin at the Brandon Road Lock and Dam. The pathways are comprised of a combination of twelve waterways: North Shore Channel (NSC); North Branch Chicago River (NBCR); North Branch Canal (NBC); South Branch Chicago River (SBCR); Chicago River;

Figure 1.2 Focus Area 1: GLMRIS Report Chicago Area Waterway System

Chicago Sanitary and Ship Canal (CSSC); Little Calumet River (LCR); Calumet-Sag Channel, Calumet River; West Branch of the Grand Calumet River (GCR); Indiana Harbor and Canal (IHC); and, Burns Ditch/Burns Small Boat Harbor (Burns SBH).

Table 1.2 identifies which waterways comprise the five aquatic pathways in the CAWS.

The CAWS is a complex, multipurpose waterway that has many uses and users that developed to accommodate the needs of the City of Chicago as its population grew and economy expanded. Uses and users of the CAWS include, but are not limited to: stormwater management; effluent conveyance; water supply and discharge; emergency response vessels; commercial navigation; recreational boating; sport fishing; and power generation. The CAWS is operated by the Metropolitan Water Reclamation District of Greater Chicago (MWRD) primarily to accommodate stormwater and effluent conveyance and USACE for the purposes of commercial and recreational navigation. A change in waterway conditions resulting from the implementation of a given alternative may require significant adaptation on the part of users of the CAWS and extensive change of system operations. Major users that rely upon the current configuration or conditions of the CAWS may face significant challenges in updating their infrastructure and management practices in order to meet new requirements.

Table 1.2 Pathway and Waterway Matrix

	Waterway											
Pathway	North Shore Channel	NBCR	North Branch Canal	SBCR	Chicago River	CSSC	Little Cal	Cal-Sag Channel	Calumet River	West Branch Grand Cal	Indiana Harbor	Burns Ditch
Wilmette	X	X	X	X		X						
CRCW				X	X	X						
Calumet Harbor						X		X	X	X		
Indiana Harbor						X		X		X	X	
Burns SBH						X	X	X				X

Focus Area 1 CAWS Team Organization

In Focus Area 1, the CAWS Team was diversified into functional teams, comprised of regional or multidisciplinary collections of technical specialists. These Product Teams incorporate expertise from across the USACE organization, including subject-matter experts from USACE Centers of Expertise, District-based regional technical experts, and the USACE Engineering Research and Development Center. Product Teams focused on broad topic areas that represented key data-gathering and modeling needs for the study. Each Product Team and Sub-Team includes a local (Chicago District-based) Team Lead, who serves as the nucleus of the study team. Team and Sub-Team Leads are responsible for oversight of team activities, compilation of information in a coordinated, hierarchical manner, and communication with the CAWS Project Management staff.

Table 1.3 identifies the Project Management and Product Team elements in Focus Area 1 and provides a brief description of the responsibilities of the teams.

Table 1.3 Focus Area 1 Product Teams

Role	Mission Summary
Project Management Team	Coordinate all elements of study activities among functional teams; responsible for staff-level implementation of all aspects of GLMRIS.
Navigation and Economics Team - Cargo Navigation Sub-Team - Non-Cargo Navigation Sub-Team - Fisheries Sub-Team - Flood Risk Management Sub-Team	Compile baseline information on economic aspects of the study area, including commercial and recreational navigation, fisheries, regional economics, hydropower, and water quality; conduct with-project analyses for cargo navigation, flood risk, and regional economics, and evaluate mitigation for impacts of various alternatives.
Natural Resources Team - NEPA Sub-Team	Identify and quantify significant natural resources relevant to problems and opportunities; identify existing ANS, possible habitat, and potential transfer mechanisms; quantify baseline risks associated with ANS transfer. Initiate scoping processes and baseline analyses consistent with NEPA.
Hydrology and Hydraulics Team	Develop and apply hydrologic models to address relevant data requirements, including the identification of flood risks, and identify flood impact mitigation requirements for various alternative plans.
Environmental Quality Team	Identify and quantify existing water quality constraints, including the forecasting and modeling of future conditions; identify other environmental factors including air quality, industrial users, and hazardous, toxic, or radioactive waste sites; and evaluate water quality impacts of various alternatives.
Technology Team	Identify controls for identified ANS of Concern and estimate the cost to construct, operate, and maintain such ANS Controls; forecast effectiveness of controls on reducing ANS transfer risks.
Communications Team	Establish a strategy for GLMRIS to ensure effective communication of pertinent, project-related information to project stakeholders and the public; facilitate an internal communications framework; and facilitated receipt of comments from stakeholders.
Plan Formulation Team	Comprised of representatives from each of the above functional teams; responsible for the integration of the multiple study components, including coordination of the GLMRIS Report.

1.12.2 Focus Area 2: Other Aquatic Pathways

Focus Area 2 of GLMRIS evaluates potential surface-water connections between the Great Lakes and Mississippi River basins in the states of New York, Pennsylvania, Ohio, Indiana, Wisconsin, and Minnesota (Figure 1.3). Any surface water connections within the state of Illinois are incorporated within Focus Area 1 of GLMRIS. Focus Area 2 encompasses all natural and man-made aquatic surface water pathways and hydraulic connections that exist or may form intermittently between the basins outside of the CAWS. The focus of this investigation is along the approximately 1,500-mile basin divide that delineates the Great Lakes basin drainage from the drainage of the Mississippi River basin.

Focus Area 2 Other Aquatic Pathways Team Organization

In Focus Area 2, the Other Aquatic Pathways Team followed a parallel "team of teams" approach. Due to the significant natural variability associated with the hydrology and biology the vast geographic area following the watershed boundary, the Other Aquatic Pathways Team identified available experts from both within USACE as well as from outside sources. Local, state, and federal hydrologists and biologists were engaged to identify and assess conditions at each potential aquatic pathway along the basin divide. In addition, a sub-team within Focus Area 2 was formed to complete the ANS Controls Report for Eagle

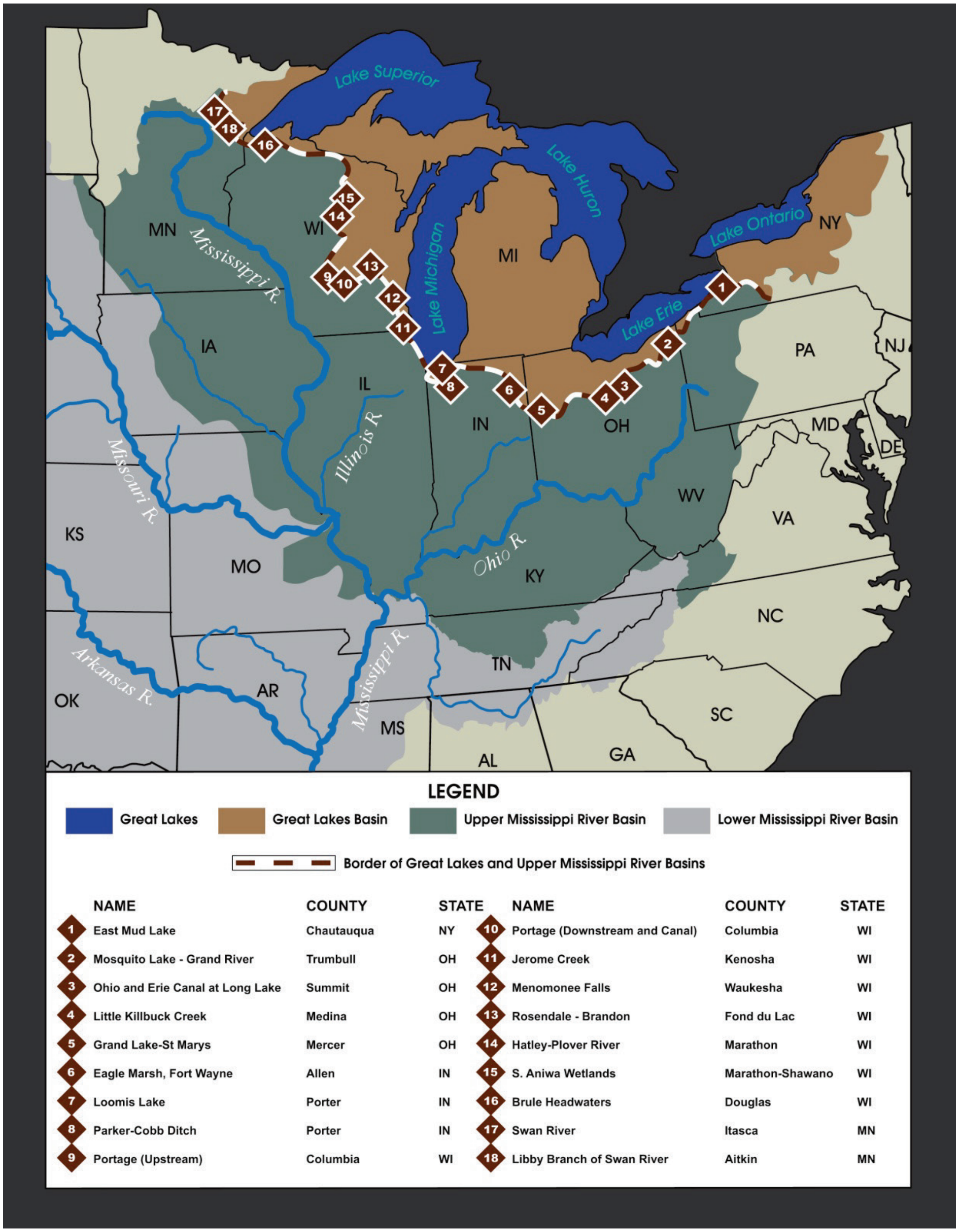


Figure 1.3 Focus Area 2: Other Aquatic Pathways

Marsh. This team was led by USACE Louisville District which collaborated closely throughout the development of the report with the Indiana Department of Natural Resources (INDNR), U.S. Geological Survey (USGS), Natural Resources Conservation Service (NRCS), U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (EPA), White House Council on Environmental Quality (CEQ), Little River Wetlands Project, Maumee River Basin Commission, Allen County Soil and Water Conservation District, and the Allen County Surveyor's Office. The entire report is available at: http://glmris.anl.gov/documents/interim/fa2/index.cfm.

Staff from several USACE Districts as well as from state departments of natural resources, USGS, USFWS, and NOAA worked collaboratively to complete the Preliminary Risk Characterization in 2010. Following this report and its recommendations, a broader team of aquatic biologists, water resource scientists, and engineers was assembled to complete 18 detailed site investigations and provide input and guidance during the assessments. Pathway assessment teams were formed for each potential pathway location and were organized by state, all under project management by USACE. Approximately 30 personnel from eight USACE Districts participated. Additionally, over 30 professionals from other federal and state organizations made significant contributions to these investigations over a 2.5 year period, including natural resource agencies, environmental quality agencies, conservation/protection agencies, as well as other state and local organizations. Many of these other agency personnel were embedded directly on the pathway assessment teams in the field assisting with ratings and providing data and professional judgment in the areas of aquatic biology, ANS, and hydrology. Approximately 20 individuals from eight organizations also helped to complete independent technical reviews on the draft pathway assessment reports as well as a Summary Report for Focus Area 2 (FA2). The significance of the contributions from all of these non-USACE organizations cannot be overstated, and added greatly to the scientific rigor, thoroughness, and timely completion of the FA2 assessments. Further detail is provided in Appendix N to this report, as well as within the specific pathway assessment reports that are available at the website provided above.

1.12.3 Coordinated Study Oversight

To ensure consistent communication and coordination during the study, USACE leadership from the Great Lakes and Ohio River Division (LRD), as well as the Mississippi River Valley Division (MVD), formed an executive-level oversight committee known as the Senior Executive Review Group (SERG). The SERG is comprised of the Commanding Generals and Senior Executive Service representatives from LRD and MVD, District Commanders and Deputies for Project Management, or their designees, as well as the LRD and MVD Regional Integration Team representatives from Headquarters, USACE. The SERG meets quarterly to receive updates on the progress and direction of GLMRIS, and works directly with the Program Manger and Focus Area Project Managers to provide internal guidance in accordance with USACE policies and directives.

1.12.4 GLMRIS Report Study Area Focus

The MAP-21intervening legislation (Section 1.4) directed USACE to focus the GLMRIS Report on the Chicago Area Waterway System. As such, the alternatives presented in Chapter 3 were developed for Focus Area 1. Additional information about study activities for Focus Area 2 can be found in Appendix N.

1.13 Study Scoping

At the initiation of the GLMRIS effort, the USACE project team originally scoped the study to include the development of a recommended plan and an associated Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA). As part of that effort, NEPA public scoping meetings were conducted and cooperating agencies were sought.

After the enactment of Section 1538 of Public Law 112-141 of the *Moving Ahead for Progress in the 21st Century Act* (MAP-21), which required the submission of this Report on an expedited timeline, USACE determined that a recommended plan and the associated EIS could not be completed within the 18-month timeframe set forth in the MAP-21 legislation. Thus, the GLMRIS Report does not include a recommendation but, consistent with the unique authority in Section 3061 of WRDA 2007, presents "a range of options and technologies available" to prevent the transfer of ANS between the basins. As a result, this Report does not include NEPA documentation such as an EIS, because "planning and technical studies which do not contain recommendations for authorization or funding for construction, but may recommend further study" are categorically excluded from NEPA documentation requirements. See 33 C.F.R. 230.9 (d). Although MAP-21 allows the Secretary to proceed to Preconstruction Engineering and Design (PED) if a project is found to be justified, NEPA compliance documentation, along with other additional analyses and requirements, would need to be completed prior to USACE recommending a specific plan.

1.13.1 Cooperating Agencies

In late 2009, USACE transmitted federal agency and Tribal scoping letters to agencies and tribes within the study area. The letters invited recipients to join the study team and participate in a collaborative GLMRIS effort. Cooperating Agency agreements were formalized with the U.S. Environmental Protection Agency, the U.S. Coast Guard, and the U.S. Fish and Wildlife Service. In addition, a formal memorandum of understanding (MOU) was signed by the U.S. Geological Survey to support GLMRIS efforts.

1.13.2 NEPA Public Scoping

As discussed above in Section 1.10, the USACE project team originally scoped the study to include an EIS under NEPA. When preparing an EIS, NEPA, requires the preparation and implementation of public participation plans to guide the public and stakeholder involvement process. 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 from the public at twelve (12) locations within the Great Lakes and the Mississippi River basins. These meetings occurred between December 2010 and March 2011. Dates and locations of the public scoping meetings are listed in Table 1.4. During the scoping period, the public was provided with several methods for submitting comments or suggestions on GLMRIS, 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 and ended March 31, 2011.

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 2011), is also available online. However, as discussed in detail in Section 1.10, after Section 1538 of MAP-21 was enacted, USACE determined that a recommended plan and the associated EIS could not be completed within the 18-month timeframe set forth in the MAP-21 legislation. Thus, the GLMRIS Report does not include a recommendation or associated NEPA documentation.

Table 1.4 Locations and Dates for GLMRIS Public Scoping Meetings

City	Date	Location
Chicago, IL	Dec.15, 2010	University of Chicago, Gleacher Center
Buffalo, NY	Jan. 11, 2011	Buffalo Conference Center, Hyatt Regency
Cleveland, OH	Jan. 13, 2011	Great Lakes Science Center
Minneapolis, MN	Jan. 20, 2011	University of Minnesota, McNamara Alumni Center
Green Bay, WI	Jan. 25, 2011	NE Wisconsin Technical College, Center for Business & Industry
Traverse City, MI	Jan. 27, 2011	Northwestern Michigan College, Hagerty Conference Center
Cincinnati, OH	Feb. 1, 2011	University of Cincinnati, Tangeman Center
St. Louis, MO	Feb. 8, 2011	Great Lakes River Museum, Alton, IL
Vicksburg, MS	Feb. 10, 2011	Vicksburg Convention Center
Milwaukee, WI	Feb. 15, 2011	O'Donnell Park Complex, Miller Room
New Orleans, LA	Feb. 17, 2011	Port of New Orleans Administration Building
Ann Arbor, MI	Mar. 18, 2011	Eagle Crest Conference Center, Ypsilanti, MI

1.14 Stakeholder Engagement

Through the scoping process with federal, state, and local agencies, as well as the initial public scoping effort, the study team recognized the critical nature of stakeholder engagement in the execution of GLMRIS. In accordance with the USACE Implementation Guidance, the GLMRIS Team developed a variety of methods to obtain input to the study process from appropriate federal, state, local, and nongovernmental entities and the public. Key efforts included the establishment of a multi-agency advisory committee, the release of interim study products, and a strong presence on the internet and social media.

1.14.1 Executive Steering Committee

As a supplement to the internal USACE study management structure, the PMP established the GLMRIS Executive Steering Committee (ESC). The purpose of the ESC was to provide macro-level study consultation and facilitate coordination among various federal, state, and bi-national agency interests and activities. The ESC is comprised of a collaborative body of federal, state, and regional governmental authorities that provide advice to the overall study by maintaining a working knowledge of GLMRIS, advising the study management team, and facilitating coordination among partner agencies. Agencies were contacted to identify shared responsibilities among ANS prevention efforts, as well as acknowledge existing activities, while providing input on GLMRIS study efforts. ESC meetings are held quarterly, usually in conjunction with meetings of the Asian Carp Regional Coordinating Committee (ACRCC). The formation and function of the ESC is consistent with the GLMRIS study authorization, which directed the Secretary to consult with appropriate agencies in the conduct of the study. Figure 1.4 displays the GLMRIS Management Structure.

1.14.2 Interim Products

Recognizing the significant stakeholder and public interest that GLMRIS generated during the scoping phase of the study, USACE decided to produce interim reports during the study process. A non-traditional practice in USACE studies, GLMRIS Interim Products were developed during the data-gathering phases of the study to give insight to study progress, as well as to provide new study-related information to the public and stakeholder groups on a regular basis.

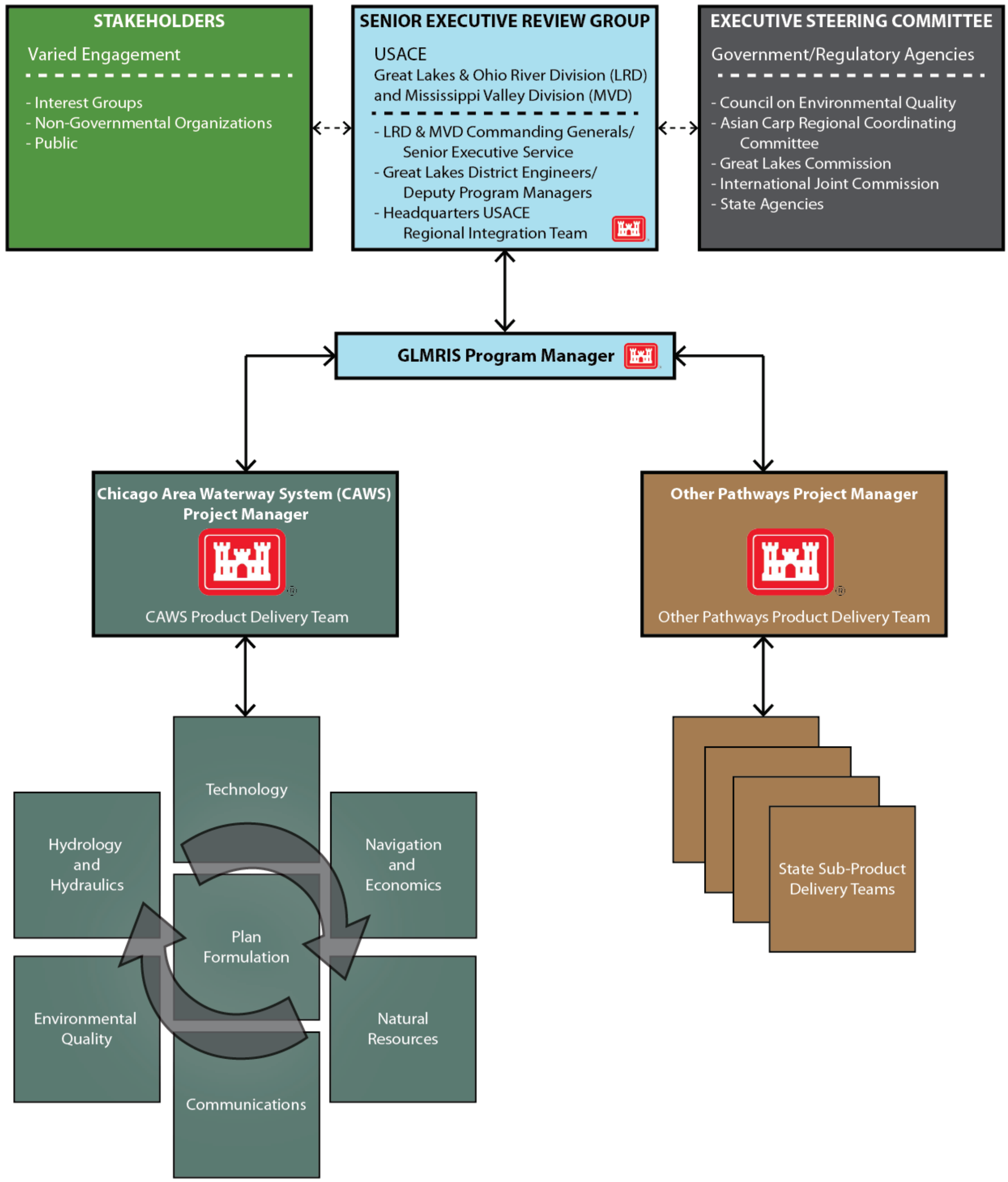


Figure 1.4 GLMRIS Management Structure

Interim Products were generated during the data-gathering phase, and included the results of baseline data collection for physical, environmental, and economic features of the study. USACE resources were dedicated to develop these documents and ensure that appropriate levels of technical review were completed, such that these reports could be released to the public. It was also recognized that potential intermediary actions might be identified as a result of these Interim Products to further focus study efforts or prompt interim actions.

The Interim Products that were completed and released for GLMRIS are contained in Table 1.5. In all, the Focus Area 1 Team released eight (8) Interim Products covering a range of baseline environmental, economic, and social/cultural data, as well as the identification of ANS of Concern for the CAWS study area and an inventory of ANS Controls that may be applicable to one or more of the "ANS of Concern" identified for the CAWS. The Focus Area 2 Team evaluated potential aquatic pathways that exist or are likely to form across the nearly 1,500-mile basin divide separating the Mississippi River and Great Lakes basin watersheds. Following a preliminary characterization report, individual pathway assessment documents were assembled for each of the 18 identified sites, as well as an overall summary report.

Table 1.5 Interim Products of GLMRIS

Product	Release Date
Focus Area 1	
ANS White Paper	Jul 2011
NEPA Scoping Report	Sep 2011
Commercial Non-Cargo Navigation Baseline	Sep 2011
Commercial Cargo Navigation Baseline	Dec 2011
ANS Control Technology Report	Apr 2012
Commercial Fisheries Baseline	May 2012
Subsistence Fishing Review	Jul 2012
Pro-Tournament Fishing Review	Jul 2012
Focus Area 2	
Preliminary Pathway Characterization Report	Nov 2010
Final Pathway Characterization Report	Sep 2012
Specific Pathway Reports (18)	Sep 2012 through Mar 2013
Eagle Marsh ANS Controls Report	Aug 2013

1.14.3 Other Engagement Activities

The identification and engagement of nongovernmental and community stakeholders who are interested in GLMRIS is a critical aspect of the overall study effort. In addition to the NEPA scoping effort that took place near the beginning of the study process, the GLMRIS Team continued to actively organize and participate in stakeholder meetings in an effort to promote coordination between agency groups, as well as the public, NGOs, and other project stakeholders. USACE primarily engaged and communicated with stakeholders via a strong online and social media presence. The GLMRIS Team established a dedicated website, glmris.anl.gov, to capture study activities and inform stakeholders, and cultivated a regular presence on social media sites including Facebook and Twitter.

Interim Products were rolled out to the public and stakeholder groups via media releases and dedicated telephonic forums, as well as announced and posted to online resources. Updates on GLMRIS activities are provided at bi-weekly ACRCC meetings to inform and coordinate with other governmental agencies, and the GLMRIS Team participates at the scheduled public sessions that the ACRCC hosts on a regular basis. Information on upcoming events, summaries of ongoing efforts, and repositories of Interim Product information are all centralized on the GLMRIS website. The GLMRIS Team continues to strive to enhance stakeholder engagement through dissemination of information on the GLMRIS website, via social media, by publishing a quarterly newsletter, and participating in variety of publicly available meetings, conferences, and stakeholder engagement forums.

1.15 Additional ANS Control Efforts

During the public scoping period in late 2010 through early 2011, numerous comments were received by USACE demonstrating public and environmental stakeholder concern regarding the possible transfer of two Asian carp species, the Bighead and Silver carp, through the CAWS into the Great Lakes. The public scoping meetings and subsequent stakeholder engagement events allowed USACE the opportunity to highlight ongoing activities to prevent Asian carp transfer into the Great Lakes that are being conducted concurrently with GLMRIS efforts.

As a member of the Asian Carp Regional Coordinating Committee (ACRCC), USACE is committed to preventing Asian carp from utilizing potential aquatic pathways to transfer into the Great Lakes. USACE is contributing to this effort through the implementation of a four-pronged strategy, which includes (1) operation of electric barriers in the Chicago Sanitary and Ship Canal (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 GLMRIS. Additional detailed information on USACE efforts against Asian carp can be found at www.lrc.usace.army.mil.

It is additionally important to differentiate between the scope and objectives of GLMRIS in comparison to other concurrent studies relating specifically to Asian carp and the CAWS. These other studies can be broadly differentiated into two categories: Efficacy Studies and Studies by Other Organizations.

1.15.1 Efficacy Studies

In addition to GLMRIS, Section 3061(b)(1)(D) of WRDA 2007 directs the Secretary to conduct a study of a range of options or technologies for reducing impacts of hazards that may reduce the efficacy of the Electrical Dispersal Barrier System located on the CSSC. USACE has specifically focused the efficacy studies on efforts that could reduce the potential for Asian carp to enter Lake Michigan.

The Efficacy Study was developed as a series of interim reports by USACE. Completed reports include: Interim I, Dispersal Barrier Bypass Risk Reduction Study and Integrated Environmental Assessment; Interim II, Electrical Barrier Optimum Operating Parameters; Interim III, Modified Structures and Operations, Chicago Area Waterways and Integrated Environmental Assessment; and Interim IIIA, Fish Deterrent Dispersal Deterrents/Barriers, Illinois and Chicago Area Waterways and Environmental Assessment. The completed and approved studies are posted on the Chicago District website at www.lrc.usace.army.mil/Missions/CivilWorksProjects/ANSPortal/Efficacy.aspx.

An additional Efficacy Study report, the Interim IV Efficacy Study Report, will be finalized in 2014. The report will document the improvements made to increase the efficacy of the Electric Barriers Project. Further, the report will include a risk analysis of the Electric Barriers Project, which will inform future improvements to the project. The report will also document efforts by other agency members of the ACRCC including monitoring, telemetry, controls, and population reduction. The Corps may complete additional Efficacy Studies in the future to document modifications to the project or to document additional recommendations consistent with the study authority. Summaries of the Efficacy Studies follow.

(1) *Interim I*, *Dispersal Barrier Bypass Risk Reduction Study and Integrated Environmental Assessment* – This interim report was approved by the Assistant Secretary of the Army for Civil Works (ASA (CW)) on 12 January 2010 to construct measures to prevent Asian carp from bypassing the electrical barrier system during flood events on the Des Plaines River and through culverts in the Illinois and Michigan (I&M) Canal. USACE awarded a construction contract on 21 April 2010 for the construction of the bypass barrier. Construction of the bypass barrier was completed in October 2010.

(2) *Interim IIA, Electrical Barrier Optimal Operating Parameters: Phase A, Laboratory Research and Safety Tests* – This interim report provided an evaluation of tests conducted to determine the optimal operating parameters for the barriers. A follow-on report may be released after additional tests and evaluation of risk factors have been completed. The subsequent report will be used primarily to further inform barrier operations.

(3) *Interim III, Modified Structures and Operations, Chicago Area Waterways Risk Reduction Study and Integrated Environmental Assessment* – This interim report presented an evaluation of the potential for risk reduction that might be achieved through potential changes in the operation of the CAWS structures, such as locks, sluice gates, and pumping stations, in consultation with the multi-agency working group. This 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 U.S. Fish and Wildlife Service (USFWS) and Illinois Department of Natural Resources (IDNR). This report was approved by the ASA (CW) on 13 July 2010. Installation of the sluice gate screens at the Chicago River Controlling Works at the Chicago Harbor Lock and at the Controlling Works at T.J. O'Brien Lock and Dam was completed in January 2011.

(4) *Interim IIIA, Fish Deterrent Barriers, Illinois and Chicago Area Waterways Risk Reduction Study and Integrated Environmental Assessment* – This interim report investigated and evaluated additional deterrent measures within USACE authority that could be quickly employed to potentially reduce the risk of the Asian carp dispersing into the Great Lakes. This report focuses on evaluating measures that apply readily available fish deterrent and guidance technologies at key locations in the CAWS and downstream in the Illinois Waterway (IWW). This analysis was initially included in the scope of Interim III, but was cycled out to consider fielding a developing technology that was thought to be quickly deployable and relatively inexpensive. This report was approved by the ASA (CW) on 13 July 2010.

(5) *Interim IV Efficacy Study Report* – This interim report will incorporate by reference the first four interim reports, documents the results of ongoing testing and analysis related to the Barriers Project, includes a systematic risk assessment of identified barrier failure modes, and identify upcoming risk reduction efforts for the Electric Barriers Project. Further, the report will include a comprehensive Environmental Assessment for the Electric Barriers Project. This report will document the efforts of the ACRCC, and various working groups to address the risks posed by

Asian carp to the Great Lakes. The Interim IV Efficacy Study Report will also include a discussion of improvements to the Electric Barriers Project that have been completed by USACE since the enactment of WRDA 2007 that serve to increase the performance of the project and reduce risk associated with barrier failure modes. The Interim IV Efficacy Study Report will also include updates on other efforts to increase the efficacy of the Electric Barriers Project and further reduce risk related to potential bypasses of the project by Asian carp. These updates include work by USACE, as well as other federal and state agencies as part of the ACRCC. Additional topics will include: monitoring and response actions, eDNA monitoring; other modes of transit including ballast water, and commercial harvesting.

1.15.2 Studies by Other Organizations

In November 2008, the Great Lakes Fishery Commission (GLFC) released a preliminary report documenting conditions of the CAWS, including history, uses, habitat, hydrology, and water quality. The GLFC report also documented potential separation technologies and scenarios toward the elimination of ANS transfer into the Great Lakes through the CAWS. The authors of the GLFC report cited "ecological separation" — prohibition of the movement or interbasin transfer of aquatic organisms between the Mississippi and Great Lakes basins via the CAWS — as the long-term approach to achieving protection for the Great Lakes and eliminating the risk of irreversible ecosystem damage. The text of the report can be found online at www.greatlakes.org/asian/carp.

In January 2012, the Great Lakes Commission (GLC) and Great Lakes and St. Lawrence Cities Initiative (Cities Initiative or CI) released the results of a dedicated, 18-month study that focused on developing and evaluating alternatives to physically separate the Great Lakes and Mississippi River watersheds in the CAWS. Hydrologic separation was identified by the GLC/CI as the most practical method for preventing the movement of aquatic nuisance species between the basins. The technical findings of the GLC/CI study are detailed in a combination of reports and appendices, available online at www.glc.org, and are summarized in a report titled *Restoring the Natural Divide: Separating the Great Lakes and the Mississippi River Basins in the Chicago Area Waterway System*.

1.16 Summary of Affected Environment

1.16.1 Overview

This section is a brief summary of the current conditions that exist in the study area, which are detailed in Appendix B – Affected Environment & Habitat. Appendix B includes documentation on baseline and future-without project conditions, for basin-wide as well as CAWS-specific resources. Future-without project conditions represent the projected or forecast conditions for resources within the study area for 50 years, beginning in 2017. The baseline year of 2017 was selected for several reasons, set forth in Appendix B, including the anticipated completion dates of the Thornton Reservoir and Stage 1 of the McCook Reservoir; the Corps' Electric Barrier System will be augmented by the operation of Permanent Barrier I and the adoption of new water quality standards for the CAWS. The GLMRIS Report utilized a 50-year period of analysis. The appendix includes a general overview of the environment of the Great Lakes and Mississippi River basins for affected resources in varying levels of detail, with detailed assessments for CAWS specific resources. Detailed assessments were prepared for the report including: the ANS Risk Assessment; Water Quality Analyses (CAWS and Lake Michigan); and Hydrologic and Hydraulic Modeling (CAWS). The appendix also summarizes future-without project conditions related to efforts of local, state, and federal agencies in the areas of ANS control, CAWS operations, and water quality regulation.

1.16.2 Baseline Conditions

The development of the Metropolitan Chicago region is to some extent the development of the area waterways and the lakefront to accommodate the needs of a growing city. As the city and the surrounding region developed from settlement to city, the natural landscape and waterways were modified. The occasional overland connection between the Chicago and Des Plaines Rivers was known historically as Mud Lake. This ephemeral overland connection between Lake Michigan and the Illinois River was converted to a permanent connection over time, beginning with the construction of the I&M Canal in 1848, just 11 years after the City of Chicago was incorporated. In 1871 much of city was destroyed in the Great Chicago Fire. Reconstruction of the city was rapid, including the need for navigation channels to connect the growing city to other ports. The construction of the Chicago Sanitary and Ship Canal by 1900 completed the reversal of the Chicago River. In 1937, the Chicago River Controlling Works were constructed at the mouth of the Chicago River and Lake Michigan. Additional channels were dug and completed, including the Calumet-Sag Channel, which reversed the flow of the Little Calumet River. A controlling works was constructed first at Blue Island in 1922. The current lock and controlling works, the T.J. O'Brien Lock and Dam, were constructed closer to the mouth of the Calumet River by 1965.

The newly constructed waterways served multiple functions for the City of Chicago. The waterways received sewage and floodwaters and conveyed the flow away from the city's water supply, homes, and businesses. The waterways also served to transport commodities between the Great Lakes cities and ports to the east and the Mississippi River cities and ports to the west and south. Existing rivers were straightened and channelized. By the start of the 20th century, most of the area's natural resources had been impacted or altered to facilitate growth of the City of Chicago and to support commerce. In addition to the development of the waterways, the physical landscape of the region was modified as residents strove to make this muddy low-lying area habitable. Modifications also included the development of large areas of landfill along the lakefront and the construction of timber crib revetments to protect the shoreline from wind and waves. USACE is currently working with the City of Chicago and the Chicago Park District to reconstruct 9.2 miles of original lakefront revetment which will protect critical infrastructure.

In addition to shoreline protection, USACE and other federal and local agencies are working to restore ecosystems throughout the metropolitan area including the lakefront and the CAWS. Every weekend throughout the year, volunteers gather at numerous locations to work on restoring the preserves and natural habitats. An example of this type of effort is the North Branch Restoration Project which is currently restoring fourteen sites along the North Branch of the Chicago River. The restoration projects support local flora and fauna, as well as migratory species that utilize Lake Michigan as a part of a globally significant flyway. Ecosystem restoration within the Mississippi River basin is also occurring at many locations including the Emiquon Project along the Illinois River. The Emiquon Project is one of the largest floodplain projects in the Midwest. The Mississippi River Environmental Management Program (EMP) is restoring and monitoring over 100,000 acres of aquatic habitat with the completion of 54 projects. An additional 81,000 acres of restored habitat will result from the completion of 36 more projects currently under construction or in design.

Concerns about public health resulted in the formation of the Sanitary District of Chicago and the construction of sewage treatment plants in the early 1900s. Additional capital projects, including the Deep Tunnel Project initiated in the 1960s, were constructed to reduce the discharge of raw sewage to area waterways. Currently, USACE is working with MWRD to construct two large reservoirs designed to store flow from the Deep Tunnels until the water can be treated at a water reclamation plant (WRP). The McCook and Thornton Reservoirs will significantly reduce the amount and frequency of combined sewer overflows (CSOs), and will also lower water levels in the CAWS, reducing flood risks to area residents.

As regulatory requirements have changed over the past 50 years, water quality in the region has improved. The Illinois Environmental Protection Agency (IEPA) and the EPA are working to address the quality of discharges to the CAWS. The intent of recent regulations and enforcement actions have been focused on improving the water quality of the CAWS. Since 1972, most segments of the CAWS have been designated for Secondary Contact use, which includes fishing, kayaking, canoeing, boating, and other activities where water contact is minimal or incidental, but excludes swimming and other Primary Contact activities. Based on information generated through a Use Attainability Analysis (UAA) conducted by IEPA, it was determined that recreation in and on the water is attainable for many segments of the CAWS. In 2012, EPA approved 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 recreational goal uses under Section 101(a)(2) of the Clean Water Act.

Aquatic Nuisance Species

Improved water quality has also increased the potential for the transfer of ANS between the Great Lakes and Mississippi River basins. Recent transferred ANS include the zebra mussel, quagga mussel, and round goby. The CAWS has been the focus of significant efforts by local, state, and federal resources agencies to address problems related to potential transfer of ANS between the Great Lakes and Mississippi River basins over the past several years. Many of the efforts that have been undertaken since 2009 have been supported by the ACRCC. The ACRCC is a bi-national organization led by the White House Council on Environmental Quality (CEQ). Supporting member agencies include: the City of Chicago (CoC); the Department Fisheries and Oceans Canada (DoF/OC); the Great Lakes Fishery Commission (GLFC); the Illinois Department of Natural Resources (IDNR); the Illinois Environmental Protection Agency (IEPA); the Indiana Department of Natural Resources (INDNR); the Michigan Department of Natural Resources (MDNR); the Michigan Office of the Great Lakes (MGL); the Minnesota Department of Natural Resources (MNDNR); the New York Department of Environmental Conservation (NYDEC); the Ohio Department of Natural Resources (ODNR); the Pennsylvania Department of Environmental Protection (PDEP); the Pennsylvania Fish and Boat Commission (PFBC); the Wisconsin Department of Natural Resources (WDNR); the Ontario Ministry of Natural Resources (OMNR); the Metropolitan Water Reclamation District of Greater Chicago (MWRD); the National Oceanic and Atmospheric Administration (NOAA); United States Army Corps of Engineers (USACE); United States Coast Guard (USCG); United States Department of Transportation/Maritime Administration (USDOT/MA); United States Department of Agriculture (USDA); United States Environmental Protection Agency (EPA); United States Fish and Wildlife Service (USFWS); and the United States Geological Survey (USGS).

The ACRCC's 2013 Framework documents the member agencies efforts in the upcoming year to address the problem of ANS in the CAWS, particularly Asian carp. As noted in the 2013 ACRCC Framework,

> Asian carp, particularly bighead, silver, and black carp, pose a significant threat to the waters that they invade. One of the most severe aquatic invasive species (AIS) threats facing the Great Lakes today is movement of Asian carp species through the Chicago Area Waterway System (CAWS) and possibly other pathways that can connect the Great Lakes to the Mississippi River Basin. The Administration is implementing an unprecedented and comprehensive set of actions to prevent introduction and establishment of Asian carp populations in the Great Lakes.

These actions are being carried out by the ACRCC, with support from federal, state, provincial, and local agencies, and from private stakeholders and citizens. The ACRCC implements actions for protecting and maintaining the integrity and safety of the Great Lakes ecosystem from an Asian carp invasion via all viable pathways. The ACRCC management strategy and current and future actions are reported annually in the Asian Carp Control Strategy Framework (ACRCC 2013).

Actions that comprise the Framework's strategy include:

- Prevention and development of prevention technologies;
- Monitoring and development of monitoring technologies;
- Development of control technology and impact mitigation; and
- Other supporting actions (education, outreach, and regulatory support).

The primary role of USACE in the ACRCC includes the construction, operation, and maintenance of the Electric Dispersal Barriers located on the Chicago Sanitary and Ship Canal (CSSC) in Romeoville, IL. USACE personnel also play key roles in the Monitoring and Rapid Response Workgroup (MRRWG) of the ACRCC as participants in monitoring programs and in the development of monitoring techniques and strategies to evaluate and improve the functionality of the Electric Dispersal Barriers. These efforts include the use of telemetry and DIDSON cameras to evaluate barrier effectiveness and participation in interagency use and refinement of environmental DNA (eDNA). While eDNA sample collection and testing have been transferred to the USFWS, USACE is completing calibration studies on the methodology.

In addition, USACE has developed a series of studies to improve the efficacy of the Electric Barriers Project. These studies, completed by USACE as a series of interim reports, documented interim measures that could be undertaken to address identified problems within the project study area and as potentially implementable technologies and actions to deploy in support of this multi-agency effort were identified. To date, USACE has completed four Efficacy Studies: Interim I, Interim II, Interim III and Interim IIIA, and will complete the Interim IV Efficacy Study in 2014. Recommendations from three of the four completed studies have been implemented including the construction of the Des Plaines and I&M Canal Bypass Barriers, modification of barrier operating parameters, and the installation of fish screens on sluice gates at two lakefront controlling works. The Efficacy Studies were not intended to evaluate permanent solutions to ANS interbasin transfer. In all cases, permanent solutions to the interbasin transfer of aquatic nuisance species were deferred to GLMRIS.

A 2011 GLMRIS white paper identified 254 aquatic nuisance species as being present in the MR basin and GL basin (Veraldi et al. 2011). Screening and evaluation of these species narrowed the field to 35 species of concern, 10 of concern for potential transfer to the GL basin, and 25 of concern for potential transfer to the MR basin. The ANS risk assessment characterized the risk of each of these 35 species undergoing interbasin transfer and determined that 13 species pose a High or Medium risk of adverse impacts to either basin (Hlohowskyj et al. 2012). Risk is understood as the likelihood of adverse impacts resulting from the establishment of ANS in the new basin. The level of risk associated with each species is characterized by considering both the probability and consequences of establishment.

The adverse impacts caused by interbasin ANS transfer may be environmental, economic, and social/political. Environmental impacts may include disruptions to important ecosystem functions such as nutrient cycling and primary production, and may alter food web dynamics. ANS establishment may also result in adverse impacts to habitat quality and availability, competition and predation, biodiversity, and species protected under the Endangered Species Act. Adverse economic impacts of ANS establishment may include loss of consumer surplus, decreased coastal property values, and reductions in charter boat activity, recreational fishing, commercial fish abundance, and service industry jobs and income. ANS establishment may result in increased water treatment costs and increased maintenance costs for water withdrawal structures and fouled boat hulls. Interbasin ANS transfer also has the potential to result in social/political consequences, including the perceived impacts to swimming, fishing, hunting, and boating and changes to related regulations.

Significance of Resources

As part of the baseline assessment, preliminary assessments were completed on the significance of the Great Lakes and Mississippi River ecosystems in terms of institutional and technical recognition. The analysis provides some background into the importance of the resources that are proposed for protection, and also supports the criteria that will be used to evaluate each of the alternative plans developed for this report.

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, tribes, or private groups. Sources of institutional recognition include public laws, executive orders, 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 area; 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 statements of private groups. The following are the laws, regulations, and federal programs that demonstrate the value of the Great Lakes, Mississippi River, and the Chicago Area Waterway System to the nation.

- Boundary Waters Treaty, U.S.-Gr. Br., Jan. 11, 1909, 36 Stat. 2448
- Clean Water Act, 33 U.S.C.§ 1251–1387
- Atmospheric Deposition to the Great Lakes, Clean Air Act, 42 U.S.C.§ 7412(m)
- Coastal Zone Management Act, 16 U.S.C.§ 1451–1466
- Great Lakes Coastal Barrier Act of 1988, Pub. L. No. 100-707
- Great Lakes Critical Programs Act of 1990, Pub. L. No. 101-596
- Great Lakes Fish and Wildlife Tissue Bank Act, 16 U.S.C.§ 943–943c
- Great Lakes Fishery Act of 1956, 16 U.S.C.§ 931–939c
- Great Lakes Legacy Act of 2002, 33 U.S.C.§ 1271a
- Great Lakes Legacy Reauthorization Act of 2008, Pub. L. No. 110-365
- Great Lakes Fish and Wildlife Restoration Act, 16 U.S.C.§ 941–941g
- Great Lakes Fishery and Ecosystem Restoration, 42 U.S.C.§ 1962d-22
- Great Lakes Oil and Gas Drilling Ban, 42 U.S.C.§ 15941
- Great Lakes Oil Pollution Research and Development Act, Pub. L. No. 101-537
- Great Lakes Planning Assistance Act of 1988, 33 U.S.C.§ 426p
- Great Lakes Shoreline Mapping Act of 1987, Pub. L. No. 100-220
- Great Lakes-St. Lawrence River Basin Water Resources Compact, Pub. L. 110-342
- Great Lakes Tributary Models, 33 U.S.C.§ 2326b
- Great Lakes Restoration Initiative
- Great Lakes Water Quality Agreement, United States-Canada.
- Mississippi National River and Recreation Area, 16 U.S.C.§ 460zz–460zz-6
- Mississippi River Commission, 33 U.S.C.§ 641–653a
- Mississippi River Corridor Study Commission Act of 1989, Pub. L. 101-398
- Pollution Control in the Great Lakes, 33 U.S.C.§ 1258
- Upper Mississippi River Wild Life and Fish Refuge Act, 16 U.S.C.§ 721–731
- Establishment of the Great Lakes Basin Commission, Exec. Order No. 11,345
- American Heritage Rivers, Exec. Order No. 13,061
- Marine Protected Areas, Exec. Order No. 13,158
- Great Lakes Interagency Task Force, Exec. Order No. 13,340
- Stewardship of the Ocean, Our Coasts, and the Great Lakes, Exec. Order No. 13,547
- Blue Pike Activities in the Great Lakes
- Detroit River International Wildlife Refuge
- Ecosystem Management in the Lower Great Lakes

- Episodic Events, Great Lakes Experiment
- Evaluation and Restoration of Great Lakes Estuaries and Tributaries
- USFWS Implementation of the August 7, 2000 Consent Decree regarding the 1836 Fisheries Treaty
- Great Lakes Basin Program for Soil Erosion Sediment Control, 16 U.S.C.§ 3839bb-3
- Great Lakes Binational Toxics Strategy
- Great Lakes Coastal Program
- Great Lakes Lake Sturgeon Rehabilitation Program
- Great Lakes Monitoring Program
- Great Lakes National Program Office, 33 U.S.C.§ 1268
- GLNPO Pollution Prevention Grant Assistance Program, 42 U.S.C.§ 13104
- Great Lakes Remedial Action Plans and Sediment Remediation
- HHS Great Lakes Human Health Effects Research Program
- Integrated Atmospheric Deposition Network
- Lakewide Management Plans
- Lake Ontario Atlantic Salmon Reintroduction Program
- Lake Ontario/St. Lawrence River American Eel Restoration Program
- Lower Great Lakes Lake Trout Restoration Program
- Lower Great Lakes Ruffe Surveillance Program
- Mississippi River Basin Healthy Watersheds Initiative
- Mississippi River/Gulf of Mexico Watershed Nutrient (Hypoxia) Task Force
- National Fish Hatchery System - Great Lakes Operations
- Navigation and Ecosystem Sustainability Program (NESP)
- NOAA Great Lakes Environmental Research Laboratory
- NPS Midwest Region Great Lakes Strategic Plan Activities
- RCRA Subtitle C State Program Support Great Lakes Initiative
- State of the Lakes Ecosystem Conference
- Upper Mississippi River Restoration – Environmental Management Program
- EPA Coastal Environmental Management Program

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 Great Lakes and Mississippi River basins and the problems associated with the transfer of ANS. Organizations exist throughout the area promoting 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. Great Lakes stakeholders include the following organizations: Great Lakes Forever; Alliance for the Great Lakes; John G. Shedd Aquarium; Great Lakes Program (supported by The Nature Conservancy); Great Lakes Bird Conservation; Great Lakes Information Network (GLIN); and the Great Lakes Commission (GLC) There are also many stakeholder organizations that would support the removal of any threat to the health of the Mississippi River basin which includes the Illinois Waterway. Mississippi River stakeholder organizations include: the Mississippi Interstate Cooperative Resource Association (MICRA); the Upper Mississippi River Conservation Committee (UMRCC); the Lower Mississippi River Conservation Committee (LMRCC); the Mississippi River Delta Restoration Commission; the Upper Mississippi River Basin Association; the

National Audubon Society Upper Mississippi River Campaign; the Nature Conservancy Great Rivers Partnership; the McKnight Foundation; and the American Rivers.

Drinking Water. Over 32 million people receive their drinking water from the Great Lakes. About 8 million people in Illinois receive their drinking water from Lake Michigan. Local municipalities have the responsibility to provide adequate and clean drinking water to their populace, which largely depends on the Great Lakes' water quality. Additionally, over 30 million people rely on the Mississippi River for drinking water.

Sport Fishing Industry. The sport fishing industry contributes to the economy of the Great Lakes and Mississippi River basins. Numerous companies operate guided fishing tours and boat trips throughout the Great Lakes and Mississippi River basins or support small boat harbors scattered across these regions. Suitable fishing is a good indicator of the health of these ecosystems, which can be negatively impacted by the destruction of aquatic habitat and an increase in pollution.

Recreation. The Great Lakes support many water-related recreational opportunities including swimming, beach-going, boating, sailing, kayaking, canoeing, and the use of jet skis and water skis. Similar recreational opportunities are available in tributaries and connected lakes, as well as in the Mississippi River basin. These two watersheds touch include portions of 37 states, so the opportunities afforded by recreation touch a significant portion of the nation's population. It was estimated that there were over 12 million daily recreational visits to the Upper Mississippi River in 1990, supporting over $1.2 billion in national economic impacts (1990 price levels) and over 18,000 jobs nationwide (Carlson et al 1995). The Upper Mississippi River System has 10 National Wildlife Refuges within its boundaries and supports a paddlewheel tour boat industry.

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 vary based on differences across geographical areas and spatial scale. While 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. The Upper Mississippi River System is the only U.S. river system designated as both a nationally significant navigation system and a nationally significant ecosystem by the Federal Government.

Status and Trends. Efforts are underway at federal, state, and local levels to improve and restore the portions of the Great Lakes and Mississippi River basins. The Great Lakes Restoration Initiative (GLRI), an Administration Initiative, includes funding for projects that will serve to restore the Great Lakes including aquatic ecosystem restoration, remediation of Areas of Concern, and addressing the transfer of ANS. GLRI currently supports a number of ACRCC efforts focused on the control of silver and bighead carp. Support is also being provided by the IDNR, IEPA, USGS, and USFWS on efforts related to monitoring and the development of new monitoring methodology. Additional regional initiatives including ongoing efforts by the Great Lakes Commission/St. Lawrence Seaway Cities Initiative to develop a collaborative solution to the transfer of ANS between the Great Lakes and Mississippi River basins.

The current condition of the Upper Mississippi River System is heavily influenced by its agriculture-dominated basin and by the dams, channel training structures, dredging, and levees that regulate flow distribution during most of the year. Although substantial improvements in some conditions have occurred since the 1960s because of improvements in sewage treatment and land use practices, the system still faces substantial challenges including: high sedimentation rates in some backwaters and side channels; an altered hydrologic regime resulting from modifications of river channels, the floodplain, and land use within the basin, and from dams and their operation; loss of connection between the floodplain and the river, particularly in the southern reaches; non-native species (e.g., common carp, Asian carp [*Hypophtalmichthys* spp.], zebra mussels); high levels of nutrients and suspended sediments; and degradation of floodplain forests (Johnson and Hagerty 2008).

Improvements in the environmental resources of these two large watersheds can be expected to continue throughout the study period, based on the laws regulating the protection and improvement of these watersheds. These improvements support both native and resident aquatic species which include ANS. Consequently, there is a high level of concern that some ANS have the ability to significantly alter the environmental and dependent economic resources of these two watersheds. These concerns have been voiced by scientists, governmental agencies, and the public.

Connectivity. The shoreline of Lake Michigan serves as a significant visual north-south sight-line for millions of migratory birds including a signification fraction of the total number of neotropical songbirds. The completion of aquatic ecosystem restoration projects along the shoreline enhances the flyway ecosystem and improves the potential for successful migration for both local and migratory species. Nearly half of North America's bird species and about 40 percent of its waterfowl spend at least part of their lives in the Mississippi River flyway. There are at least 34 migratory fish species in the Upper Mississippi River System that rely upon connected habitats to complete their life cycle.

As noted above, there have been continuing improvements to the aquatic habitat throughout the Mississippi River and Great Lakes basins. Improvements in water quality, physical habitat, and natural processes that maintain them are ongoing. These efforts include hydrologic regime reestablishment, dam removal, river meandering, reconnecting floodplains, reintroduction of fire, etc. Efforts to restore the natural characteristics of aquatic systems help to combat ANS. The prime reason ANS successfully colonize an area after invasion is due to impairments in the natural system, which opens up new niches for pioneer species. For example, one measure to increase native species richness and reduce non-native species richness would be to remove dams and other control structures that inhibit riverine meandering and reduced connection to the floodplain. Structure removal reduces conditions favorable to some invasive species. An example is the removal of the Hofmann Dam in suburban Riverside, IL. The three post-construction monitoring events have shown a notable increase in the number of native riverine specialist species and a concurrent reduction in the abundance of common carp.

Biodiversity. The presence of Asian carp in the Great Lakes could cause declines in abundances of native fish species. Asian carp will compete with native fish for food—native fish like ciscos, bloaters, and yellow perch, which in turn are fed upon by predator species including lake trout and walleye. The Great Lakes are home to federally and/or state-listed threatened or endangered fish, mollusks, plants, mammals, insects, and reptiles. Other Great Lakes invasives have been implicated in adverse effects on approximately 46 percent of the local federally listed endangered plant and animal species. Introduction of Asian carp to the region could further harm these organisms and threaten their existence in the Great Lakes (ACRCC 2013). In the Upper Mississippi River System, non-native fishes composed a high percentage of total fish biomass (about 30–60 percent) in all locations monitored by the Long Term Resources Monitoring Program. Most of the non-native biomass is from common carp, but the numbers and biomass of invading Asian carps have increased substantially. A high percentage of non-native fishes in the community is generally considered an ecological impairment (Johnson and Hagerty 2008).

1.16.3 Future Without Project Conditions

A significant amount of documentation was developed to fully define baseline conditions and define the significance of environmental resources for the GLMRIS Report. Baseline conditions, and by extension future conditions, were broadly evaluated to include not only 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 formulated plans. In addition to the discussion in the previous section, Appendix B – Affected Environment & Habitat, and other technical appendices document the evaluations that have been complete to fully define baseline conditions.

Quantification of target resources expected to change is not the only consideration for determining the future without project conditions. For the GLMRIS Report, USACE utilized a 50-year period of analysis. It is also important to have a general idea of area activities, plans, operations and significant changes that lie in the future. USACE sent letter requests (Appendix M – Correspondence) to agencies whose missions: (1) could impact relevant future conditions in and around the CAWS; and, (2) address ANS prevention, control, and abatement in the Mississippi River and Great Lakes basins. USACE requested information for a 50-year time period ending in 2067. Information gathering meetings were held with the agencies to discuss the information required. USACE presented an overview of GLMRIS and detailed how each respective agency's actions could impact planning for the study. After the submission deadline date passed, nonresponsive agencies were contacted by phone or email. Any agency that did not respond was assumed to not impact GLMRIS.

Responder-provided ANS control efforts are currently underway by many federal, state, and local agencies. Respondents to GLMRIS information requests reported projects underway to address the interbasin transfer of the silver carp, bighead carp, black carp, and ruffe:

- The Illinois Department of Natural Resources (IDNR) plan calls for the monitoring mapping and control of ANS within the State of Illinois. The identified species include: ruffe, round goby, alewife, and Asian carp.

- The Iowa Department of Natural Resources (Iowa DNR) ANS management plan reports both bighead and silver carps reside in its waters. As part of its management efforts, Iowa DNR conducts watercraft inspections, public outreach and education, fish monitoring, and commercial fishing operations to prevent the spread of these species.

- The City of Chicago has passed an ordinance making it illegal to possess live Asian carp in the city.

- The Kentucky Department of Fish and Wildlife has backed legislation to outlaw the transport of live Asian carp throughout the state. Other ANS control efforts include: monitoring, detection, commercial fishing, and public education.

- The Michigan Department of Natural Resources has developed an Asian Carp Management Plan that proposes improvements to ANS prevention and detection measures, interagency information sharing, and eradication efforts, should any Asian carp be detected in the state. The plan states that it will prevent transport and release of Asian carp and fish stocking efforts, through legislation, education, and increased inspections. The state will develop an Asian carp task group. Additional tasks include: detect through use of eDNA, education, surveys, and the monitoring of fish passage systems; gather population data where Asian carps are detected; eradication of Asian carps, if populations are detected, through use of chemicals, electric dispersal barriers, commercial fishing, or any new technologies as they are developed.

- The Minnesota Department of Natural Resources (MNDNR) Plan establishes actions such as watercraft cleaning, establishing deterrent barriers, lock closures, education, and preventing spread through bait transport. The Pennsylvania Fish and Boat Commission (PAFBC) ANS Plan will utilize tools to include information education, identification, legislation, prevention, control, and research.

- The United States Fish and Wildlife Service (USFWS) is the lead for eDNA monitoring for Asian Carp, to monitor the presence of the fish so that appropriate management actions can be taken to combat the spread of the fish. It is are also an active participant in the ACRCC and in the Monitoring and Rapid Response Work Group of the ACRCC.

- The International Joint Commission (IJC) ANS Control Plan identified the need for an initial and/or continued training program for different levels of the Incident Command System (ICS) for all potential responders, the development of formalized and centralized communication protocols and rapid response Standard Operating Procedures, and, finally, better planning of facilities and technologies for use during rapid response.

- In 1991, the Ruffe Control Committee was formed with the stated goal to prevent or delay the further spread of ruffe through the Great Lakes and prevent their spread to other inland lakes and watersheds. As of 1996, the committee members have representatives from the following organizations: USFWS, Minnesota Department of Natural Resources, Great Lakes Commission, U.S. Coast Guard, Michigan Sea Grant, U.S. Department of Agriculture, EPA, National Biological Service, University of Minnesota, Great Lakes Sport Fishing Council, Port Authority of Duluth, Chippewa-Ottawa Treaty Fishery Management Authority, and Canadian Department of Fisheries and Oceans.

While many agencies have taken and will continue to take action to prevent the spread of aquatic nuisance species, there are no actions currently planned by others that will reduce the risk of interbasin transfer for all 13 High and Medium risk species.

Actions by USACE related to GLMRIS that are expected to continue through future conditions for this study include the following:

ANS:

- Operation and maintenance of the Electric Dispersal Barriers Project on the Chicago Sanitary and Ship Canal;

- Monitoring of fish in the vicinity of the barrier to ensure that target species do not pose a threat to bypass the Electric Dispersal Barriers Project;

- Continue to evaluate ways to improve the functionality and efficacy of the Electric Dispersal Barriers Project and document these evaluations in efficacy studies;

- Support regional monitoring efforts including electro-fishing, netting, and rapid-response actions with the CAWS and IWW; and
- Support efforts to improve monitoring and control techniques for ANS in concert with other resource agencies.

Flood Risk Management:

- Construction of the McCook Stage I and Stage II Reservoirs;
- Support construction activities at the Thornton Reservoir under construction by MWRD; and
- Completion of the Little Calumet River Flood Control Project in NW Indiana.

Complete Other Relevant Studies including:

- Bubbly Creek (South Fork, South Branch Chicago River) Aquatic Ecosystem Restoration Feasibility Study and
- Calumet River and Harbor Dredged Material Management Plan.

Table 1.6 includes a summary of conditions for various study area resources for baseline and future-without project conditions. Detailed future-without project conditions analyses have been completed for resources where the GLMRIS Team anticipates significant impacts due to ANS transfer and establishment and implementation of alternatives. These analyses are also documented in Appendix B – Affected Environment & Habitat and in other technical appendices. The projection of future-without project conditions forms the basis for fully evaluating study problems and opportunities, as well as providing the base against which alternatives may be evaluated.

Table 1.6 Baseline and Future Conditions for Focus Area 1 Study Area Resources

Resource	Baseline Condition	Future-without-project Condition
PHYSICAL RESOURCES		
Air Quality	Air quality in the vicinity of the CAWS is highly affected by local industries, power generating stations, and vehicle traffic. As a result, the area air quality has been designated as nonattainment for several criteria pollutants. A criteria pollutant is a pollutant for which National Ambient Air Quality Standards (NAAQS) have been established under the Clean Air Act (CAA). A nonattainment designation is based on the exceedances or violations of the air quality standard.	Counties in the project area are currently in nonattainment or maintenance for a number of criteria air pollutants, and due to the industrial nature of the area it is expected that these designations will continue into the future study period. The maintenance plan establishes measures to control emissions to ensure the air quality standard is maintained into the future.
Water Quality	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. Based on information generated through a Use Attainability Analysis (UAA) conducted by IEPA, it was determined that recreation in and on the water is attainable for many segments of the CAWS. High counts of fecal coliform indicator bacteria impair many of the waterways for recreational use, and chemical constituents such as phosphorus, mercury, polychlorinated biphenyls (PCBs), and dissolved oxygen (DO) impair many of the waterways for aquatic life. In 2012, EPA approved 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 101(a)(2) recreational goal uses.	Numerical water quality modeling can be used to inform FWOP conditions for some constituents. Substantial improvements in DO concentrations during storm periods can be seen at all locations for both baseline and future without project conditions, because CSO flows are being captured in the reservoirs. The review of the compliance results show that Baseline and Future conditions yield much higher compliance with the IEPA proposed DO standards at the locations prone to low compliance under the Current condition (e.g., Loomis Street, Cicero Avenue on the CSSC, and Bubbly Creek). MWRD modeling of required diversion to maintain water quality is expected in 2014. This will inform future decisions about water quality mitigation required for GLMRIS project alternatives. It is also expected that IEPA and EPA will continue to re-evaluate portions of the CAWS that do not meet Section 101 (a)(2) of the CWA states the national goal of achieving "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water" wherever attainable. When states adopt WQS that do not include Section 101(a)(2) uses for a particular water body segment, they are required to re-examine the water body segment every three years to determine if any new information has become available. States may demonstrate to EPA that section 101(a)(2) uses are not attainable on a water body, and EPA may approve new and/or revised WQS for those waters. It is expected that IEPA will continue to re-examine those areas that do not meet the intent of Section 101(a)(2) in the future, and that there will be ongoing efforts for all segments of the CAWS to meet those requirements.

Table1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Sediment Quality	CAWS sediment quality has been degraded by historical industrial activities and unregulated discharges to the waterways prior to the Clean Water Act. In general, CAWS sediments are contaminated throughout with persistent organic pollutants such as polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), heavy metals, dioxins and furans, and oil and grease. Overall, the surficial sediments are less contaminated than the deeper sediments throughout the system. Ongoing sediment remediation includes work at the Indiana Harbor and Canal, the Bubbly Creek Aquatic Ecosystem Restoration Study, and the Calumet Harbor DMMP, which is evaluating the need for confined disposal of Calumet River and Harbor sediment, as well as sediments from the Cal-Sag Channel. The Calumet River and Harbor sediments are currently confined in the Chicago Area CDF, which is nearing capacity.	Improvements in sediment quality will be dependent on sediment remediation through the actions of local, federal and state agencies. Efforts to address sediment quality, especially sediments containing legacy pollutants require years of coordination, planning and often times legal actions. For some portions of the waterway, authorities exist and interested parties are pursuing improvements in water quality. The Great Lakes Legacy Act provides EPA with the authority to remediate sediment in Great Lakes AOCs. Within the CAWS, sediment remediation has been focused on two Areas of Concern (AOC): the Indiana Harbor/Grand Calumet River and the Waukegan Harbor. Currently, EPA is conducting a remediation project on the Grand Calumet River (GLRI) that compliments navigation dredging in the Indiana Harbor and Canal by the USACE. There is a possibility that sediment remediation could occur within the Cal-Sag Channel, and Bubbly Creek within the planning horizon for the GLMRIS, implemented either as Corps projects, or by state and local entities. Because of the long planning horizon for sediment projects, it is not currently anticipated that sediment in other reaches of the CAWS would be remediated.
Land Use	Many of the drainage areas of the CAWS such as the upper CSSC, Chicago River and Calumet River are fully built out with little change in the land use over the last few decades. 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.	No significant changes in land use are anticipated during the study planning horizon.

Table1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Hydrology & Hydraulics	Natural fluvial geomorphology and processes within the CAWS is significantly altered from natural condition due to the years of anthropogenic activities. The majority of the CAWS is comprised of man-made canals with sporadic remnant fragments of natural stream and slough that flow into the navigable waterway.	Numerical modeling for the GLMRIS Report included an assessment of future conditions. An evaluation of changes that could impact either the hydrologic or hydraulic modeling was completed. The evaluation considered changes such as land use, the implementation of Green Infrastructure within the City of Chicago, the impacts of climate change, and the implementation of significant flood storage projects (McCook, Stage I, Thornton and McCook Stage II). Based on the analysis, assumptions regarding future conditions takes into account the effect of Thornton and McCook Stage-1 reservoirs in the hydrologic analysis for the baseline condition, and it includes the additional effect of the McCook Stage-2 reservoir in the hydrologic analysis for the future condition. Regarding the potential or continued changes in climate, land use, and implementation of green infrastructures in the future, it was assumed in the current study that the effects induced by these factors are quantitatively undeterminable with acceptable confidence or would be mostly offset amongst themselves. (See Appendix D for additional details on the future condition analysis.)
BIOLOGICAL RESOURCES		
Summary of CAWS Area Habitat	The shoreline of Lake Michigan within the study area was modified through development and the construction of shore protection projects affecting both habitat and littoral process. Modifications protected critical infrastructure, facilitated recreational opportunities and added to the aesthetic value of the city's waterfront to residents and visitors. The CAWS is composed of man-made channels and channelized river segments, providing little habitat in channels and varied habitat along natural rivers and channelized streams. Ongoing regional efforts to restore segments of the Lake Michigan Shoreline and the CAWS are being supported by various local, state and federal agencies. GLRI funding is supporting study and implementation.	Restoration of CAWS Area Habitat is expected to continue within the future planning horizon by local, state, and federal agencies, based on the significance of the resources. However, opportunities for restoration will be constrained by the several factors including the availability of suitable sites, the current condition of the site, and history of site usage. The focus on Great Lakes restoration is currently anticipated to continue through fiscal year 2019. Restoration efforts are also supported by USACE through the Great Lakes Fishery and Ecosystem Restoration Program, and small Continuing Authorities (Section 206 and Section 1135).

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Plant Communities	Generally, the riparian areas along the CAWS are highly disturbed lands with small patches of volunteer plant communities. Forested areas are a mixture of wet floodplain forest and mesic woodland with small areas of emergent marsh. Riverbanks are wooded with openings dominated by herbaceous species.	Some improvements to plant communities may be seen in the future planning horizon with the implementation of restoration projects over time within the study area. Increases in the use of Best Management Practices for storm water runoff, and continued stewardship of public lands and open space could result in improved plant communities. The opportunities to improve plant communities will be constrained by numerous factors including land use, the current condition of the sites, water quality and the history of site usage.
Macroinvertebrates	A majority of the CAWS is dominated by urban and industrial development which has changed the majority of the landscape and left patches of remnant high quality habitats fragmented. Hence, a majority of the insect species found within the CAWS corridor are those that are known to thrive in degraded habitats. An increase in species richness is only found within the remnant high quality habitats that are scattered throughout the riparian corridor.	Some improvement in the health of the macroinvertebrate communities may be seen within the study planning horizon based on more stringent water quality requirements and restoration within the basin through other authorities. However, the opportunities to improve this resource will be limited by available sites, site conditions and the suitability of the habitat for macroinvertebrates.
Fishes	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 constructed channels and canals. In 2011, a total of 58 species were recorded from the CAWS. Based on the 2011 collections, the majority of fish species that occur are either non-native (9 species) or ecologically tolerant, which means they are able to thrive in degraded habitats.	Some improvement in the health of the area fish communities may be seen within the study planning horizon based on more stringent water quality requirements and restoration within the basin through other authorities. However, the opportunities to improve this resource will be limited by available sites, site conditions and the suitability of the habitat for fishes. Further, because of concerns related to two ANS fish species, it is likely that non-target fish species will be affected by non-selective ANS control techniques being promulgated by the ACRCC, and state and local agencies.
BIOLOGICAL RESOURCES		
Reptiles & Amphibians	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. The Chicago region is currently a mosaic of urban, industrial, and small natural habitats. Natural areas within the riverine corridors of the Chicago and Calumet River Systems are where amphibians and reptiles are most likely to be abundant. Of the 50 amphibian and reptile species that have historically occurred in the Chicago region, approximately 18 species are considered common in the region currently.	Some improvement in the health of the reptile & amphibian communities may be seen within the study planning horizon based on more stringent water quality requirements and restoration within the basin through other authorities. However, the opportunities to improve this resource will be limited by available sites, site conditions and the suitability of the habitat for reptiles and amphibians.

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Birds	Within the Chicago region, natural areas scattered along the Chicago and Calumet River Systems provide crucial foraging and breeding habitat for migratory birds. Since 1970, over 300 species of birds have been recorded from the Chicago region. 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.	Some improvement in the health of the resident and migratory bird communities may be seen within the study planning horizon based on more stringent water quality requirements and restoration within the basin along the Lake Michigan flyway through other authorities. However, the opportunities to improve this resource will be limited by available sites, site conditions and the suitability of the habitat for both resident and migratory birds.
Mammals	The mammalian community within the study area has been degraded due to hydrologic and geomorphic alterations and fragmentation of habitats by industrialization. Open space within the region includes Forest Preserves composed of anthropogenically induced bottomland forest. Other open space includes former industrial sites.	Some improvement in the health of the mammal communities may be seen within the study planning horizon based on more stringent water quality requirements and restoration within the basin through other authorities. However, the opportunities to improve this resource will be limited by available sites, site conditions and the suitability of the habitat for mammals.
Aquatic Nuisance Species	Thirty-five species were identified as having a potential risk for both transferring from one basin to another, and a potential risk in that if they do disperse, the invaded ecosystem type would be moderately to severely affected by their colonization.	The future-without project conditions for ANS has a specific assessment performed to support GLMRIS. The Risk Assessment identified 13 species that had a High or Medium risk of establishment within either the Great Lake (ANS coming from the Mississippi River Basins) or the Mississippi River (ANS coming from the Great Lakes).
Summary of CAWS Natural Areas & Parks	Natural areas, parks and other significant open spaces were identified along the CAWS. Utilizing GIS analytical tools, all of these areas were selected within 1,000-feet of CAWS waterways. Approximately 231 parks, nature preserves, natural areas, and greenways were identified.	The future-without project conditions for natural areas, parks and significant open spaces is not expected to change dramatically over the planning horizon.

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Threatened & Endangered Species	There are thirteen federally-listed and proposed to be listed species within the study area. The high quality, but vulnerable ecosystem at Lockport Prairie, supports three federally listed species: the federally endangered Leafy Prairie Clover 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 Barriers Project. One state endangered species, *Nycticorax nycticorax* black-crowned night heron has been observed in the study area. Currently, no black-crowned night heron colonies are identified within the project area.	No significant changes anticipated affecting T&E Species within the planning horizon for the study.
CULTURAL & ARCHEOLOGICAL RESOURCES		
Prehistoric Archeological Sites	The Chicago Portage National Historic Site is the only known prehistoric archaeological sites located on the Chicago Area Waterway.	No significant changes anticipated affecting Prehistoric Archeological sites within the planning horizon for the study.
Historic Archeological Sites	The Chicago Portage National Historic Site is the only known historical archaeological sites located on the Chicago Area Waterway.	No significant changes anticipated affecting Historic Archeological sites within the planning horizon for the study.
Historic Structures	The three counties in northeastern Illinois contain a large number of listed historic structures the National Register of Historic Places. Chicago maintains its own list of City Landmarks and Historic Districts totaling 256 individual structures and 47 historic districts. Numerous properties in northern Indiana are listed on the *National Register of Historic Places*.	Three properties listed on the National Register of Historic Places in Illinois could be affected by changes in the operation of the CAWS during the planning horizon for this study. These properties are located within historic districts associated with the CAWS and the IWW (downstream of Brandon Road L&D).
INFRASTRUCTURE	The CAWS is both a natural and artificial system for the conveyance of sanitary and storm water. Predominate direction of flow for the CAWS is towards the Mississippi River but has the capacity to convey extreme storm water overflow events to Lake Michigan. In addition to the natural riverine and canal system the region has invested heavily in the conveyance of storm water through a complex network of combined sewer and separated storm water network	The term infrastructure includes many elements that could be explored in the urban area of the CAWS. For the future without project conditions, infrastructure was assumed to be related to transportation in and around the waterway and water quality of the waterway and Lake Michigan. Agencies responsible for these actions were queried. Improvements are expected in water quality and in some facets of waterway regulation. Upgrades to area Water Reclamation Plants are expected within the planning horizon. No additional modifications to waterway regulation, including ballast water, are expected.

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
RECREATION	The numerous community and county parks in the six counties provide a wide range of public recreational facilities including tennis courts, field houses, and soccer and baseball facilities. Chicago's Lake Michigan shoreline includes 29 public beaches: The Indiana Dunes National Lakeshore provides public beaches for swimming and surfing. The undeveloped nature of large portions of the area makes it a popular destination for outdoor sports including picnicking, bird watching, hunting, fishing and boating.	No significant changes in area recreation are anticipated during the study planning horizon.
HTRW	An HTRW investigation has not been conducted for this phase of the study, due to the expansive area being considered in the study, and the lack of detailed alternatives. In general, properties along the CSSC, South Branch Chicago River(SBCR), Calumet River, Grand Calumet River (Grand Cal), Indiana Harbor and Canal, Cal-Sag Channel, and Little Calumet River (Little Cal) downstream of the Cal-Sag Channel confluence are likely to have Recognized Environmental Conditions (RECs) due to current or past industrial uses.	No significant changes in HTRW within the study area are expected during the planning horizon.
ECONOMICS		
Commercial Fisheries	This document establishes the current value (in pounds and dollars) of commercial fishing in the Great Lakes, Upper Mississippi River and Ohio River Basins.	USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on commercial fisheries. Therefore, a FWOP condition was not developed.
Recreational Fishing	This document establishes the current value (in dollars) of recreational fishing activities in the Great Lakes, Upper Mississippi River and Ohio River Basins by utilizing the travel-cost method. Expenditure data associated with recreational fishing activities was also collected.	USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on targeted recreational fisheries. Therefore, a FWOP condition was not developed. However, a contingent valuation model was developed in order to identify future changes in the value of recreational fishing if USACE is able to obtain sufficient information to quantify the impact of ANS in the future.
Charter Fishing	This document establishes the current revenues associated with charter fishing activities within the Great Lakes Basin. A charter fishing industry within the Upper Mississippi River and Ohio River Basins was not able to be identified.	USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on targeted charter fisheries. Therefore, a FWOP condition was not developed.

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Subsistence Fishing	This report describes the cultural and economic importance of subsistence fishing activities within the Great Lakes, Upper Mississippi River and Ohio River Basins.	USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on targeted subsistence fisheries. Therefore, a FWOP condition was not developed.
Pro-Fishing Tournaments	This literature review identifies the key characteristics of professional fishing tournaments within the Great Lakes, Upper Mississippi River, and Ohio River Basins.	USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on targeted pro-fishing species. Therefore, a FWOP condition was not developed.
Commercial Cargo Navigation	This report establishes the current commercial cargo navigation movements (by commodity type and quantity) within the CAWS, as well as historic trends.	This document provides a projection of future cargo navigation movements on the CAWS. This is represented via commercial cargo commodity type, quantity (tonnages), and associated transportation cost savings associated with the project evaluation period (2017-2066).
Non-Cargo Navigation	This report provides a description of non-cargo navigation vessels that utilize the CAWS - such as passenger vessels, water taxis, recreational vessels, and government vessels. The document also highlights lock usage characteristics.	This document provides an estimate of current passenger vessel revenues, as well as projections during the 50-year project evaluation period. Surveys were also conducted in order to determine willingness to pay to keep the CAWS locks open for use of recreational vessels.
Flood Risk Management	This document serves to characterize the flood risk in Chicago Metro Area - and is displayed via expected annual damages (EAD) for the years between 2017 (when McCook Phase I is to become operational) and 2029 (when McCook Phase II is to become operational).	This document serves to characterize the future flood risk in Chicago Metro Area - and is displayed via expected annual damages (EAD) for the years between 2029 (when McCook Phase II is to become operational) and 2066 (the last year of the 50-year project evaluation period).
Water Quality	This document identifies the major sources of water that enter the CAWS, as well as the major water uses on the CAWS. A complimentary document was produced that displays the beaches along the Chicago shoreline (to include locations, amenities, and an estimate of beach usage).	The CAWS document highlights water treatment costs for the main dischargers to the CAWS during the project evaluation period (2017-2066). The Lake Michigan water quality document identifies the beaches that are expected to exist in the FWOP condition, as well as estimated beach usage during the project evaluation period.
Water Supply	This assessment establishes a baseline of water use for water originating from Lake Michigan, diverted along the Illinois shoreline, and distributed to users in the Chicago area.	The water supply baseline assessment was a qualitative review - therefore, a FWOP condition was not developed.
Hydropower	This document estimates the current economic value (dollars per year) of Lockport Powerhouse (hydropower generation).	This document estimates the future economic value (dollars per year) of Lockport Powerhouse (hydropower generation).

Table 1.6 (Cont.)

Resource	Baseline Condition	Future-without-project Condition
Regional Economics	This document estimates the current economic contribution (measured via sales and jobs) of commercial fishing, recreational fishing, charter fishing, cargo navigation, and non-cargo navigation activities within the GLMRIS detailed study area (Great Lakes, Upper Mississippi River, and Ohio River basins).	The activities expected to change in the FWOP condition are commercial, recreational, and charter fishing. However, USACE was not able to obtain sufficient information to quantify impacts or establish the timing of ANS transfer on the targeted fisheries. Therefore, a FWOP condition was not developed.

Chapter 2 Alternative Plan Development

This chapter of the GLMRIS Report provides a description of the process that was used to scope, refine, and identify the alternative plans described in this document, including strategies for project implementation and stakeholder engagement and the refinement of the ANS Controls identified for use in the alternatives. Per the direction in the MAP-21 authority, this report focuses primarily on the activities in Focus Area 1, which is comprised of the watersheds of the rivers and tributaries associated with the Chicago Area Waterway System. A more complete description of the analyses and results of the Other Aquatic Pathways (Focus Area 2) characterization and probability assessment are summarized in Appendix N – Focus Area 2.

2.1 SMART Planning

In 2012, the USACE organization formally adopted a new framework revising the traditional approach to the formulation of Corps planning studies. Termed "SMART Planning," the name given for this transformational initiative highlights the key characteristics describing the goals of new planning studies: Specific, Measurable, Attainable, Risk-Informed, and Timely. This modernization initiative strives to improve upon the efficiency of USACE plan delivery and enhance accountability for planning products. Under the transformational framework, USACE is emphasizing the use of a risk-informed decision-making approach, focusing on the level of detail necessary to make decisions as the study effort progresses toward identifying possible alternatives. In SMART Planning, it is recommended that the level of detail is commensurate with the issues being evaluated. A risk register is used to identify risks early in the process, including the recognition of data gaps and the identification of necessary data required to reduce unacceptable uncertainty in alternative evaluation and comparison.

The new process is not intended to eliminate salient detail from the integrated feasibility process, especially with regard to environmental compliance under NEPA and engineering analyses related to life safety. Rather, the framework emphasizes the development of data in correspondence to the timing of study efforts, and commensurate with the level of detail describing the alternatives. In this vein, the efforts undertaken to date to develop the GLMRIS Report, as well as the level of detail of the information contained within this document, positively align with the intent of the SMART Planning framework. GLMRIS is also well positioned to adhere to the agency's adoption of the SMART Planning framework as the study has developed a risk-informed process for collecting the appropriate level of detail and utilizing risk-based tools to identify ANS of Concern and screen alternative measures.

2.2 Options and Technologies

To tackle the problem of preventing ANS from transferring between basins, the first step was to determine the specific ANS at risk for transfer. The GLMRIS Team began by identifying ANS of Concern; the process is discussed in detail in Section 2.2.1. The GLMRIS Team identified ANS Controls that could affect the identified ANS of Concern; the development of the ANS Controls Paper is detailed in Section 2.2.2. The GLMRIS Team then conducted a qualitative Risk Assessment to further refine the list of ANS of Concern specific to the CAWS. The Risk Assessment process, discussed in detail in Section 2.2.3 resulted in the development of a list of 13 High and Medium risk species. The full suite of ANS Controls were screened down to include the only those controls determined to be most effective at preventing the transfer of the High and Medium risk ANS. The ANS Controls screening process is detailed in Section 2.2.4, and the final array of ANS Controls is detailed in Section 2.2.5.

2.2.1 Identified ANS of Concern (254→35)

The Aquatic Nuisance Species (ANS) White Paper: *Non-native Species of Concern and Dispersal Risk for the GLMRIS* was drafted to document the occurrence of aquatic non-native species within the Great Lakes and Mississippi River basins, the associated risk of dispersal, and the likelihood of becoming invasive. A total of 254 non-native aquatic species were initially identified as occurring in one or both basins of the entire study area. Of the 254 non-native aquatic species, a total of 103 were found to already have established populations in both basins and were subsequently removed from the list. In addition, 31 species were removed from the list because they were not yet located in either basin, are known to be extensively transported via terrestrial pathways, or were not considered as a potential for becoming invasive or a nuisance. The remaining list of 120 non-native and native species was finalized to a list of 35 ANS of Concern, which were identified as having a potential risk for both transferring from one basin to another, becoming invasive if they would disperse and would moderately to severely affect the invaded ecosystem. Those species are found in Table 2.1. A flowchart of the ANS of Concern screening process can be found in Appendix A.

2.2.2 Identified Spectrum of Controls (96)

In December 2011, USACE published the ANS Control Paper and produced by the GLMRIS Technology Team. This paper identified 96 ANS Controls that could be applied to prevent ANS transfer via aquatic pathways. 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 as an alternative:

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.

Shortly after the investigation began, the Technology Team learned even though extensive research had been conducted on a variety of ANS issues and concerns, comparatively little research had been completed on many of the 35 ANS of Concern – CAWS. The team identified the eight (8) 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 study progressed, 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 Technology Team included a particular ANS control based on the team's expertise and the documented use of the control on the Organisms of Concern – CAWS in an aquatic pathway. However, the controls identified in the ANS Control Paper may not be effective at controlling all growth forms or life stages of a particular organism. For example, a herbicide may be effective against a mature plant to which it is applied, but may not impact seeds already present in the soil. Similarly, algaecides may kill algal cells present in water, but not impact algal spore viability, and piscicides (such as rotenone) kill juvenile and adult fish but do not impact fish eggs.

Table 2.1 Aquatic Nuisance Species Occurring in Either the Mississippi River or Great Lakes Basin to Be Evaluated for Risk of Adverse Impacts

Mississippi River Basin Species		
Species Type	**Common Name**	**Scientific Name**
Fish	Bighead carp	*Hypophthalmichthyes nobilis*
	Black carp	*Mylopharyngodon piceus*
	Inland silverside	*Menidia beryllina*
	Northern snakehead	*Channa argus*
	Silver carp	*Hypophthalmichthys molitrix*
	Skipjack herring	*Alosa chrysochloris*
Crustacean	Scud	*Apocorophium lacustre*
Plants	Cuban bulrush	*Oxycaryum cubense*
	Dotted duckweed	*Landoltia punctata*
	Marsh dewflower	*Murdannia keisak*
Great Lakes Basin Species		
Species Type	**Common Name**	**Scientific Name**
Fish	Blueback herring	*Alosa aestivalis*
	Ruffe	*Gymnocephalus cernuus*
	Sea lamprey	*Petromyzon marinus*
	Threespine stickleback	*Gasterosteus aculeatus*
	Tubenose goby	*Proterorhinus semilunaris*
Crustacean	Bloody red shrimp	*Hemimysis anomala*
	Fishhook waterflea	*Cercopagis pengoi*
	Harpacticoid copepod	*Schizopera borutzkyi*
	Parasitic copepod	*Neoergasilus japonicas*
	Waterflea	*Daphnia galeata galeata*
Plants	Reed sweet grass	*Glyceria maxima*
	Swamp sedge	*Carex acutiformis*
	Water chestnut	*Trapa natans*
Algae	Cryptic algae	*Cyclotella cryptica*
	Diatom	*Stephanodiscus binderanus*
	Grass kelp	*Enteromorpha flexuosa*
	Red algae	*Bangia atropurpurea*
Mollusk	Eurpoean fingernail clam	*Sphaerium corneum*
	European stream valvata	*Valvata piscinalis*
	Greater European pea clam	*Pisidium amnicum*
Protozoa	Testate amoeba	*Psammonobiotus communis*
	Testate amoeba	*Psammonobiotus dziwnowi*
	Testate amoeba	*Psammonobiotus linearis*
Bryozoans	Freshwater byrozoan	*Lophopodella carteri*
Virus	Viral Hemorrhagic Septicemia Virus	*Novirhabdovirus*

The identified controls range from those that are currently used to manage ANS, such as aquatic herbicides, algaecides, benthic barriers, irrigation water chemicals, light attenuating dyes, molluscicides, piscicides, and introduced predatory fish species (biological control), to controls that are currently in research and development.. For those currently in use, information regarding the targeted use, proper application, and operating constraints impacting their effectiveness are generally known. These controls could be used to target ANS populations where ANS are currently found instead of targeting an ANS when it arrives or is newly detected at an interbasin transfer location.

Some controls addressed ANS transfer by modifying the flow conditions of a water body. Examples of these modifications include vertical drop barrier (controls upstream transfer by requiring upstream movement through a waterfall), accelerated water velocity (water traveling at high velocities controls upstream swimming or migration), and hydrologic separation (controls the flow of water within a channel or contains water within an enclosure). Technologies such as ultrasound, ultraviolet light, and electron beam irradiation would require water to be routed through or come in contact with a treatment system.

Some controls consist of the physical removal of ANS from a target water body. These controls include mechanical harvesting (using machinery to remove plant ANS), manual harvesting (using manual labor to remove plant ANS), dredging and diver dredging, controlled harvest/overfishing (fishing or netting of fish), and a variety of nonmechanical and mechanical screens. Mechanical and manual harvesting, dredging and diver dredging, and controlled harvest/overfishing are additional examples of controls that can be implemented to reduce or eliminate the ANS populations where ANS are currently established versus targeting an ANS when it arrives or is newly detected at an interbasin transfer location.

Another set of controls calls for modifying the water quality of a water body as means of controlling ANS transfer. These controls include altering the water quality with chemicals such as alum (removes phosphorus from water, inhibiting algae growth and reproduction), gases such as carbon dioxide, ozone or nitrogen, oxygen-depleting chemicals, and lethal temperature (raising the water temperature to lethal levels).

The identified ANS Controls were further refined and served as management measures used for alternative development. The ANS Control Paper can be found on the GLMRIS website, glmris.anl.gov.

2.2.3 Identified ANS of High and Medium Risk of Adverse Impacts (35→13)

The GLMRIS Team used a risk-based approach to identifying which ANS would be the focus of plan development. The goal was to identify which of the 35 ANS are a High or Medium risk of causing adverse impacts to a new basin. The ANS would cause these negative impacts by using a CAWS pathway for interbasin transfer and then becoming established in the new basin. This assessment was based on available information about the species.

For each ANS evaluated, the risk assessment was based on two components: (1) the probability of an ANS entering and becoming successfully established in a new basin; and (2) the negative consequences of that establishment on ecological, economic, and social aspects of the new basin's environment. The combination of these two components together provide an assessment of the risk of adverse impacts that could occur as a result of the establishment of a "new" ANS (each basin currently includes previously established ANS) in a new basin. This may be depicted by the following risk model:

Risk (likelihood) of adverse impacts occurring as a result of the establishment of ANS X in Basin Y	=	Probability of ANS X becoming established in Basin Y (Basin Y becomes *exposed* to ANS X)	×	The consequences of ANS X becoming established in Basin Y (the *effects* to Basin Y of exposure to ANS X)

The establishment assessment addresses the highlighted term of the risk model:

Risk (likelihood) of adverse impacts occurring as a result of the establishment of ANS X in Basin Y	=	**Probability of ANS X becoming established in Basin Y (Basin Y becomes *exposed* to ANS X)**	×	The consequences of ANS X becoming established in Basin Y (the *effects* to Basin Y of exposure to ANS X)

This term examines the probability that an ANS will successfully transfer from one basin to the other using one or more of the CAWS aquatic pathways and become established in the new basin. The probability of establishment is determined as follows:

$$P_{establishment} = P_{path} \times P_{arrival} \times P_{passage} \times P_{colonize} \times P_{spread}$$

where:

P_{path} = Probability that a complete aquatic pathway is available for interbasin transfer;

$P_{arrival}$ = Probability that the ANS will arrive at the pathway from its current distribution within a specified time;

$P_{passage}$ = Probability that the ANS can successfully move through the aquatic pathway from one basin to the other;

$P_{colonize}$ = Probability that the ANS can establish a colony in the newly invaded basin;

P_{spread} = Probability that the ANS can spread to elsewhere in the new basin; and

$P_{establishment}$ = Probability of the ANS becoming established in the new basin.

Each of these probability categories is discussed in detail in Appendix A – Alternative Development Analyses.

Probability Ratings

For the establishment assessment (see Section 3.2.6), each of the probability elements is assigned one of the following qualitative likelihood ratings:

High = The event (e.g., successful passage through a pathway) will almost certainly occur;

Medium = The event is likely to occur, but it is not certain;

Low = The event will likely not occur, but is possible; and

None = The event is certain not to occur (it is impossible).

The application of these ratings to each probability element is described in Section 3.2.3. Note that these probability elements are multiplicative, and thus $P_{establishment}$ takes on the lowest probability rating of the other probability elements. For example, if the lowest qualitative rating for any of the five non-$P_{establishment}$ probability elements is Medium, then the likelihood rating for $P_{establishment}$ would be Medium. Alternately, if the lowest rating were Low, then $P_{establishment}$ would be Low.

Consequence Ratings

The consequence assessment qualitatively considers three categories of consequences: environmental, economic, and social. The overall consequences from the establishment of a new ANS are estimated as:

Overall Consequences = **Environmental Consequences** + **Economic Consequences** + **Social/Political Consequences**

where:

Environmental Consequences = Effects on ecosystem structure and function, including effects on resident species, populations, communities, and habitats.

Economic Consequences = Effects on economic activities, such as changes in employment, unemployment, and earnings; changes in labor force and income.

Social/Political Consequences = Perceived effects on leisure, recreation or subsistence activities, as well as changes in regulatory requirements.

Overall Consequences = Qualitative combination of all environmental, economic, and social consequences.

Each of these consequence categories is discussed in detail in Appendix A – Alternative Development Analyses. Note that these consequence elements are additive, which differs from the probability elements. The overall consequence rating is not driven by the lowest rated consequence element.

For each ANS-specific consequence assessment, it is assumed that the ANS has successfully become established in the new basin. In addition, any consequences that may be associated with the new establishment are either “localized” or “widespread.” The term “localized” means that the potential spatial extent of any indicated consequences may be limited in the new basin due to the specific biotic and abiotic (e.g., physical, chemical, and/or climatological) habitat requirements and the relatively limited availability and distribution of suitable habitat (i.e., the habitat for the ANS occurs in disjunct and widely separated locations). In contrast, “widespread” means that the potential spatial extent of consequences may occur throughout the basin due to the general availability of suitable habitat for the ANS throughout the basin (e.g., in large contiguous patches or in numerous locations throughout the basin). With these assumptions, each of the three consequence categories was assigned one of the following qualitative ratings:

High (H)	=	High consequence rating due to the larger number of consequence categories affected, the nature and severity of the consequences, and the broader spatial extent of the consequences.
Medium (M)	=	Medium consequence rating due to the number of consequence categories affected, the nature and severity of the consequences, and the spatial extent of the consequences.
Low (L)	=	Low consequence rating due to the lower number of consequence categories affected, the lesser nature and severity of the consequences, and the more localized extent of the consequences.
None (N)	=	No consequences are anticipated.

These ratings are broad and flexible in their application, and their assignment is based on the amount of consequence information that is available for that ANS (or closely related species), the anticipated distribution of the ANS in the new basin, and the interpretations of this information by the GLMRIS Risk Assessment Team.

Three consequence categories (environmental, economic, and sociopolitical) were considered in the risk assessment, each with several consequence subcategories. To determine a consequence level for each of these three categories, the Risk Assessment Team considered (1) the number of consequence subcategories that could be affected following ANS establishment, (2) the nature and severity of the potential effects of those subcategory consequences as suggested by the available scientific literature and best professional judgment of the Risk Assessment Team, and (3) the spatial extent (localized or widespread) of where subcategory effects may be incurred. For each consequence category, the greater the number of subcategories potentially affected and the greater the severity and spatial extent any associated affects, the greater the consequence rating assigned to that ANS. For example, an ANS becoming widespread in a new basin and severely affecting all seven of the environmental subcategories could be assigned a High environmental consequence level. In contrast, an ANS with a very localized distribution and minimally affecting only one or two of the environmental subcategories could be assigned a Low environmental consequence rating. An overall consequence rating for an ANS was assigned based on the environmental, economic, and social consequence ratings assigned for that species. See the Risk Assessment methodology report in Appendix C for a detailed description of the assignment of consequences.

Results of Risk Assessment

The complete risk assessment including methodology, summary report and detailed risk assessments for each of the 35 species can be found in Appendix C – Risk Assessments. The following summary identifies which species were found to pose a High or Medium risk to their invaded basin.

Risks of Species Invading the Great Lakes Basin. No species were found to pose a High risk to the Great Lakes basin. Three species — scud, silver carp and bighead carp — were found to pose a Medium risk to the basin (Table 2.2). Seven species — northern snakehead, black carp, skipjack herring, inland silverside, Cuban bulrush, dotted duckweed, marsh dewflower — were found to pose a Low risk to the basin.

Table 2.2 Aquatic Nuisance Species of Concern for the Great Lakes Basin

Species	Mode of Interbasin Transfer
Species Posing High Risk	
None	
Species Posing Medium Risk	
Scud (*Apocorophium lacustre*)	Passive drift, hull fouling
Silver carp (*Hypophthalmichthys molitrix*)	Active swimming
Bighead carp (*Hypophthalmichthys nobilis)*	Active swimming
Species Posing Low Risk	
Northern snakehead (*Channa argus*)	Active swimming
Black carp (*Mylopharyngodon piceus*)	Active swimming
Skipjack herring (*Alosa chrysochloris*)	Active swimming
Inland silverside (*Menidia beryllina*)	Active swimming
Cuban bulrush (*Oxycaryum cubense*)	Passive drift
Dotted duckweed (*Landoltia punctata*)	Temporary vessel attachment, passive drift
Marsh dewflower (*Murdannia keisak*)	Passive drift, temporary vessel attachment

Risks of Species Invading the Mississippi River Basin. Ten species were found to pose a High or Medium risk to the Mississippi River basin (Table 2.3). Two pose a High risk: bloody red shrimp and fish hook water flea; and eight, grass kelp, red algae, diatom, reed sweet grass, threespine stickleback, tubenose goby, ruffe and Viral Hemorrhagic Septicemia Virus, pose a Medium risk to the Mississippi River basin. Fifteen species — sea lamprey, blueback herring, parasitic copepod, waterflea, harpacticoid copepod, European fingernail clam, greater European peaclam, European stream valvata, testate amoeba (psammonobiotus communis), testate amoeba (psammonobiotus dziwnowi), testate amoeba (psammonobiotus linearis), cryptic algae, water chestnut, swamp sedge, freshwater bryozoans — were found to pose a Low risk to the basin.

Risk Assessment Limitations

While the risk assessment characterizes the potential for each ANS to undergo interbasin transfer, become established in the new basin, and adversely impact the new basin and its resources, the risk assessment is not intended to provide a definitive estimation of risks associated with each ANS or quantify the magnitude of potential consequences of an ANS invasion. Risk ratings consider how ecosystem structure and function, economic activity, and the regulatory environment might be affected following ANS establishment and attempt to evaluate the nature and severity of potential environmental, economic, and social/political effects. The characterization of potential consequences also considers whether these impacts would be localized or widespread in spatial extent. However, there are relatively few published studies or other available information on a number of ANS of Concern, and when more detailed information was available for selected species, it was considered beyond the scope of GLMRIS to try to quantify potential future consequences of ANS invasions. GLMRIS focuses on prevention of ANS transfer between the MR and GL basins, so it does not address the original establishment of ANS in either basin.

Table 2.3 Aquatic Nuisance Species of Concern for the Mississippi River Basin

Species	Mode of Interbasin Transfer
Species Posing High Risk	
Bloody red shrimp (*Hemimysis anomala*)	Passive drift
Fishhook waterflea (*Cercopagis pengoi*)	Passive drift, hull fouling
Species Posing Medium Risk	
Grass kelp (*Enteromorpha flexuosa*)	Passive drift, temporary vessel attachment
Red algae (*Bangia atropurpurea*)	Passive drift, temporary vessel attachment
Diatom (*Stephanodiscus binderanus*)	Passive drift, temporary vessel attachment
Reed sweet grass (*Glyceria maxima*)	Passive drift
Threespine stickleback (*Gasterosteus aculeatus*)	Active swimming
Tubenose goby (*Proterorhinus semilunaris*)	Active swimming
Ruffe (*Gymnocephalus cernuus*)	Active swimming
Viral Hemorrhagic Septicemia (*Novirhabdovirus* sp.)	Passive drift; host & hull transport
Species Posing Low Risk	
Sea lamprey(*Petromyzon marinus*)	Active swimming, temporary vessel attachment
Blueback herring (*Alosa aestivalis*)	Active swimming
Parasitic copepod (*Neoergasilus japonicas*)	Host fish movement, passive drift
Waterflea (*Daphnia g. galeata*)	Passive drift, hull fouling
Harpacticoid copepod (*Schizopera borutzkyi*)	Passive drift
European fingernail clam (*Sphaerium corneum*)	Passive drift, temporary vessel attachment
Greater European peaclam (*Pisidium amnicum*)	Passive drift, temporary vessel attachment
European stream valvata (*Valvata piscinalis*)	Passive drift, temporary vessel attachment
Testate amoeba (*Psammonobiotus communis*)	Passive drift
Testate amoeba (*Psammonobiotus dziwnowi*)	Passive drift
Testate amoeba (*Psammonobiotus linearis*)	Passive drift
Cryptic algae (*Cyclotella cryptica*)	Passive drift, temporary vessel attachment
Water chestnut (*Trapa natans*)	Passive drift, temporary vessel attachment
Swamp sedge (*Carex acutiformis*)	Passive drift, temporary vessel attachment
Freshwater bryozoan (*Lophopodella carteri*)	Passive drift, hull fouling

Residual Risk

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 effort.

In GLMRIS, 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 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, due to the inter-basin movement of commercial cargo vessels via the CAWS, as well as hull fouling by organisms semi-permanently attached to vessels below the waterline. However, transport by recreational or other types of smaller vessels that are put on trailers or otherwise portaged over land from one basin to the other was considered outside the scope of this study.

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 include 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); 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 to include 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.

Appendix C identifies other pathways for the GLMRIS 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 circumstance is very important to consider when considering a long-term recommendations 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 due to 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 aquaria and water gardens, accidental and unregulated stocking, and the live food fish market.

2.2.4 Controls Screening (96→)

After USACE identified the High and Medium risk ANS of Concern, the revised species list was used to screen the ANS Controls down to a smaller subset of controls that could be used as measures in GLMRIS Alternatives. Initially, the controls were screened based on the following criteria:

- 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 bryozoans, mollusks, and protozoa. The controls were screened and only those that were potentially effective for the organism types for the High and Medium risk algae, crustaceans, fish, and plants were retained. The viral hemorrhagic septicemia virus was identified as a Medium risk species after this process was completed, but alternatives were developed to reduce the risk of VHS to the maximum extent possible.

- 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 that were based on proven technologies that were backed by research and field application; therefore, non-conventional 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 that are under research and development (R&D) that may NOT be available within ANS' time period for arrival to the pathway.
  - The risk assessment identified the probability of an ANS was anticipated to arrive at the CAWS pathway. The R&D controls potentially effective for each of the ANS were compared to the applicable ANS's arrival to the pathway. If based on a review of information regarding the status of R&D such as whether the control was solely a concept; had undergone bench scale, larger scale laboratory, or field testing; or had published research on its effectiveness was included in this assessment. The controls that were thought to not be developed sufficiently by the time an ANS's probability of arrival to the CAWS reached Medium or High, these controls were discarded.

In November of 2012, USACE held a three-day meeting with stakeholders from the Executive Steering Committee. The intention of this meeting was to review the results of the ANS Controls screening process and to solicit any new information regarding the ANS Controls. As a result of the meeting, lethal temperature was removed from the list of available controls. It was determined that while lethal temperatures were viable controls in a closed setting, they would not be effective in the open, free-flowing channels of the CAWS. It was determined to be infeasible to keep a section of the CAWS frozen in such a way that it would act as a physical barrier. A less energy intensive option was installing physical barriers. As for elevated water temperature, it was determined to be problematic and energy intensive to heat and adequately mix a large enough cross-section of an open flowing system to control upstream movement and to kill species that would be passing through the heated water. Additionally, the elevated water temperature would cause significant downstream water quality impacts. Water temperature is a regulated water quality constituent. USACE also hosted a 30-day public comment period on the GLMRIS website to solicit comments on the available controls per organism type. The comments are also posted on the website. For additional information on the controls screening process refer to Technology Team Screening Charts in Appendix A – Alternative Development Analyses.

Figure 2.1 is a flowchart illustrating how USACE identified ANS Controls that would be used in the development of alternatives. This flowchart also includes the next phase of the study process, which is plan development and assessment of risk reduction.

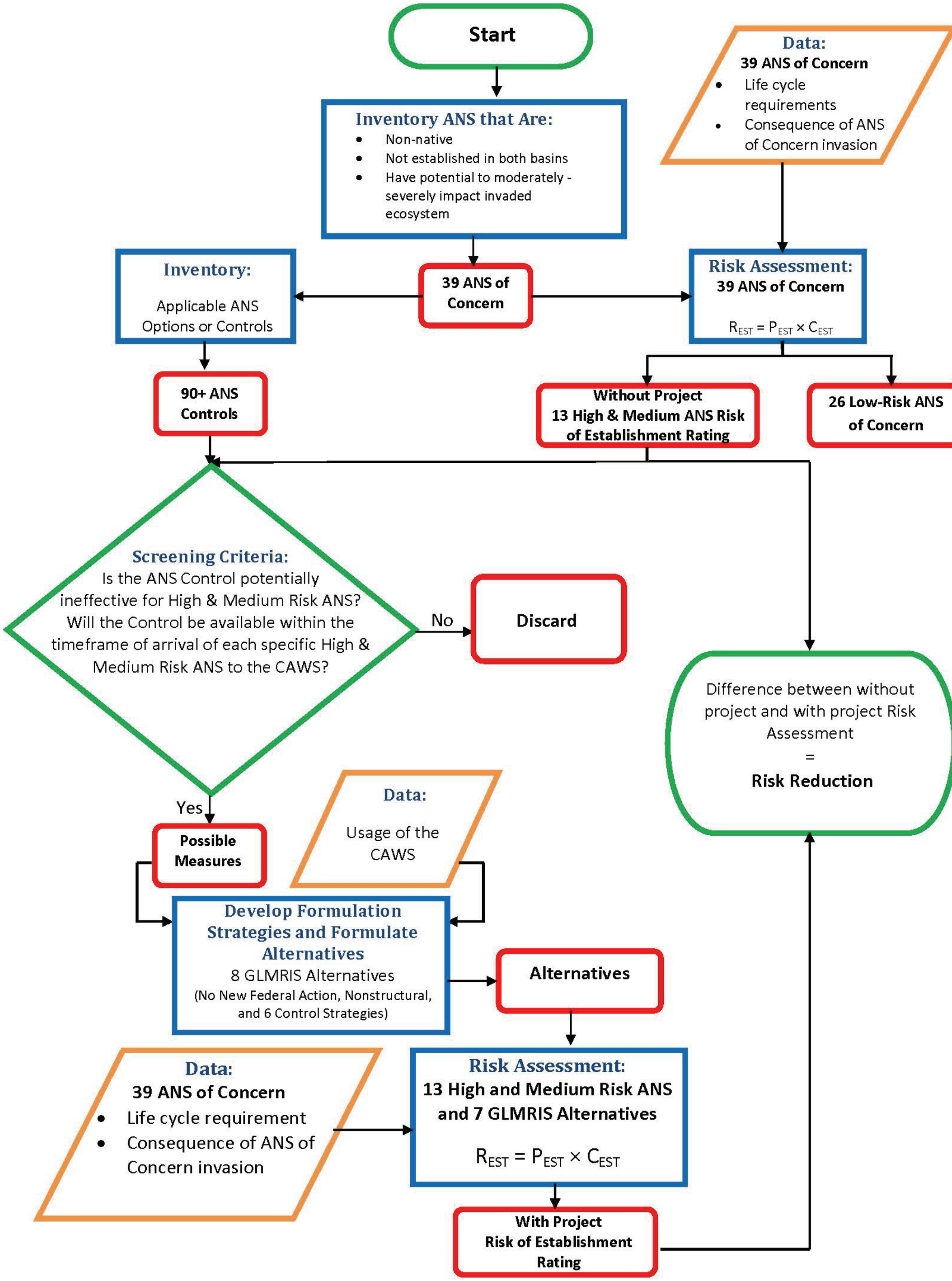


Figure 2.1 ANS Control Alternative Development Process

2.2.5 High and Medium ANS Targeted Measures

This section includes descriptions of the ANS control measures that remained after the controls screening process that were refined into detailed plan measures. These measures were used to develop the alternatives detailed in Chapter 3. If future controls are developed that would more effectively address certain ANS, or if future controls would be equally effective but have fewer impacts, further analysis would need to be conducted and incorporated into the study. Refer to Appendix I for addition details on the GLMRIS Lock, electric barrier, screened sluice gates, and physical barrier and refer to Appendix F for additional detail on the ANS Treatment Plant.

GLMRIS Lock

The purpose of the GLMRIS Lock is to allow for vessel transportation while reducing the risk to the maximum extent possible of passive drift GLMRIS species transferring during lockages. After a vessel enters the lock and sector gates close, the GLMRIS Lock's pump-driven filling and emptying system removes water from one end and, on the opposite end, fills the lock with water, therefore maintaining a pool for vessels during the lockage. Pumped inflow flushes and replaces the water originating in the lock (Figure 2.2). Depending on the alternative, the source of the filling water could originate from an ANS Treatment Plant or an adjacent Buffer Zone. Flushing operations may be conducted for lockages of vessels traveling upstream or downstream. Additional details on these processes are contained in Appendix A. This measure will be effective at controlling the passage of ANS that move via passive means, such as floating plants, spores, and eggs. However, this measure will not control the passage of species that are known to be hull foulers because the operation of the GLMRIS Lock will not dislodge attached organisms.

GLMRIS Locks were considered for implementation at a number of locations within the CAWS. However, special design features were added to the GLMRIS Lock proposed at the current location of the Chicago Lock and Controlling Works. During high winds, Lake Michigan waves currently overtop the lakefront structures near the Chicago Lock and splash into the CAWS. In order to prevent the potential overtopping/bypass of this control point, breakwater rubble mounds would be constructed lakeside of the GLMRIS Lock to reduce incoming wave energy and the potential for an overtopping bypass.

For additional details on the evaluation of the GLMRIS Lock, refer to Appendix A.

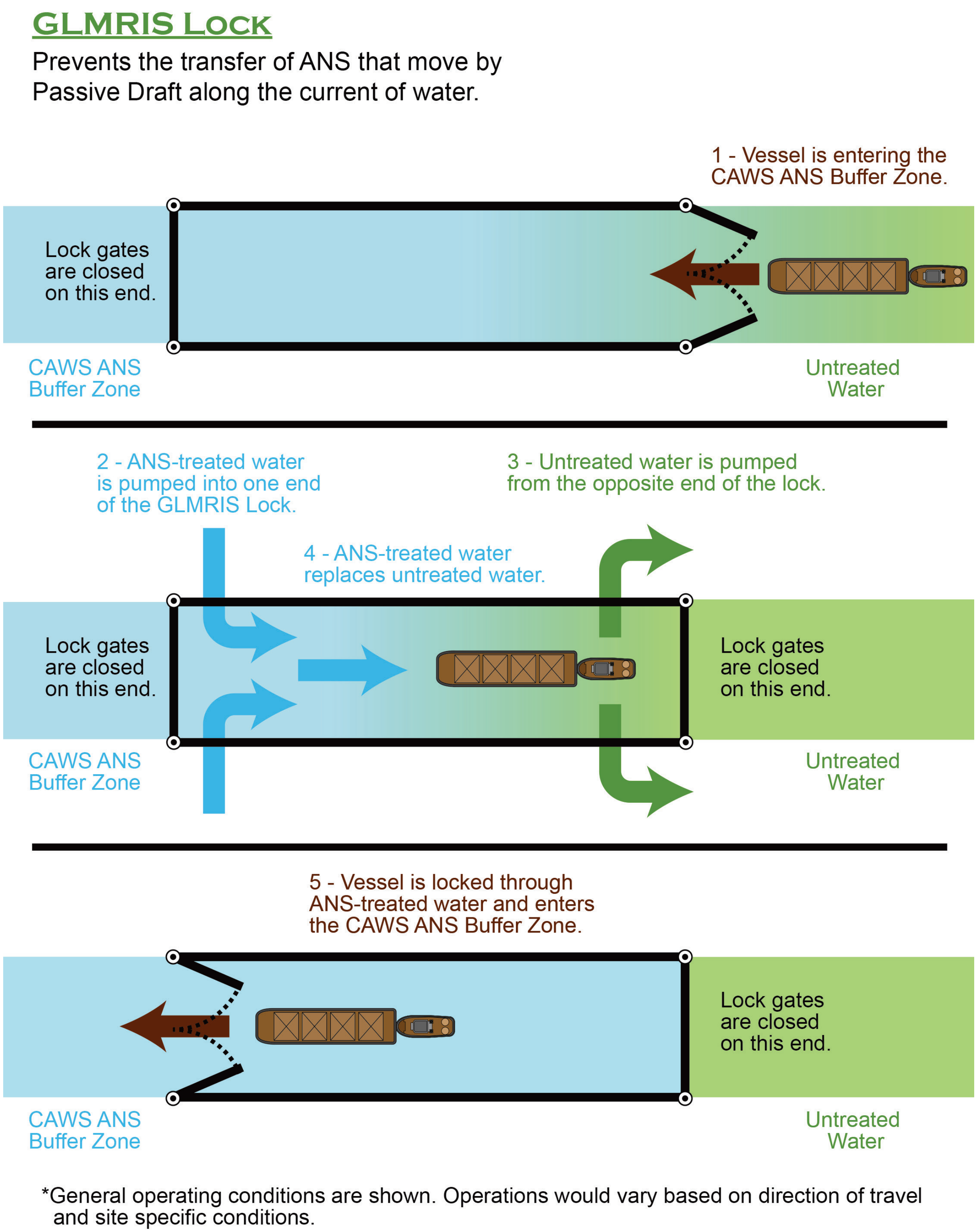


Figure 2.2 GLMRIS Lock

ANS Treatment Plant (ANSTP)

The purpose of the Aquatic Nuisance Species Treatment Plant (ANSTP) (Figure 2.3) is to remove aquatic nuisance species from Lake Michigan basin water before discharging it to the Mississippi River basin side of a control point. ANSTP effluent will supply ANS-treated water to the GLMRIS Locks and will also be used to mitigate water quality impacts of GLMRIS project alternatives, such as low flows, stagnant zones, and low dissolved oxygen concentrations.

Design of the ANSTP is based on treatment processes typically used in municipal water and wastewater treatment. Treatment technologies included in the ANSTP would include a combination of screening, filtration, and ultraviolet radiation (UV) to remove or deactivate High and Medium risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes basin. In the first treatment step, self-cleaning screens will exclude ANS and other organic matter greater than 0.75 inch (19.05 mm). Organisms passing the 0.75-inch screens would proceed to either filtration or UV treatment, depending on project location.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and prevent the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Water quality data collected by MWRD between 2007 and 2011 indicates that screening and UV treatment is likely to be an effective treatment process at the Wilmette, Chicago, and T.J. O'Brien project locations, due to their close proximity to Lake Michigan and the low turbidity and suspended solids concentrations typically found in Lake Michigan water. Water quality data also indicate that higher turbidity and suspended solids concentrations at the Stickney and Alsip project locations may substantially reduce the effectiveness of UV treatment. Consequently, pre-filtration is included in ANS treatment process prior to UV treatment at Stickney and Alsip.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater. While it effectively inactivates bacteria, viruses, protozoa, and spores, different strains of bacteria and viruses to react differently to UV due to variations in DNA content and how that DNA absorbs UV light. Limited literature is available on the effect of UV treatment on some GLMRIS target species, as discussed in Appendix C. Site-specific dose-response tests will be required to determine the UV dose necessary to inactivate target species and determine the influence of local water quality. Pilot-scale testing will be required to evaluate dose requirements, possible interferences, and other design questions. Future work would be needed to determine if additional treatment processes would be required.

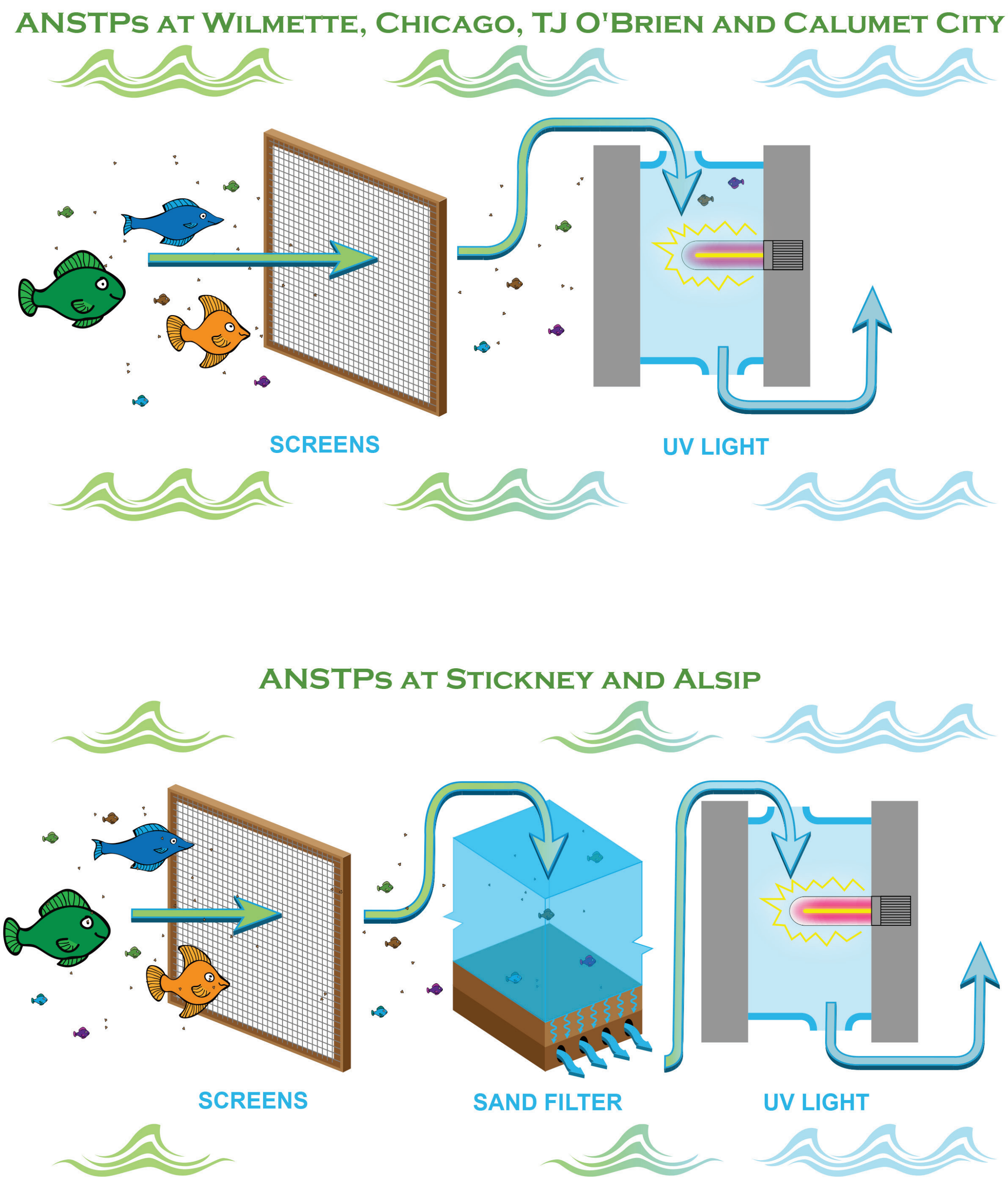


Figure 2.3 ANS Treatment Plant Processes

Electric Barrier

The purpose of an electric barrier is to reduce the risk to the maximum extent possible of fish transfer into an invading basin via operation of the GLMRIS Lock. The electrical barrier consists of steel electrodes mounted across the bed of the lock approach channel and on-land power generation and distribution equipment. The on-land equipment sends a pulsing direct current through the electrodes, creating an electric field in the water that repels and stuns fish, preventing them from entering the lock while allowing boat to freely pass (Figure 2.4).

The electrodes consist of steel bars resting on concrete blocks on the approach channel bottom. The active electrodes and associated parasitic arrays span the width of the channel bottom. The 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.

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, etc. Electric barriers are also susceptible to power outages and generator failures. Regardless of the cause, fish can swim past the electric barrier when a barrier is inactive. If the electric barrier is placed immediately before a GLMRIS Lock, when maintenance is required or during a

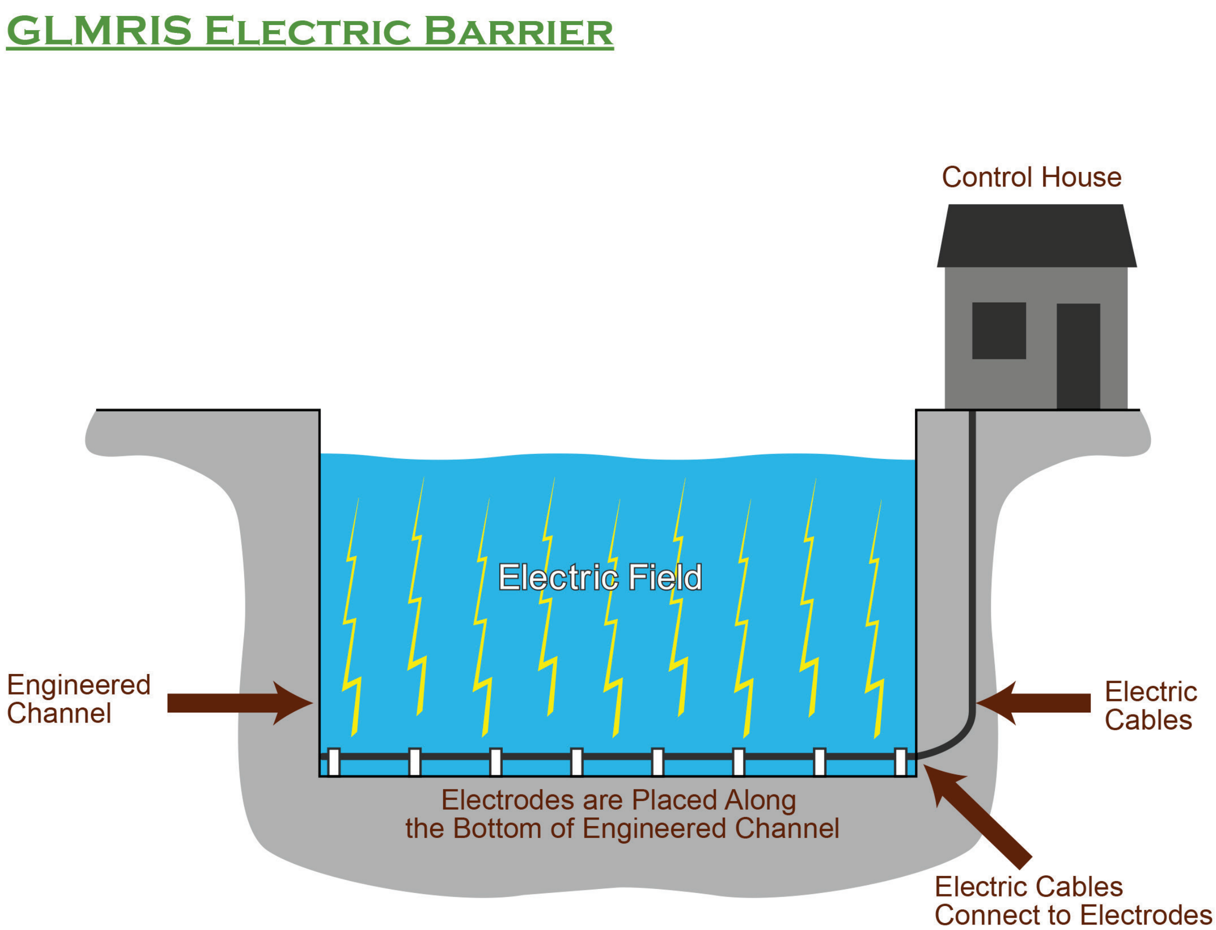


Figure 2.4 Cross section of the Electrical Barrier

power failure, the lock would remain closed until response crews clear fish from the approach channel and electrical barrier area, and the electric barrier is once again operational.

There are several safety concerns related to operation of electric barriers: the potential of the electrified water to generate sparking within or between barges or other vessels; the potential risks that the electrified water poses to people who contact it; potential risks created by on-land ground currents; potential risks from exposure to airborne electromagnetic fields; and electrical hazards to which workers onsite may be exposed. Operation of the electric barriers also has other potential side effects such as accelerated corrosion of metal in the vicinity and interference with other nearby electronic equipment. These safety concerns and operational impacts must be understood and considered when construction of a new electric barrier is considered.

The U.S. Coast Guard may implement special rules and a Safety Zone and Regulated Navigation Area to mitigate such risks. Currently the Coast Guard restricts vessels less than 20 feet in length from passing through the electric barriers in Romeoville, IL.

The efficacy of the electric barrier will continue to be studied by USACE under Section 3061(b)(1)(d) of WRDA 2007, and any additional findings relevant to the barrier's efficacy will be factored into any future studies on GLMRIS Alternatives including this component. Currently, there are ongoing studies about the efficacy of the electric barrier against very small fish. More detail on these efforts is set forth in Appendix B. At this point, the electric barrier was determined to be the most effective technology for preventing fish passage, not including physical barriers. However, any new information about any other technologies that could be a more effective deterrent against fish passage will be considered in any ongoing studies. Refer to Section 1.15.1 for additional detail on current efforts to improve the efficacy of the existing electric barrier.

Screened Sluice Gates

The purpose of the screened sluice gates (Figure 2.5) is to allow for the passage of flood waters from the CAWS to Lake Michigan while still reducing the risk to the maximum extent possible the transfer of GL ANS fish into the Mississippi River basin. This measure is only included in those alternatives that include an ANS Buffer Zone in the CAWS. Therefore, during large storm events, these gates may be opened at Wilmette Pumping Station, Chicago River Controlling Works, and T.J. O'Brien Lock and Dam to facilitate a system backflow. Water would pass through the screened sluice gates designed with a 0.4-inch screen mesh. The 0.4-inch opening is expected to control the passage of the following adult GL High and Medium risk ANS fish from Lake Michigan to the CAWS: tubenose goby, ruffe (Fuller et al. 2012), and threespine stickleback (Bergstrom 2002).

Additionally, standard operating procedures for operating the screened sluice gate would be to accommodate the system's flood risk management requirements while reducing the risk to the greatest extent possible of the transfer of ANS between the basins during backflows. Besides the adult GL ANS fish, the remainder of the GL High and Medium risk ANS are passive drift species and are not able to travel against a current. Consequently, these gates would be opened when conditions in the CAWS provide for flow exiting the CAWS into Lake Michigan.

Similar to existing conditions, if the flow were to ever exceed the capacity of the screened sluice gates, the lock structures at Chicago (IL) and T.J. O'Brien (IL) would be opened to pass water. Under these situations, it is anticipated that the rate of flow would control the transfer of ANS that rely on passive drift, and fish would still not be able to transfer due to the presence of electric barriers. Further study may examine whether screened sluice gates are necessary where adjacent lock structures provide the ability to backflow stormwater.

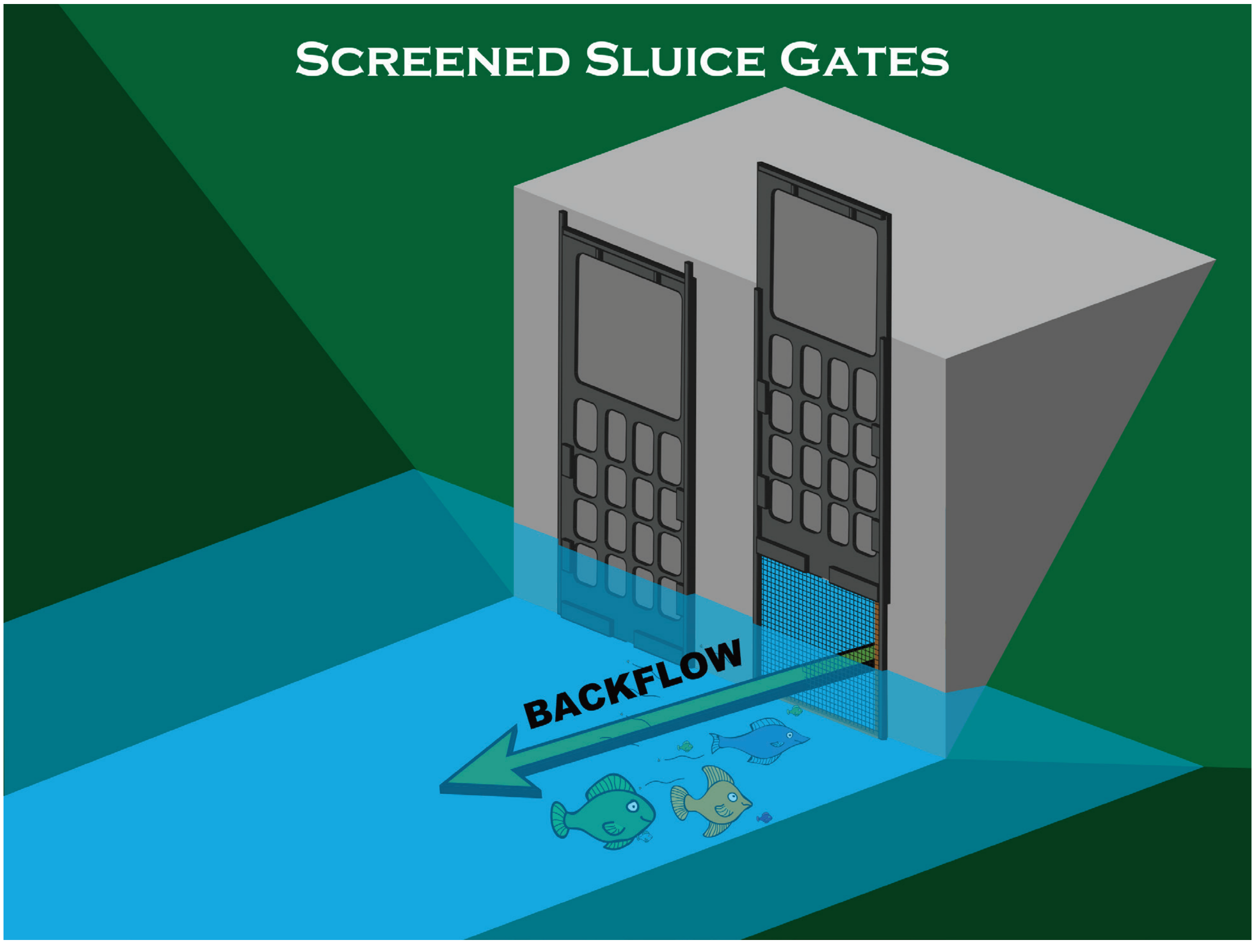


Figure 2.5 Screened Sluice Gates

Physical Barriers

The purpose of the physical barriers is to prevent the transfer of untreated surface water in the CAWS, thus severing the aquatic pathway. The physical barrier itself can be designed for multi-purpose uses, such as park space or pedestrian bridges, however intended to block an aquatic pathway. For this report, the physical barriers design consisted of concrete and steel sheet pile. If any alternative that includes a physical barrier is selected for further study, additional design and coordination of the structure would be conducted to ensure that structure is accurately described and estimated.

2.6 Alternative Development

2.6.1 Alternative Development Strategies

Acknowledging that each potential approach to the problem of ANS transfer would present its own unique benefits and drawbacks, the GLMRIS Team proposed approaches that were optimized for implementation time, flood-risk management, and water quality. Accordingly, the team developed five approaches: Nonstructural; Technologies without a Buffer Zone; Technologies with a Buffer Zone; Hydrologic Separation; and a Combination of Technologies and Hydrologic Separation. The Buffer Zone is defined as the channel area between sets of upstream and downstream controls within the CAWS. Each strategy is described below.

Nonstructural

This strategy focused on the development of one or more alternatives that could be implemented without any physical construction allowing for rapid implementation of a project.

Technologies without a Buffer Zone

This strategy focused on maintaining the current operations of the CAWS with a minimal number of control points.

Technologies with a Buffer Zone

This strategy focused on maintaining the current operations of the CAWS by analyzing the system and then creating a Buffer Zone within the CAWS. This Buffer Zone is the segment of the waterway located between the lakefront and downstream controls points. The water within this zone would be composed of discharge from ANSTP, treated WRP effluent, precipitation and stormwater. The Buffer Zone provides for redundancy in control points in the system and serves as a zone where an ANS response action could occur, if necessary.

Hydrologic Separation

In 2011, the GLMRIS Team met with local, state, and federal agencies to gather input on considerations for the design and evaluation of a Hydrologic Separation of the Great Lakes basin and the Mississippi River basin at the CAWS.

The meeting provided insight on the complexity associated with the implementation of a Hydrologic Separation, which helped define the scope of analysis for this alternative. The meeting participants developed the following definition of Hydrologic Separation for GLMRIS:

> Hydrologic separation (Hydro-Sep) – the use of physical means to permanently separate two, or more, previously connected watersheds, in order to prevent the mixing of all untreated surface waters of the disconnected watersheds.

The key statement in this definition is “prevent mixing of all UNTREATED surface waters.” This allows for water that has moved through a water treatment plant to move from one basin to the other.

Combination of Technologies and Hydrologic Separation

The last alternative development strategy the PDT used was to combine both technologies and hydrologic separation strategies and to minimize impacts to existing CAWS uses and users.

2.6.2 Waterway Uses and Users Impacts Analysis

At the 2011 stakeholder meeting, a list of CAWS uses and users was developed by meeting participants. These uses and users shaped how all the GLMRIS Alternatives were formulated, with the specific goal of minimizing impacts to the identified uses and users. Where impacts to a Use or User could not be minimized within the design of a particular alternative, mitigation measures for those impacts were considered for that alternative. The uses and users for this analysis were identified as the following:

Chicago Area Waterway System Uses:

- *Water Quality CAWS* – Under the Clean Water Act and associated state laws, water quality in the CAWS is protected for designated uses such as Aquatic Life, Fish Consumption, Public Food Processing Water Supplies, Primary Contact Recreation, Secondary Contact Recreation, Indigenous Aquatic Life, and Aesthetic Quality. State agencies have established water quality standards to protect these designated uses and regulate discharges to the CAWS to ensure that the water quality standards are achieved. Water quality standards include antidegradation policies that prevent deterioration of the waterway's existing uses.

- *Water Quality Lake Michigan* – Under the Clean Water Act and associated state laws, water quality in Lake Michigan is protected for designated uses such as Aquatic Life, Fish Consumption, Public Food Processing Water Supplies, Primary Contact Recreation, Secondary Contact Recreation, and Aesthetic Quality. State agencies have established water quality standards to protect these designated uses and regulate discharges to the Lake Michigan basin to ensure that the water quality standards are achieved. Water quality standards include antidegradation policies that prevent deterioration of existing water quality in Lake Michigan.

- *Flood Risk Management (FRM)* – The CAWS is used to convey floodwater away from the Chicago area to minimize the risk of flood damages impacts.

- *Human Safety* – The CAWS provides Emergency Responders access to critical facilities.

- *Ecosystem* – The CAWS provides habitat for a variety of species.

Chicago Area Waterway System Users:

- *Commercial Cargo Navigation* – Commercial shippers utilize the CAWS to move goods within the Chicago area and to the rest of the nation.

- *Non-Cargo Navigation (*includes recreational navigation) – The CAWS offers recreational boating opportunities, public transportation in the form of water taxis, and provides the Coast Guard and other organizations with abilities to utilize the waterway.

- *Hydropower* – Lockport Lock and Controlling Works utilizes the CAWS flow to create electricity through a hydroelectric plant. Power generated at this facility is used for operations, and is not sold.

2.6.3 Initial Alternative Development (Plans for DMP I)

Figure 2.6 displays the locations of ANS control measures and mitigation measures for all GLMRIS Alternatives. Each alternative does not contain a measure at every location on this figure.

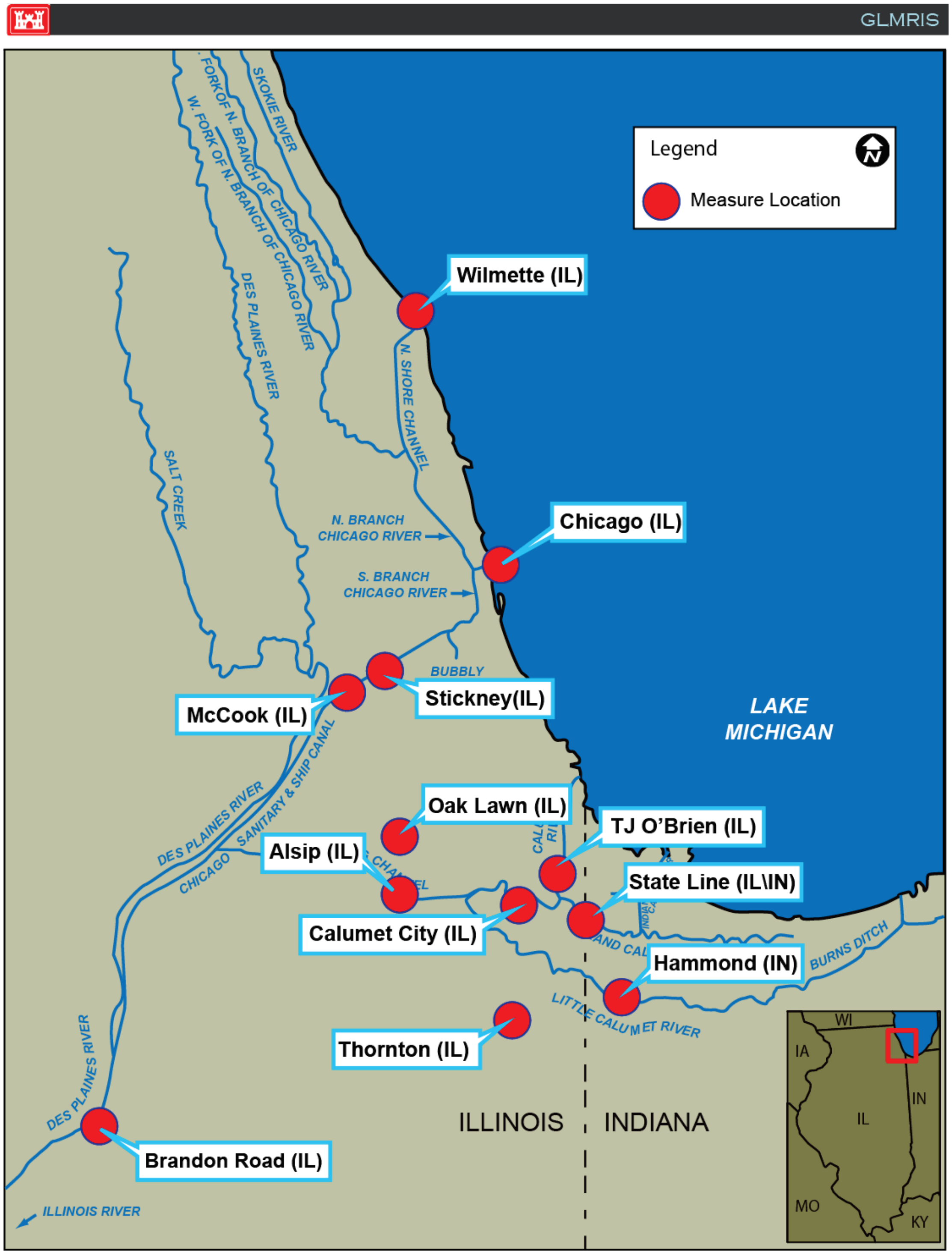


Figure 2.6 GLMRIS Measure Locations

Nonstructural

The nonstructural alternative evaluated measures that: (1) may be implemented relatively quickly (T_0); (2) pose little or no risk to human health or safety; (3) would not require the construction of any type of infrastructure; (4) could act to stop or reduce (slow) the arrival at and passage of at least some ANS; and (5) have been or are being currently implemented for other ANS elsewhere in North America, which would ensure the measure is consistent with U.S. laws and regulations.

Examples of nonstructural control measures include removal (e.g., netting), chemical control (e.g., use of herbicides), controlled waterway use (e.g., inspection and cleaning of watercraft before or after entry to a water body), and educational programs. Additional details on this alternative is included in Appendix A – Alternative Development Analyses.

Traditionally, USACE does not actively administer many of the nonstructural measures that were considered in the GLMRIS Report. The GLMRIS PDT believes that these nonstructural measures would have to be coordinated with stakeholder groups such as other federal agencies, state agencies, local municipalities, and NGOs. Implementation would require the collaboration of many agencies to effect shared responsibility of this alternative.

A nonstructural component has been included as part of each proposed structural alternative. The inclusion of nonstructural measures will facilitate opportunities to enhance structural measures with targeted nonstructural measures. For example, in the alternatives that contain a CAWS Buffer Zone, nonstructural measures could be deployed in a rapid response action in the Buffer Zone, should they be necessary. Further, nonstructural alternatives could be implemented quickly, while remaining elements of a primarily structural plan were being designed and constructed.

Technologies without a Buffer Zone

Concurrent with the screening of the ANS Controls, the GLMRIS PDT evaluated which of these controls may effectively work at single point locations to control the transfer of ANS in both directions. The PDT chose to locate these technologies at the same control points that the Hydrologic Separation alternatives were located. This was done in anticipation that application of these control technologies may have some FRM impacts to the CAWS and that the Hydrologic Separation locations were going to be evaluated specifically on their FRM impacts.

Preliminary Technologies without a Buffer Zone Alternatives

- **Lakefront Technologies without a Buffer Zone.** This alternative has four ANS control technology locations at Wilmette (IL), Chicago (IL), Calumet City (IL), and Hammond (IN). The ANS control technology at each location involved diverting the flow of the CAWS through water treatment plants, having a GLMRIS Lock to maintain navigation and electric barriers on either end of the GLMRIS Lock. This maintained many of the current operational capabilities of the CAWS but has significant impacts to FRM and human safety.

- **Mid-System Technologies without a Buffer Zone.** This alternative has two ANS control technology locations, in Stickney (IL) and Alsip (IL), that are roughly located where the divide between the Mississippi River basin and Great Lakes basin existed more than 100 years ago. The ANS control technology at each location involved diverting the flow of the CAWS through water treatment plants and having a GLMRIS Lock to maintain navigation and electric barriers on either end of the

GLMRIS Lock. This maintained many of the current operational capabilities of the CAWS but has significant impacts to FRM and human safety.

- **Downstream Hydrologic Separation.** This alternative has a single ANS control technology location, initially considered near the Lockport Controlling Works, where all five pathways in the system could be controlled at a single point. The ANS control technology at this location involved diverting the flow of the CAWS through water treatment plants and having a GLMRIS Lock to maintain navigation and electric barriers on either end of the GLMRIS Lock. This maintained many of the current operational capabilities of the CAWS but has significant impacts to FRM and human safety.

Technologies with a Buffer Zone

The presence of a Buffer Zone allows for greater freedom in the selection of ANS Controls. Since transfer is managed at two points, the control technology at each point only needs to be effective in a single direction.

Hydrologic Separation

The GLMRIS PDT recognized from the outset that any Hydrologic Separation scenario was going to have a significant impact on navigation of the CAWS. Hydrologic Separation alternatives were formulated to either minimize flood risk management (FRM) impacts on the CAWS or minimize water quality (WQ) impacts to Lake Michigan. During the development of the Hydrologic Separation alternatives, potential optimization of barrier locations with a specific focus on minimizing impacts to navigation was coordinated with the Navigation and Economics Team.

Seventeen initial scenarios were simulated using Hydrologic and Hydraulic (H&H) Models of the CAWS. Modeling scenarios included various combinations of separation locations for each of the five primary connections. Upon evaluation, three Hydrologic Separation alternatives were selected for continued analysis. The fourteen scenarios that were screened out included combinations of the three selected alternatives. Alternatives were screened out because they did not meet the strategies of protecting the water quality of Lake Michigan or minimizing FRM impacts of the CAWS as effectively as the three alternatives below, based on the modeling results. Additional discussion on the site screening analysis is included in Appendix E.

Preliminary Hydrologic Separation Alternatives

Three Hydrologic Separation alternatives were identified from the H&H modeling efforts for continued evaluation. They are as follows:

- **Lakefront Hydrologic Separation.** This alternative started initially with five physical barriers, one for each aquatic pathway in the system that connected the CAWS to Lake Michigan. This alternative was further refined to a total of four physical barriers with a single barrier to block the connections of the Calumet River and Grand Calumet River systems between the CAWS and Lake Michigan. The four physical barrier locations are Wilmette (IL), Chicago (IL), Calumet City (IL), and Hammond (IN). This alternative minimized the impacts to the water quality of Lake Michigan, but has significant impacts to FRM, human safety, and navigation.

- **Mid-System Hydrologic Separation.** This alternative has two physical barrier locations, in Stickney (IL) and Alsip (IL), that are roughly located where the divide between the Mississippi River basin and Great Lakes basin existed more than 100 years ago. This alternative minimized the impacts to FRM in the Chicago area, but has significant impacts to the water quality of Lake Michigan, the ecosystem, and navigation.

- **Downstream Hydrologic Separation.** This alternative has a single physical barrier location, in the vicinity of the Lockport Controlling Works, where all five pathways in the system could be controlled at a single point. This alternative has significant impacts to the water quality of the CAWS, water quality of Lake Michigan, FRM in the Chicago area, human safety, navigation, and hydropower.

Physical barriers were included in the hydraulic models at specific points in the waterways. Further study of a specific alternative would be needed to optimize an exact location for a specific physical barrier.

Combination of Technologies and Hydrologic Separation

The CAWS is a complex system with five aquatic connections between the Great Lakes and Mississippi River basins. As discussed above, the control strategies identified consisted of single methodologies, i.e., the Technologies Strategy seeks to control those connections through the use of various measures, and the Hydrologic Separation Strategy seeks to sever all of these connections outright. Since each approach has merit, additional alternatives were developed that consisted of hybrid of these two strategies.

Four different combinations of the two independent strategies were developed into four alternatives. The combinations were developed by applying one strategy to the CSSC arm of the CAWS and the two aquatic pathways it contains and another strategy to the Cal-Sag arm of the CAWS and the three aquatic pathways it contains.

The first pair of these combinations focused on applying the measures identified in the Technology with a Buffer Zone Alternative to the Cal-Sag arm of the CAWS. These would allow a significant portion of commercial navigation to continue largely unaffected. The CSSC arm of this alternative would have either the Mid-System Hydrologic Separation at Stickney (IL) or the Lakefront Hydrologic Separations at Chicago (IL) and Wilmette (IL).

The second pair of these combinations focused on applying the measures identified in the Technology with a Buffer Zone Alternative to the CSSC arm of the CAWS. The Cal-Sag arm of this alternative would have either the Mid-System Hydrologic Separation at Alsip (IL) or the Lakefront Hydrologic Separations at Calumet City (IL) and Hammond (IN).

Preliminary Combination of Technologies and Hydrologic Separation Alternatives

- **Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone.** This alternative has a physical barrier on the CSSC at Stickney (IL). At Brandon Road (IL) and T.J. O'Brien (IL), GLMRIS Locks and electric barriers would installed and create an ANS-free Buffer Zone between the two locations. There would be physical barriers at Stateline (IL/IN) and Hammond (IL) to address potential ANS transfer on the Grand Calumet and Little Calumet Rivers. This alternative would have significant impacts to water quality of Lake Michigan, and water quality of the CAWS.

- **Lakefront Separation Cal-Sag Open Control Technologies with a Buffer Zone.** This alternative has physical barriers at Wilmette (IL) and Chicago (IL). At Brandon Road (IL) and T.J. O'Brien (IL), GLMRIS Locks and electric barriers would installed and create an ANS-free Buffer Zone between the two locations. There would be physical barriers at Stateline (IL/IN) and Hammond (IL) to address potential ANS transfer on the Grand Calumet and Little Calumet Rivers. This alternative would have significant impacts to the water quality of the CAWS, FRM, human safety, and noncommercial navigation.

- **Mid-System Separation CSSC Open Control Technologies with a Buffer Zone.** This alternative has a physical barrier on the Cal-Sag Channel at Alsip (IL). At Brandon Road (IL) and Chicago (IL), GLMRIS Locks and electric barriers would installed and create an ANS-free Buffer Zone between the two locations. There would be new sluice structures constructed at Wilmette (IL) to address ANS transfer on the North Shore Channel. At the time of DMP-1, the PDT determined that this alternative would have significant impacts to the water quality of the CAWS, water quality of Lake Michigan, and commercial navigation.

- **Lakefront Separation CSSC Open Control Technologies with a Buffer Zone.** This alternative has physical barriers at Calumet City (IL) and Hammond (IN). At Brandon Road (IL) and Chicago (IL), GLMRIS Locks and electric barriers would installed and create an ANS-free Buffer Zone between the two locations. There would be new sluice structures constructed at Wilmette (IL) to address ANS transfer on the North Shore Channel. This alternative would have significant impacts to the water quality of the CAWS, FRM, human safety, and commercial navigation.

2.7 Alternative Plan Evaluation (DMP-I)

In January 2013, USACE conducted a meeting of the Project Delivery Team (PDT) at all levels of the organization. The meeting was attended by GLMRIS PDT members from Chicago District, St. Paul District, Huntington District, Alaska District, Jacksonville District, Lakes and Rivers Division, HQUSACE, IWR, the Office of the ASA-CW, and Argonne National Laboratory. The format of the meeting followed the SMART Planning Process. The goal of the meeting included the development of alternatives and consensus on methods to screen and evaluate alternatives.

At this meeting, the USACE team developed the path forward for GLMRIS through the formulation of two Decision Management Plans (DMPs). These DMPs were written for two distinct points in the study process. The first DMP (referred to hereon as DMP-1) addressed the immediate future of the study, and determined a screening process for the twelve alternatives that USACE was evaluating at the time. This list of twelve needed to be screened so that USACE could focus time and resources on the further development of specific alternatives. The screening criteria and associated metrics that were identified for DMP-1 are summarized in Table 2.4.

Table 2.4 Screening Criteria for DMP-I

Criterion	Metric
Lifecycle Cost of the Project	Qualitative Ranking of 1–12
Impacts to Waterway Uses	List uses (WQ, FRM, etc.)
Impacts to Waterway Users	List Users (Rec. Nav., Commercial Nav., etc.)
Required by Law or Policy	Yes or No

When preliminary information had been developed for each alternative, the GLMRIS PDT held a team meeting to evaluate each alternative utilizing the DMP-1 criteria.

For the "Lifecycle Cost of the Project" criterion, the PDT discussed each alternative and associated features, then ranked the alternatives on their total anticipated costs relative to each other. The ranking "1" was the anticipated highest cost alternative, with the ranking "12" being the anticipated lowest cost alternative.

For the criteria "Impacts to Waterway Uses" and "Impacts to Waterway Users," the GLMRIS Team identified for each alternative which waterway uses and users would be impacted, and whether it would be a significant impact. These were rough order of magnitude determinations based on the extensive knowledge of the study area across multiple disciplines of the GLMRIS Team. These impacts were then listed next to each alternative in a matrix. The Impacts to waterway uses and users shown in DMP-1 are UNMITIGATED impacts.

The final criterion, "Required by Law or Policy," recognizes that USACE has committed to fully evaluating a Hydrologic Separation alternative and that at least a single Hydrologic Separation alternative would be contained in the GLMRIS Report and should not be screened out of the Planning Process.

The PDT retained at least one alternative from each Formulation Strategy, including Hydrologic Separation, which is consistent with the MAP-21 authorizing language.

During the screening analysis, alternatives within each formulation strategy were assumed to have equal risk reduction. There was no formal analysis of risk reduction for each plan conducted at this point in study. Alternatives were screened based on a comparison of their costs and their unmitigated impacts to waterways uses and users, meaning that an alternative within a formulation strategy that had a lower cost or fewer significant impacts to waterway uses and users was preferred and retained for further analysis.

Screening Results

The following are the screening results from DMP-1 (Table 2.5).

Nonstructural

The Nonstructural Alternative was retained for further analysis.

Technologies without a Buffer Zone

The screening process outlined in DMP-1 resulted in removing the Lakefront and Downstream Technologies without a Buffer Zone Alternatives from further consideration. The three alternatives outlined in the strategy all had similar impacts. The Mid-System location of the Technologies without a Buffer Zone Alternative was retained further analysis because it had the lowest relative cost of the three.

Technologies with a Buffer Zone

The Technology with a Buffer Zone Alternative was retained for further analysis.

Table 2.5 DMP-1 Evaluation Table

	Screening Criteria			
Alternative	**Lifecycle Costs**	**Impacts to Uses**	**Impacts to Users**	**Screening Decision**
Non Structural Alternatives				
Nonstructural	12	HS ECO		**Retained**
ANS Control Technologies without a Buffer Zone Alternatives				
Lakefront	3	**FRM** **HS** ECO	NCNAV	**Removed –** Cost and significant impacts
Mid-System	7	**FRM** **HS** ECO		**Retained**
Downstream	1	**FRM** **HS** ECO		**Removed,** Cost and significant impacts
ANS Control Technologies with a Buffer Zone				
Technology Alternative	11	HS ECO	NCNAV	**Retained –** Cost, minimal impacts
Hydrologic Separation* ***Analysis of hydrologic separation was included consistent with the MAP-21 Act requirements**				
Lakefront	4	**WQCAWS** **FRM** **HS**	**CNAV** **NCNAV**	**Retained –** Protects WQ of Lake MI
Mid System	6	**WQCAWS** **WQLM** FRM **ECO**	**CNAV** HP	**Retained –** Reduces FRM and HS impacts
Downstream	2	**WQCAWS** **WQLM** **FRM** **HS** ECO	**CNAV** **HP**	**Removed** – Cost and significant impacts
Combination of Control Technologies with a Buffer Zone and Hydrologic Separation				
Combination Mid-System Separation Cal-Sag Open	8	**WQCAWS** **WQLM** FRM HS ECO	CNAV HP	**Retained –** Cost and minimized significant impacts
Combination Lakefront Separation Cal-Sag Open	5	**WQCAWS** **FRM** **HS** ECO	CNAV **NCNAV**	**Removed –** Combination Mid-System Separation Cal-Sag Open Alternative achieves the same with lower cost and less significant impacts
Combination Mid-System Separation CSSC Open	10	**WQCAWS** **WQLM** FRM HS ECO	**CNAV** HP	**Retained** – Cost and minimized significant impacts

Table 2.5 (Cont.)

	Screening Criteria			
Alternative	**Lifecycle Costs**	**Impacts to Uses**	**Impacts to Users**	**Screening Decision**
Combination of Control Technologies with a Buffer Zone and Hydrologic Separation (Cont.)				
Combination Lakefront Separation CSSC Open	9	**WQCAWS** **FRM** **HS** ECO	**CNAV**	**Removed –** Combination Mid-System Separation CSSC Open achieves the same risk reduction with lower cost and less significant impacts

Hydrologic Separation

The screening process outlined in DMP-1 resulted in removing the Downstream Hydrologic Separation Alternative from further consideration. The impacts of the Downstream Hydrologic Separation Alternative were almost identical to the Mid-System Hydrologic Separation Alternative but the anticipated costs were significantly higher. Both the Lakefront Hydrologic Separation Alternative and the Mid-System Hydrologic Separation Alternative were retained for further consideration because of their differences in impacts to waterway uses and users. This was expected based on the formulation strategies to protect the water quality of Lake Michigan and to minimize the FRM impacts to the Chicago area.

Combination of Technologies and Hydrologic Separation

The screening process outlined in DMP-1 resulted in removing the Combination Lakefront Hydrologic Separation Cal-Sag Open Alternative and the Combination Lakefront Hydrologic Separation CSSC Open Alternative from further consideration. The Lakefront–Technology combinations were screened because they has more significant impacts to waterway uses and users and were higher cost than the Mid-System–Technology combinations.

2.8 Mitigation for Alternative Plan Impacts

As DMP-1 succinctly identifies, every alternative in GLMRIS has some impacts to waterway uses and users. USACE would have an obligation to provide mitigation for some of these impacts, such as potential flooding impacts. While the mitigation for some impacts, such as water quality impacts, may fall within the responsibility of third parties, these impacts and associated costs were included in the development of the alternatives for completeness from an engineering, environmental, regulatory, and social perspective.

Because the CAWS supports many uses and users, evaluation of alternatives impacts and mitigation was very complex. It is difficult to affect a single use or user of the waterway without also having an effect on additional uses and users.

The following figures provide perspective on the flow regime of the CAWS under both typical flow conditions (Figure 2.7) and flow conditions during a storm with a 0.2% annual chance exceedance (ACE) (Figure 2.8). ACE represents the chance that a storm will occur in a given year. In many areas of the CAWS during the 0.2% ACE event, flow is opposite of the direction under normal weather conditions. This event causes additional difficulties in determining appropriate mitigation measures for alternatives.

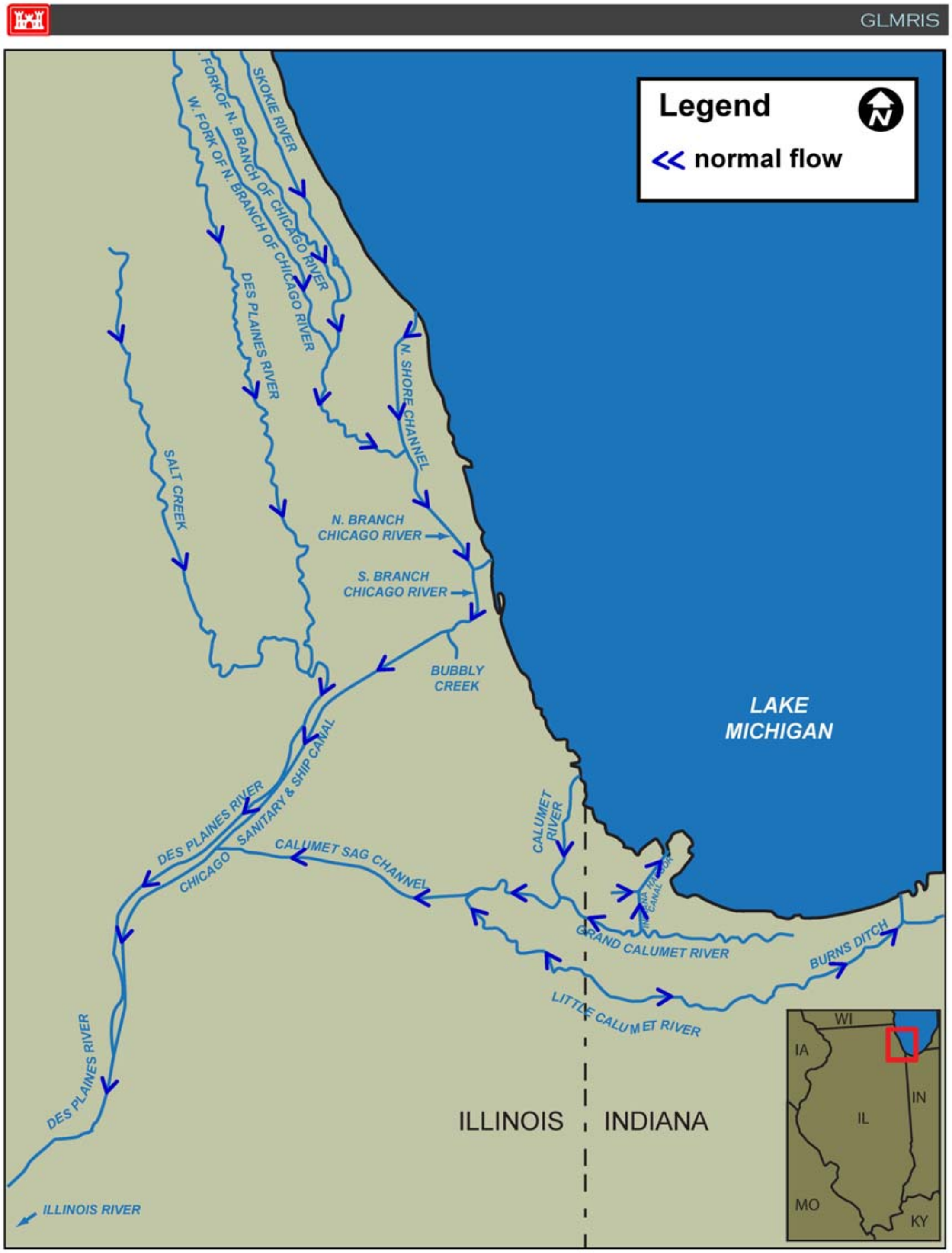


Figure 2.7 Flow of Water in the CAWS under Typical Flow Conditions

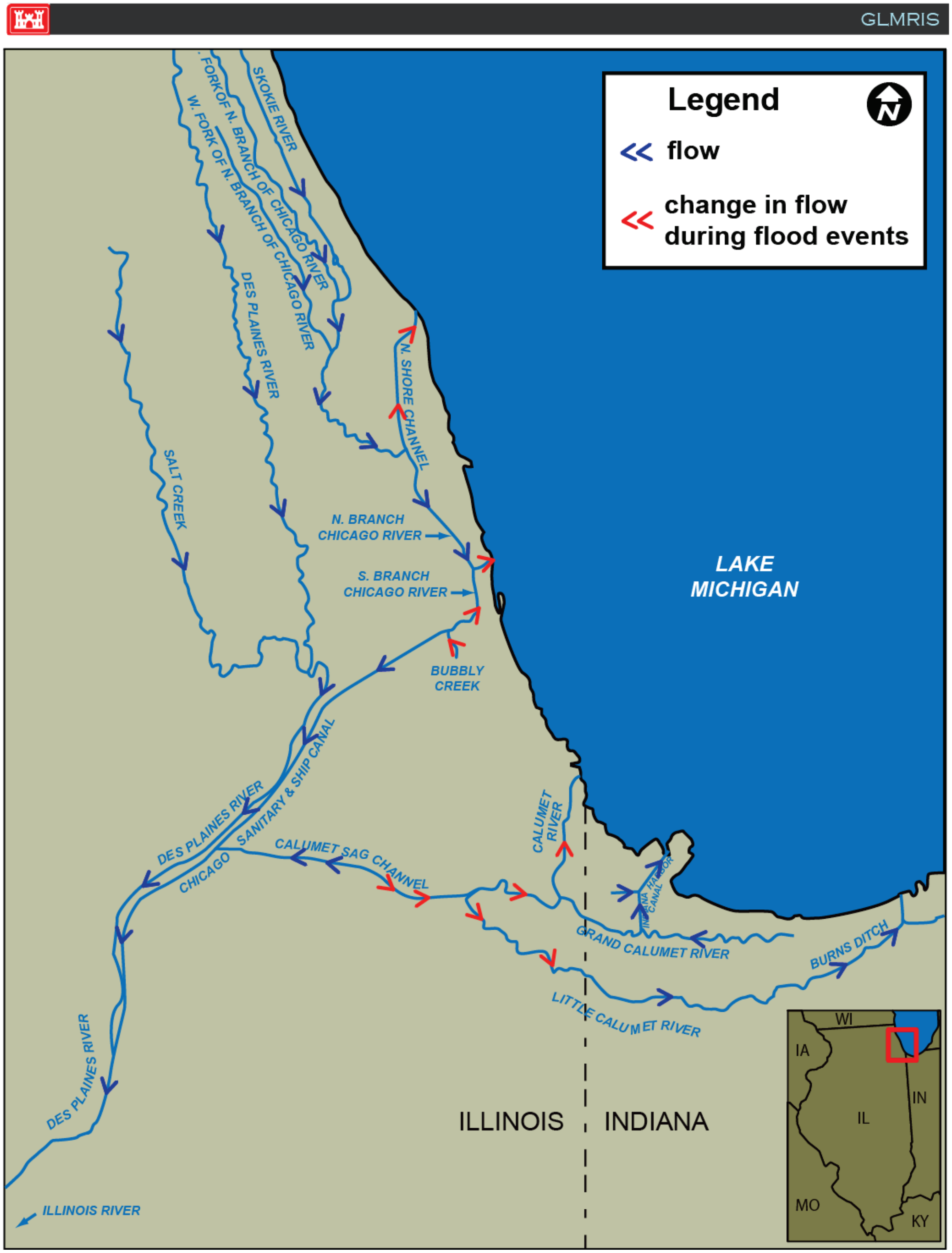


Figure 2.8 Flow of Water in the CAWS under a 0.2% Annual Chance Exceedance Event Flow Conditions

Types of Impacts to Uses/Users

Table 2.6 identifies types of impacts to each waterway use and user category that was considered during GLMRIS Alternatives development. This list is not comprehensive.

Table 2.7 identifies the type of impacts to CAWS uses and users that are expected from each GLMRIS Alternative. A more detailed description of the impacts of each alternative may be found in Chapter 3, Alternative Plans, under the description of each alternative.

Table 2.6 Potential Waterway Impacts on Use and User Categories

Use/User	Type of Impact
CAWS Ecosystem	Loss or impairment of aquatic habitat.
	Loss or impairment of riparian habitat.
	Loss or impairment of connectivity between habitats.
Water Quality CAWS	Loading levels for a variety of constituents such as dissolved oxygen, fecal coliform bacteria, and chloride.
Water Quality Lake Michigan	Loading Levels of a variety of constituents such as CBOD, total nitrogen, total phosphorus, total suspended solids, chloride, and fecal coliform bacteria.
Flood Risk Management (FRM)	Stage (increase in water levels of the CAWS).
	Induced flooding overbank.
	Induced flooding sewer backup.
Human Safety	Emergency response delays.
	Electric barrier restrictions.
	Increased risk to life safety due to flooding.
Commercial Cargo Navigation	Delay to shipping times.
	Inability to navigate the existing channel.
Non-Cargo Navigation	Restrictions on entering existing locks.
	Inability to navigate existing channel.
Hydropower	Reduction in flow through hydroelectric plant.

Mitigation Assumptions

Design of mitigation for each GLMRIS Alternative was based on several specific assumptions:

1. Current local and state Lake Michigan managed water uses and CAWS operation are not impacted by this project unless stated. The current operational constraints, controls, and management will remain in place unless stated. A full discussion of alternative impacts to CAWS uses and users can be found in Appendix A.

Table 2.7 Impacts to CAWS Uses and Users that Are Expected from Each GLMRIS Alternative

Use/User	Type of Impact	No New Federal Action	Nonstructural	Control Technology without a Buffer Zone – Flow Bypass	Control Technology with a Buffer Zone	Lakefront Hydrologic Separation	Mid-System Hydrologic Separation	Hybrid – Mid-System Separation Cal-Sag Open	Hybrid – Mid-System Separation CSSC Open
CAWS Ecosystem	Loss or impairment of aquatic habitat.			X	X	X	X	X	X
	Loss or impairment of riparian habitat.					X	X	X	X
	Loss or impairment of connectivity between habitats.			X	X	X	X	X	X
Water Quality CAWS	Loading levels for a variety of constituents such as dissolved oxygen, fecal coliform bacteria, and chloride.					X	X	X	X
Water Quality LM	Loading levels of a variety of constituents such as CBOD, total nitrogen, total phosphorus, total suspended solids, chloride, and fecal coliform bacteria.						X	X	X
FRM	Stage (increase in water levels of the CAWS).			X	X	X	X	X	X
	Induced flooding overbank.			X	X	X	X	X	X
	Induced flooding sewer backup.			X	X	X	X	X	X
Human Safety	Emergency response delays.			X	X	X	X	X	X
	Electric barrier restrictions.			X	X			X	X
	Increased risk to life safety due to flooding.			X	X	X	X	X	X
Commercial Cargo Navigation	Delay to shipping times.			X		X	X	X	X
	Inability to navigate the existing channel.					X	X	X	X
Non-Cargo Navigation	Restrictions on entering existing locks.		X	X	X			X	X
	Inability to navigate existing channel.					X	X	X	X
Hydropower	Reduction in flow through hydroelectric plant						X	X	X

2. After consulting with state and federal regulators, mitigation measures were designed to be consistent with current and reasonably anticipated regulatory agency requirements. Final mitigation requirements are subject to the approval of various state and federal regulatory bodies. A full discussion of alternative impacts and mitigation measures to CAWS uses and users can be found in Appendix A.

   It was assumed that the current or more stringent water quality standards for Lake Michigan and the CAWS would be the applicable standards for the alternative. It is likely not practicable to meet Lake Michigan discharge standards and antidegradation requirements for most flows, due to the difficulty of treating trace anthropogenic compounds and removing chloride, among other water quality treatment challenges. A full discussion of impacts of each alternative to the water quality of Lake Michigan can be found in Appendix F.

3. Due to the sensitivity of Lake Michigan and the difficulty in meeting both short-term and long-term water quality protection requirements, all treated waters will be discharged to the downstream or "river" side of a barrier or control point. A full discussion of this assumption can be found in Appendix A.

4. For H&H modeling, the Lake Michigan water level was set at 580 NAVD. This is a long-term average lake level that represents neither high nor low lake level conditions. This assumption was considered valid for the modeling simulations, but formulation did consider the potential impacts of high lake level conditions for with project conditions. For a full discussion of climate change considerations and this assumption, refer to Appendix B.

5. For H&H modeling, the 0.2% ACE event (500-year storm event) at a 24-hour precipitation duration was used as the design event. A critical duration analysis was completed to identify the modeling duration. The selection of the 0.2% ACE event as the design event was based on an analysis of historic events, including several significant events in the past five years. For a full discussion of this assumption, refer to Appendix B.

6. In designing the floodwater storage needed to size any new GLMRIS reservoirs, the planned CUP reservoirs capacity was assumed to be available for the 0.2% ACE event. In the event of back-to-back 0.2% ACE events, the identified capacity would not be sufficient to mitigate impacts. The likelihood of back-to-back 0.2% ACE events occurring in a given year is very low. A full discussion of this assumption can be found in Appendix E.

7. Currently excavated sites may be available to meet the total identified storage requirement needs. However, for this report, the cost of constructing each reservoir includes the complete excavation. For any alternative that includes a reservoir, further analysis would need to be conducted to determine an exact location for the reservoir(s) and to refine the cost estimate.

8. After considerable investigation, mitigation for commercial navigation was not included as part of any GLMRIS Alternative. Based on the findings of the Navigation and Economics PDT, most commercial shippers would not utilize a multi-modal facility due to additional re-handling costs. It would be more cost-effective to use another mode of transportation entirely, rather than re-handle commodities within the CAWS. A complete discussion of the evaluation completed is contained in Appendix A – Alternative Development Analyses.

9. Lifting barges or recreation vessels out of water and around or above any physical barrier was not considered during formulation. Based on knowledge of vessel design, for many vessels it would not be technically feasible to lift the vessels out of water. Additionally lifting vessels around barriers would increase the risk of ANS transfer via hull fouling, and ballast and bilge water, and prevention of transfer from hull fouling is one of the main benefits of hydrologic separation with physical barriers when compared with the technology alternatives.

10. The locations of ANS control technologies would require further investigation to ensure they were not being bypassed by an unknown aquatic connection, such as an interconnected local sewer system. For the evaluation of effectiveness of alternatives, it was assumed that these connections, if they existed, were identified and had been eliminated.

2.8.1 Mitigation Measures

The following are descriptions of the mitigation measures that remained after detailed analysis. For full detailed on the development of these mitigation measures and additional mitigation measures that were considered see Appendix A.

ANS Treatment Plant

In addition to functioning as an ANS control measure, ANSTPs were also used as water quality mitigation measures in some GLMRIS Alternatives. The technology would remain the same as was described in Section 2.2.5.

Conveyance Tunnel

The purpose of conveyance tunnels in GLMRIS Alternatives is to create a controlled environment for stormwater or wastewater to be collected and diverted to a storage reservoir. The diversion of these flows would reduce FRM and water quality impacts of some alternatives.

Reservoirs

The purpose of reservoirs in GLMRIS Alternatives is to provide storage for excess flows. By storing the excess flows before treating and/or releasing the water back into the CAWS, negative FRM and/or water quality impacts to the environment can be avoided.

Sediment Remediation

Physical barriers included in GLMRIS Alternatives 6, 7, and 8 will increase the potential for contaminated sediments in the Chicago and Calumet River systems to impact Lake Michigan. Sediment is naturally suspended and transported in the direction of flow. The proposed physical barriers will change the flow direction in parts of the CAWS and direct sediment and dissolved contaminants from the CAWS toward Lake Michigan, instead of to the Mississippi River basin. CAWS sediment quality has been degraded by historical industrial activities and unregulated discharges to the waterways prior to the Clean Water Act. As described in Appendix B, CAWS sediments are contaminated throughout with persistent organic pollutants such as polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, dioxins and furans, and oil and grease.

Comprehensive sediment investigation is recommended to determine the chemical concentrations in the sediment and the extent of remediation necessary to prevent degradation to the Lake Michigan environment. It is anticipated that extensive sediment remediation will be needed for the proposed alternatives to be considered environmentally acceptable.

The conceptual design for sediment remediation is based on the work performed by EPA and others on the Grand Calumet River Area of Concern (AOC). The West Branch Grand Calumet River project excavated 3–4 feet of sediment for disposal in an upland commercial landfill. A reactive carbon mat designed to capture residual contaminants released from the remaining underlying contaminated sediment was installed and secured by a two-foot sand layer. Riprap was added for scour protection. A similar approach is assumed for remediating sediments on the Lake Michigan side of proposed hydrologic separation barriers; however, any contaminated sediment would be properly addressed pursuant to applicable laws and regulations.

Chapter 3 Alternative Plans

This chapter discusses the alternative plans considered, including the No New Federal Action – Sustained Activities Alternative. Each alternative plan includes the following subsections: Alternative Plan Description; ANS Risk Reduction; Estimated Alternative Cost; Estimated Alternative Implementation Duration; and Complexity of Regulatory Compliance.

3.1 Alternative Plan Description

Each section includes a description of the alternative plan, including ANS control measures, impacts to CAWS uses and users and mitigation measures to address impacts.

3.2 ANS Risk Reduction

While the intent of the GLMRIS authority speaks to prevention of interbasin transfer of ANS, the options and technologies available to meet this goal may, in fact, reduce risk to varying degrees. 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. For example, one may suggest that an alternative such as hydrologic separation could effectively prevent the transfer of ANS through an aquatic pathway; however, the efficacy of this particular alternative is tied to engineering constraints that would be overwhelmed by storm events larger than those used to design the physical barrier. The GLMRIS hydrologic separation alternatives were designed to meet an extreme storm event, the 0.2%ACE event. Additionally, ANS may transfer between basins through non-aquatic pathways such as human-meditated transport — importation, catching, transport, and subsequent release, etc. — and other non-aquatic transfer such as algae attached to a duck's feathers, etc. The GLMRIS Team has endeavored to develop alternatives that adhere as closely as possible to the ideal of prevention as outlined by the study authority.

Without the availability of observed or practical data to measure the effectiveness of a particular alternative, the team developed a predictive model to help forecast the efficacy of a plan based on the best available information. To this end, a qualitative risk assessment was conducted to evaluate the potential risk of ANS transferring between the basins through the CAWS, establishing in the newly invaded basin and causing adverse environmental, economic, and sociopolitical consequences. This risk assessment is referred to as the "Without Project" risk assessment.

Alternatives were formulated for the 13 ANS of Concern that exhibited "High" or "Medium" risk in the "Without Project" risk assessment. Qualitative risk assessments were used to evaluate whether the implementation of each GLMRIS Alternative (referred to as the "With Project" condition) could result in risk reduction. The alternatives were formulated to control one or more of the following:

- The presence of a continuously available aquatic pathway (the CAWS) connecting the MR and GL basins;
- The arrival of ANS from its current location to the CAWS pathway; or
- The interbasin transfer of ANS through the CAWS aquatic pathway.

The "With Project" risk assessments were conducted using the methodology developed for the GLMRIS risk assessment, which can be found in Appendix C: the GLMRIS Assessment Approach for Characterizing the Risks of Adverse Impact from the Movement through the CAWS and Establishment of

Aquatic Nuisance Species in the Great Lakes and Mississippi River Basins. As a result of evaluating the CAWS as a system, for most alternatives, the ANS control measures of an alternative vary for each pathway. A with-project risk assessment was conducted for all five CAWS pathways to determine which pathway or pathways have the highest risk of adverse impacts. The effectiveness of the alternative is based on the highest-rated pathway. As with the "Without Project" risk assessments, the "With Project" risk assessments were conducted for four time steps encompassing a 50-year time period. The four time steps are defined as follows:

T_0 = Potential for establishment based on the current distribution of the ANS;
T_{10} = Potential for establishment 10 years from T_0;
T_{25} = Potential for establishment 25 years from T_0; and
T_{50} = Potential for establishment 50 years from T_0.

Residual Risk

After implementation of a GLMRIS Alternative, residual risk would remain in the aquatic pathway and in the non-aquatic pathway. Residual risk in the aquatic pathway refers to the risk of transfer through the aquatic pathway along the GL and MR basin divide but outside the CAWS (See Appendix N for information on aquatic pathways along the basin divide), and the risk remaining after implementation of the GLMRIS Alternatives in the CAWS. As for the risk of transfer along the GL and MR basin divide outside of the CAWs, no attempt was made to reflect this risk in the risk assessments described here. As for the risk remaining in the CAWS aquatic pathway, if an alternative reduces the "High" or "Medium" ratings of one or more of the probability elements to a "Low," then the resultant risk of adverse impacts for that ANS due to transfer through the CAWS would be reduced to "low." A "Low" risk rating does not indicate that "no" risk remains.

For instance, after implementation of the Lakefront Hydrologic Separation Alternative, the tubenose goby received a "Low" risk rating because the physical barriers are constrained by the storm size they were designed to withhold. No combination of High or Medium risk ANS and alternative received a risk rating of "None." A rating of "None" would indicate there is no risk of adverse impacts due to transfer through the CAWS aquatic pathway.

As for residual risks in the non-aquatic pathway, the GLMRIS Alternatives address, at 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 (see Appendix A for additional detail on non-aquatic pathways). However, residual risk of interbasin transfer through non-aquatic pathways would remain, although no attempt was made to reflect this risk in the risk assessments described here.

Effectiveness at Preventing Interbasin Transfer (At time of implementation)

A rating was assigned to each alternative that was based on the number of ANS whose probability of establishment was lowered at one or more time steps because of the alternative. The higher number of stars in the "Effectiveness at Preventing Interbasin Transfer (at time of implementation)" column in Table 4.2 indicates which alternative controls more species, relative to the other alternatives. A greater number of stars means an alternative is likely to control more species. The number of stars is also influenced by the comparative levels of uncertainty associated with the impact an alternative has on the elements of P(establishment). Note, the top-ranked alternatives cannot guarantee the complete elimination of negative consequences that would result from ANS transfer and establishment, given that an absolute solution guaranteeing the complete prevention of ANS transfer may not be feasible or even technologically possible. The ratings do not consider the duration needed to implement the alternative relative to the likely timing of arrival and passage of "High" and "Medium" risk species. This more detailed analysis is generally discussed in Chapter 4.

3.3 Estimated Alternative Cost

Each section includes a discussion of the estimated cost of all the project components and mitigation measures associated with the alternative. While the mitigation for some impacts may fall within the responsibility of third parties, these impacts and associated costs were included in the development of the alternatives for completeness from an engineering, environmental, regulatory, and social perspective.

The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

3.4 Estimated Alternative Implementation Duration

The duration of the implementation period is dependent upon a variety of factors, some of which may be controlled by third parties. This section lists the assumptions in the schedule.

Risks to Implementation

There are a few key risks that have the potential to increase the implementation time and therefore the overall costs. These risks cannot be quantified at this time and could have impacts upon the presented implementation schedule for each alternative. For the purposes of the GLMRIS Report, the following risks were not taken into account due to a high level of uncertainty. Further evaluation of these risks to the implementation schedule and costs will be completed prior to a recommendation for authorization:

- *Funding*. The assumption is timely funding to support progress annually. Delays could result in a construction inflationary impact of 3-4 percent annually compounded over several decades. The GLMRIS Team felt that such an unknown would create risks and add contingencies far beyond the goal of simple comparison between measures and alternatives.

- *Real Estate*. The GLMRIS Team excluded the risk of needed real estate for each measure, alternative, and site location. Real estate implementation of each alternative assumes that the navigation servitude can be asserted for project lands required below the ordinary high water mark and for interference with riparian rights. The GLMRIS Team assumes a 24-month real estate acquisition period which would be completed prior to contract award. This risk of obtaining the identified real estate could be extremely high for certain locations, but any significant real estate formulation has not yet occurred.

- *Permitting*. The GLMRIS Team also excluded the risk of obtaining the necessary permits for construction of various measures at various locations. The risk of delays or project modifications associated with obtaining the necessary permits could be extremely high for certain locations. However, it is very difficult to predict such future permit issues with certainty.

3.5 Complexity of Regulatory Compliance

Each alternative will need to comply with all applicable laws and regulations. In light of the potential impacts of some of the alternatives on water quality and FRM, the regulatory requirements for mitigation measures could be significant or complex. Alternative plans and mitigation measures were designed to be consistent with anticipated regulatory agency requirements based on consultations with the relevant agencies. Alternatives with more complex regulatory requirements have a higher risk of cost increases and schedule delays. The potential complexity of compliance with regulatory requirements is discussed in more detail for each alternative below.

3.6 Adaptive Management of Alternative Plans

Adaptive Management is a decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. For the GLMRIS Alternatives, two components to adaptive management were identified. First, is the ANS control measure working as intended? Second, if the measure is not working as intended, how easy is it to change, reverse, or adapt the measure to function more effectively?
For the first component of adaptive management, "Is the ANS Control measure working as intended?," each GLMRIS Alternative would be sufficiently flexible to ensure the ability to optimize operation or implementation of a measure currently included in an alternative. Based on the identification of new information, procedures, or technologies that address uncertainties, current measures in the plan could be altered or replaced. Adaptive management could allow for an existing ANS control measure to be replaced with a new ANS control measure that is likely to be more effective. Adaptive management would also allow for refinement of procedures or techniques based on the identification of new ANS or adjustment to changes in ANS behaviors and/or responses to ANS Controls. Adaptive management plans for a specific alternative would be further developed, if that alternative was recommended for future study.

Additionally, supportive nonstructural measures specific to the species and location could be implemented by federal, state, and local agencies to reduce, stop, or eradicate populations of the ANS. The nonstructural measures could include public education to reduce spread/transfer of ANS, monitoring and reporting of ANS infestations to inform adaptive management strategies for an alternative, assist with targeted control of specific ANS, and long-term monitoring efforts to assess whether the implementation of structural measures is successful.

The second component of adaptive management, "If the measure is not working as intended, how easy is it to change, reverse, or adapt the measure to function more effectively?," requires a more detailed consideration of the design elements of a particular plan. Certain ANS control measures, depending on their application, would require substantial investment before the effectiveness of the risk reduction could be verified. For example, a physical barrier could require construction of FRM mitigation measures such as a conveyance tunnel and storage reservoir prior to construction of the physical barrier itself. The mitigation would prevent both flood damages to homes and businesses in the region and any unintended bypasses caused by changes in the hydraulic conditions. While a physical barrier may require less adaptive management to ensure effectiveness, it typically involves longer implementation time and more significant investment before it would achieve ANS risk reduction. On the other hand, nonstructural measures and other technology-based ANS control measures could be implemented more rapidly than a physical barrier and offer more flexibility in their application. These measures would also likely require more involved adaptive management plans. For example, an electric barrier may require continuous monitoring of ANS and active management and research to maximize effectiveness, while a physical barrier will continue to block to a waterway as long as hydraulics and hydrology of the CAWS remain consistent with the design assumptions of the physical barrier.

For some alternatives, there are common plan elements which could provide flexibility during implementation to modify the original alternative to another alternative under certain circumstances. For example, the Technology with an ANS Buffer Zone could be staged for the implementation of ANS control measures at Brandon Road (IL) as the first system control point. Implementation of these ANS control measures at Brandon Road (IL) could evolve from the Technology with ANS Buffer Zone Alternative into the Mid-System Separation CSSC Open Alternative or the Mid-System Cal-Sag Open Alternative. It is anticipated that the early implementation of the Technology with an ANS Buffer Zone measures at Brandon Road (IL) would allow for the timely evaluation of the implementability and efficacy of the measures in this plan, allowing minimal deviation from achievement of its ANS risk reduction in either the total implementation of this alternative or the evolution into either of the two identified hybrid alternatives.

Similarly, the potential exists to transform the completed implementation of the Mid-System Control Technologies without a Buffer Zone Alternative into the Mid-System Hydrologic Separation scenario. The flood-risk management infrastructure constructed as part of the Mid-System Control Technologies without a Buffer Zone would likely be sufficient to handle storm flows in a hydrologic separation regime. However, other necessary mitigation including the re-routing of municipal wastewater treatment flows, as well as measures to protect the water quality of Lake Michigan — including capture of combined sewer overflows and sediment remediation — would need to be accomplished before bringing a the full Mid-System Hydrologic Separation Alternative online. As such, the full ANS risk reduction potential for this alternative would not be realized as early as if it were being constructed from the outset.

3.7 Typical Non-Federal Sponsor Requirements

Involvement of a non-federal sponsor(s) willing to cost-share a plan is required by USACE Policy in order to recommend authorization of a project. See Engineer Regulation 1105-2-100 at 4-3. Under current law, non-federal sponsors are required to pay for 35 percent of environmental 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 operation and maintenance activities. See 33 U.S.C.§ 2213(c)(7), (j). Thus, implementation of a GLMRIS Alternative could not proceed unless a non-federal sponsor is identified or the statutory authorization for implementation of a GLMRIS Alternative specifically changes these requirements.

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 percent of the project cost, provide a cash contribution to make the sponsor's total contribution equal to 35 percent.

8. The non-federal share of the cost of water quality features generally shall be 100 percent. Before there can be a federal interest to cost share a water quality improvement feature, the state must be in compliance with water quality standards for the current use of the water to be affected.

9. Upon achieving state water quality standards for current water uses, USACE may cost share improvements to water quality, if deemed cost-effective and important to ecosystem structure and function.

Under Corps' policies, civil works projects may generally not be used to address existing environmental contamination. For purposes of the GLMRIS Report, the alternatives described include all of the project components and associated mitigation measures necessary for implementation of the alternative, including remediation of contaminated sediments and mitigation measures to address water quality impacts. It is possible that none of the mitigation measures identified as part of an alternative would be eligible for cost sharing with USACE. In the cost estimate section of each alternative, USACE has identified who may be financial responsible for measures in each alternative.

3.8 Alternative Plan 1: No New Federal Action – Sustained Activities

The No New Federal Action – Sustained Activities Alternative essentially describes the current and future actions of federal, state, and local agencies in combating ANS and serves as a comparison point for the remaining alternatives. This alternative assumes that all ongoing efforts supported by federal agencies discussed for the baseline and future-without-project conditions continue through the project planning horizon, which currently includes telemetry and eDNA for Asian carp and R&D of ANS Controls. For the purposes of this analysis and based on input from state and local agencies, it was assumed that ongoing state and local support for monitoring and response directed at Asian carp would continue for at least the next decade. This alternative also assumes the continued operation of the existing Electric Dispersal Barriers (Barrier IIA and Barrier IIB), construction and operation of new Permanent Electric Barrier I, and associated monitoring and response actions by USACE and others to support Electric Barrier operations. This alternative also assumes all other ANS education, outreach, monitoring, and prevention activities currently supported will continue.

3.8.1 Alternative Plan Description

The No New Federal Action – Sustained Activities Alternative assumes that the 13 identified species of concern will continue to represent a High or Medium risk of establishment in the invaded basins. Current activities related to ANS within the CAWS have been factored into the species risk assessment, which had planning time lines of 0, 10, 25, and 50 years. As discussed in Chapter 1, and Appendix B, Affected Environment & Habitat, the efforts reported by local, state, and federal agencies to support ANS control were considered as part of the baseline and future-without-project conditions.

The National Invasive Species Council (NISC) was established by Executive Order (EO) 13112 and charged with providing coordination, planning and overall leadership for federal invasive species programs. The NISC is co-chaired by the Secretaries of the Interior, Agriculture, and Commerce and its members include the Secretaries of State, Defense, Homeland Security, Treasury, Transportation, Health and Human Services, the U.S. Trade Representative (USTR), as well as the Administrators of the U.S. Environmental Protection Agency, National Aeronautics and Space Administration, and U.S. Agency for International Development (http://www.invasivespecies.gov/main_nav/mn_about.html). Important NISC actions and duties include the development of a National Invasive Species Management Plan (NISC 2008) and annual reporting of an invasive species interagency crosscut budget. The interagency crosscut budget exercise provides an estimate of invasive species funding across federal agencies and was designed to encourage federal cooperation on invasive species issues that may benefit from an interagency approach. The February 2013 NISC interagency crosscut budget report indicated that more than $2 billion dollars was spent in 2011 and in 2012 for invasive species activities across eight NISC member agencies (NISC 2013).

For the without-project-condition, the following local, state, and federal actions are expected to continue:

Commercial Harvesting of Asian Carp

GLRI supported the State of Illinois' initiation of commercial harvesting of Asian carp on the Illinois River through the issuance of a grant. It is anticipated that an effort like this would only be employed for commercially viable species, and that there are local funds available to take over the program when GLRI funding is terminated. Constrained budgets could reduce or eliminate programs like this, which would reverse the gains made in terms of population levels of ANS. This effort is expected to continue through the first future time step (10 years).

Electrofishing and Response Actions for Asian Carp

USACE has participated in fixed site electrofishing, as part of the MRRWG Monitoring and Response Plan (MRP), since 2010. USACE and partner agencies have concentrated electrofishing efforts on habitats located downstream of the Electric Dispersal Barriers. These efforts supplement the existing efforts downstream of the barriers as outlined in the 2011 and 2012 MRP. Objectives of ongoing monitoring efforts are to (1) assess the risk of aquatic nuisance species to challenge the Electric Dispersal Barriers and (2) track the leading edge of Asian carp. Monitoring and response actions will continue for the next 10 years or so. Agencies are planning to continue monitoring and telemetry for the foreseeable future. USACE's efforts are expected to continue as part of Barrier O&M. Efforts by other agencies are expected to continue through the first future time step (10 years).

Electric Dispersal Barriers Project for Asian Carp

The electric barriers in the CSSC will continue to be operated. Future conditions will include the operation of Permanent Barrier I and Barrier IIA/IIB. Efforts will continue to evaluate the functionality and efficacy of the project and may result in proposed modifications, improvement, or new construction to increase the effectiveness of this ANS control. Monitoring to determine barrier effectiveness will also continue.

Research and Development

GLRI has supported R&D activities related to ANS monitoring and control for the past several years. It is expected that GLRI support for these activities would continue through 2019. R&D efforts are assumed to continue throughout the planning horizon for the study.

While many agencies have taken and will continue to take action to prevent the spread of aquatic nuisance species, there are no actions currently planned by others that will further reduce the risk of interbasin transfer for all 13 High and Medium risk species.

3.8.2 ANS Risk Reduction

Table 3.1 contains the baseline conditions assessment; it does not contain any risk reduction due to GLMRIS Alternatives.

Table 3.1 ANS Risk of Negative Impacts from Establishment

	T_0	T_{10}	T_{25}	T_{50}
Species Posing Risk of Adverse Impact to Great Lakes Basin				
Scud (*Apocorophium lacustre*)	M	M	M	M
Silver carp (*Hypophthalmichthys molitrix*)	L	L	M	M
Bighead carp (*Hypophthalmichthys nobilis)*	L	L	M	M
Species Posing Risk of Adverse Impact to Mississippi River Basin				
Bloody red shrimp (*Hemimysis anomala*)	H	H	H	H
Fishhook waterflea (*Cercopagis pengoi*)	L	L	M	H
Grass kelp (*Enteromorpha flexuosa*)	L	M	M	M
Red algae (*Bangia atropurpurea*)	M	M	M	M
Diatom (*Stephanodiscus binderanus*)	M	M	M	M
Reed sweet grass (*Glyceria maxima*)	L	L	L	M
Threespine stickleback (*Gasterosteus aculeatus*)	M	M	M	M
Tubenose goby (*Proterorhinus semilunaris*)	L	M	M	M
Ruffe (*Gymnocephalus cernuu*s)	L	L	L	M
Viral Hemorrhagic Septicemia (*Novirhabdovirus* sp.)	M	M	M	M

3.9 Alternative Plan 2: Nonstructural Control Technologies

3.9.1 Alternative Plan Description

Several nonstructural measures could potentially be applied to the 13 ANS of Concern. Table 3.2 summarizes the potential effectiveness of the various categories of nonstructural approaches for controlling the interbasin transfer of ANS of Concern. The Nonstructural Measures Alternative consists of implementing all of the applicable nonstructural measures in Table 3.2. The Nonstructural Alternative assumes that all of the applicable nonstructural measures be implemented because they represent Best Management Practices that may reduce the speed or potential for ANS interbasin transfer at a given time.

This alternative contemplates activities that are not traditionally performed by USACE. To achieve the risk reduction produced by this alternative may require that these measures be implemented by other stakeholder groups such as other federal agencies, state agencies, local municipalities, and NGOs. For this report, it is assumed that all of these measures are fully implemented at either the federal, state, or local level. Because the Federal Government cannot direct the activities of state or local entities, further evaluation would be required to determine whether these risk-reduction measures should be directly performed by federal agencies.

Table 3.2 Potential Effectiveness of Nonstructural Measures for Controlling Interbasin Transfer of the ANS of GLMRIS Concern

Taxon	Nonstructural Approach	Potential Effectiveness
Virus (VHSv)	Education and Outreach	Educating the public to identify and not use infected baitfish may reduce the likelihood of spread via baitfish. Voluntary cleaning of watercraft and other recreational equipment may slow transfer via these vectors.
	Monitoring	Would only provide early identification of spread and not affect transfer. Monitoring would require designated responsible agency involvement.
	Pesticides/Antimicrobial	Use of pesticides with active ingredients that are registered by the EPA to clean boat hulls, trailers, nets, and other equipment may slow transfer.
	Antifouling Materials	May reduce transport on hulls of watercraft.
	Ballast and Bilge Management	May reduce passage via this vector.
	Laws and Regulations	Mandatory disinfection of watercraft and live bait restrictions may slow spread. Uncertain how quickly new laws and regulations could be passed and implemented. There is also some uncertainty associated with the level of enforcement, compliance, and effectiveness of laws and regulations.
Algae (Diatom; Grass kelp; Red algae)	Education and Outreach	Educating public to perform voluntary cleaning of watercraft and other recreational equipment may slow transfer via these vectors.
	Monitoring	Would provide early identification of spread but not likely affect transfer. Monitoring would require the designated responsible the designated responsible agency involvement.
	Pesticides	Algaecides may be effective in localized areas, but maintaining needed concentrations in large or flowing water bodies limits effectiveness. Concerns regarding impacts to non-target species.
	Antifouling Materials	Both biocide- and non-biocide-based materials may reduce transport on hulls of watercraft.
	Habitat Alteration	Improving water quality may reduce suitable habitat and limit occurrence and spread. Limited applicability to the CAWS and possibly below Brandon Road Lock and Dam.
	Ballast and Bilge Management	May limit passage via this vector.
	Laws and Regulations	Little effect anticipated, although mandatory disinfection of watercraft and ballast and bilge water management may slow spread. Uncertain how quickly new laws and regulations could be passed and implemented.

Table 3.2 (Cont.)

Taxon	Nonstructural Approach	Potential Effectiveness
Rooted Semi-Aquatic Vegetation (Reed sweet grass)	Education and Outreach	Educating public to perform voluntary cleaning of watercraft and other recreational equipment may limit spread via these vectors. Public identification of new populations, if linked with aggressive response action, could control spread.
	Monitoring	Would provide early identification of spread but not likely affect transfer. Monitoring would require the designated responsible agency involvement. Early identification of new populations, if linked with aggressive response action, could control spread and transfer.
	Pesticides	Aquatic herbicides may be very effective, especially if application occurs quickly following discovery of new invasions. Application in large or flowing water bodies may limit effectiveness. Concerns regarding impacts to non-target species.
	Antifouling Materials	Non-biocide-based materials may reduce transport on hull soft watercraft.
	Manual or Mechanical Removal	A variety of approaches may be applicable, and could be successful in controlling spread if implemented soon after new populations are reported. May limit establishment of new populations.
	Habitat Alteration	May limit establishment of new populations.
	Ballast and Bilge Management	May reduce passage via this vector, but effectiveness unknown.
	Laws and Regulations	Little effect anticipated, although mandatory disinfection of watercraft and ballast and bilge water management may slow spread. Uncertain how quickly new laws and regulations could be passed and implemented.
Crustaceans (Fishhook waterflea; Scud; Bloody red shrimp)	Education and Outreach	Educating public to perform voluntary cleaning of watercraft and other recreational equipment may limit spread.
	Monitoring	Would provide early identification of spread but not likely affect transfer. Monitoring would require the designated responsible agency involvement.
	Pesticides	Pesticides may be effective in localized areas, but maintaining needed concentrations in large or flowing water bodies limits effectiveness. Disinfection of boat hulls and other recreational equipment may slow spread via this vector. Concerns regarding impacts to non-target species.
	Antifouling Materials	Non-biocide-based materials may reduce transport on hulls of watercraft. Effectiveness of biocide-based materials unknown.

Table 3.2 (Cont.)

Taxon	Nonstructural Approach	Potential Effectiveness
Crustaceans (Fishhook waterflea; Scud; Bloody red shrimp) (Cont.)	Habitat Alteration	The application of chemical compounds to alter water quality may limit or prevent movement of the species.
	Ballast and Bilge Management	May reduce passage via this vector, but effectiveness unknown.
	Laws and Regulations	Mandatory disinfection of watercraft and ballast and bilge water management may slow spread. Uncertain how quickly new laws and regulations could be passed and implemented.
Fish (Bighead carp; Silver carp; Tubenose goby; Ruffe; Threespine stickleback)	Education and Outreach	Educating public to not use the ANS as baitfish may reduce likelihood of accidental introduction via baitfish use and disposal.
	Monitoring	Would provide early identification of spread but not likely affect transfer. Monitoring would require the designated responsible agency involvement. Early identification of new populations, if linked with aggressive response action, may limit spread and transfer.
	Pesticides	Piscicides may be effective in localized areas, but maintaining needed concentrations in large or flowing water bodies limits effectiveness. Concerns regarding impacts to non-target species.
	Manual or Mechanical Removal	Controlled harvest and overfishing may be effective in maintaining low numbers in localized area, potentially slowing the advance into new areas.
	Habitat Alteration	Limited applicability in localized areas.
	Ballast and Bilge Management	Importance of transfer via ballast or bilge water is unknown but may be very limited. Effectiveness of management is also unknown.
	Laws and Regulations	Unknown if new legislation would be effective. Uncertain how quickly new laws and regulations could be passed and implemented.

New and ongoing development of nonstructural measures would be taken into account through an adaptive management plan associated with the Nonstructural Alternative. As effective nonstructural measures are introduced, they would be considered for use under the Nonstructural Alternative.

Nonstructural measures are not anticipated to have significant impacts to waterway uses and users. There is a chance that there could be a slight impact if a chemical application, such as rotenone, is required by adaptive management or rapid response plan. In that case, steps may be taken to mitigate or minimize the impacts to the environment (to include impacts to native species). See Appendix A – Alternative Development Analyses for additional information of the Nonstructural Alternative.

3.9.2 ANS Risk Reduction

The Nonstructural Alternative includes measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures that are dependent on the passage of new laws or regulations, because of the uncertainty regarding the time required to pass and implement new laws or regulations. The anticipated risk reduction resulting from implementation of the Nonstructural Alternative is described below. Because risk reduction of the Nonstructural Alternative depends on actions of numerous agencies and the public, the uncertainty associated with this alternative is generally higher than that obtained with hydrologic separation alternatives. A detailed discussion of this risk assessment analysis including uncertainty pertaining to the alternative's effectiveness for each of the 13 High and Medium risk species can be found in Appendix C –Risk Assessments.

ANS Potentially Invading the Great Lakes Basin

Scud (*Apocorophium lacustre*)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). The Nonstructural Alternative would not reduce the scud's risk of establishment in the GL basin compared to the risk identified in the No New Federal Action – Sustained Activities conditions. Please see Appendix C – With Project Risk Assessments for the Nonstructural Alternative for the scud. The scud is already present at the CAWS and can be transported via vessel movement. The Nonstructural Alternative does not impact vessel movement in the CAWS.

Silver Carp and Bighead Carp (*Hypophthalmichthys molitrix and Hypophthalmichthys nobilis*)

The silver and bighead carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. The Nonstructural Alternative would not reduce the risk of establishment of the bighead or silver carp when compared to the No New Federal Action – Sustained Activities conditions. Under the No New Federal Action – Sustained Activities conditions, numerous nonstructural measures to address bighead and silver carp are already being implemented by federal, state, and local entities. After evaluating the nonstructural measures currently available, no additional nonstructural measures were identified that would further decrease the probability of passage of the species into the Great Lakes Basin. If in the future, if new nonstructural technologies are developed that would be effective against these species, further analysis would need to be conducted. A detailed discussion of this analysis can be found in Appendix C – Risk Assessments.

ANS Potentially Invading the Mississippi River Basin

The Nonstructural Alternative would not reduce the risk of establishment of the following Great Lakes High and Medium risk ANS: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook water flea (*Cercopagis pengoi*), bloody red shrimp (*Hemimysis anomala*), threespine stickleback (*Gasterosteus aculeatus*), ruffe (*Gymnocephalus cernuus*), and VHSv (*Novirhabdovirus*). Nonstructural measures would not eliminate the aquatic pathway between the Great Lakes and Mississippi River basins. The diatom, red algae, fishhook water flea, bloody red shrimp, threespine stickleback and VHSv have already arrived in the lower Lake Michigan Basin and cannot be controlled with nonstructural measures such as aquatic pesticides or piscicides due to their widespread distribution. Though not currently identified as being in the southern Lake Michigan Basin, the ruffe has dispersed throughout various parts of the Great Lakes and also cannot be successfully controlled with nonstructural measures.

The Nonstructural Alternative would reduce the probability of establishment of the following Great Lakes ANS:

Grass Kelp (*Enteromorpha flexuosa*)

A 2003 study indicated that the closest population to the CAWS of *E. flexuosa* is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). Nonstructural measures, such as aquatic herbicides, would target reducing the abundance of grass kelp in these lakes. The comprehensive implementation of the Nonstructural Alternative as described in the risk assessment is expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of the Nonstructural Alternative as identified in the risk assessment would reduce the risk of *E. flexuosa* from Medium to Low for time steps T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
Nonstructural[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Reed sweet grass (*Glyceria maxima*)

Reed sweet grass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012). The Nonstructural Alternative for this species would include measures such as monitoring followed by aquatic herbicide treatment, if it is encountered. The comprehensive implementation of the Nonstructural Alternative as described in the risk assessment is expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk rating from a Medium to a Low.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
Nonstructural[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Tubenose Goby (*Proterorhinus semilunaris*)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as portions of the Detroit River system. This species is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011), and a population has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011). The tubenose goby is an active swimmer, but is able to disperse more quickly through ballast water transfer. The management of vessel ballast/bilge water in waters where tubenose gobies occur is expected to delay the time it would take for this species to arrive at the CAWS pathway and reduces the likelihood it will arrive at the CAWS at T_{10}. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected that this species can swim from its current location to the CAWS by T_{25}.

The comprehensive implementation of the Nonstructural Alternative as identified in the risk assessment would reduce the risk of tubenose goby from a Medium to a Low at T_{10}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
Nonstructural[a]	Low	***Low***	Medium	Medium

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

3.9.3 Estimated Alternative Cost

At this time, it is difficult to estimate costs that could be incurred with the implementation of a comprehensive Nonstructural Alternative that includes one or more of the nonstructural measures discussed in Table 3.2. Costs will be affected by specific implementation requirements of the approaches selected; the more involved an approach and the more frequently it must be applied, the greater the expected cost. However, annual costs for a nonstructural program that employs several of the nonstructural measures considered may be expected to be in the millions of dollars within any one state.

For example, annual operating costs have been estimated at $8,500,000 for an overall program that includes education and outreach, monitoring, pesticide application, removal, biological control, ballast and bilge inspection, watercraft inspection, and research (personal communication, Wisconsin Department of Natural Resources). In that program, education and outreach activities account for approximately half (about $4,000,000) of the estimated annual cost, while monitoring and pesticides account for nearly as much (about $1,000,000 and $2,000,000 combined). Monitoring can cost $2,500,000 to $5,000,000 and mechanical removal between $500,000 and $1,000,000. Assuming similar programs and associated costs for Minnesota, Illinois, Indiana, Ohio, Michigan, Pennsylvania, and New York (the other Great Lakes states), an estimated annual cost for a Nonstructural Alternative encompassing the eight states may be as high as $68,000,000.

When amortized over the 50-year project evaluation period (2017 through 2066), the total cost of nonstructural measures is estimated at $1.5 billion in Fiscal Year 2013 dollars.

Table 3.3 below identifies what could possibly be the annual costs for the Nonstructural Alternative. The states identified in the table are the Great Lakes states. The actual costs of the nonstructural alternative would be dependent on coordination with a number of participating local, state, and federal agencies and could be higher or lower than the value presented. Estimated initial costs for the Nonstructural Alternative are assumed negligible and sufficiently captured by the estimate for the annual OMRR&R Costs. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Table 3.3 Estimated Alternative Cost

Nonstructural Alternative[a]	
Nonstructural Measures	**Annual Cost**
Education and outreach	$4,000,000
Monitoring	$1,000,000
Pesticides	$2,000,000
Watercraft inspection and research	$1,500,000
Total Annual Cost per State	**$8,500,000**
States nearest to the CAWS participating	Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, Pennsylvania, and New York
Total Annual Cost of the Nonstructural Alternative	**$68,000,000**

[a] Costs are shown as 2014 program-year dollars.

3.9.4 Estimated Alternative Implementation Duration

The nonstructural measures evaluated are ones that may be implemented relatively quickly (T_0); as such, the Nonstructural Alternative could be implemented almost immediately with proper coordination. One exception would be any nonstructural measure dependent on new laws or regulations, because of the uncertainty on how quickly new laws and regulations could be passed and implemented.

3.9.5 Complexity of Regulatory Compliance

The Nonstructural Alternative is anticipated to have a low level of complexity associated with regulatory compliance. Although some nonstructural measures, such as pesticides, may require regulatory coordination and permitting actions, most measures require little additional regulatory compliance. These measures have been successfully employed over the past several years.

3.10 Alternative Plan 3: Mid-System Control Technologies without a Buffer Zone

3.10.1 Alternative Plan Description

Table 3.4 summarizes the measures included in the Mid-System Control Technologies without a Buffer Zone, the type of measures and the locations (Figures 3.1-3.3) of the measures.

Table 3.4 Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative

Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative		
Location	**Measure**	**Type of Measure**
Basin Wide	Nonstructural	ANS Control
TBD within the Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
Stickney (IL)	GLMRIS Lock	ANS Control
	Electric Barrier × 2	
	ANS Treatment Plant	
McCook (IL)	Conveyance Tunnel	FRM Mitigation
	11.4 Billion Gallon Reservoir	
Oak Lawn (IL)	0.2 Billion Gallon Reservoir	FRM Mitigation
Alsip (IL)	GLMRIS Lock	ANS Control
	Electric Barrier × 2	
	ANS Treatment Plant	
Thornton (IL)	15.8 Billion Gallon Reservoir	FRM Mitigation
	Conveyance Tunnel	

This alternative includes nonstructural measures and two single point ANS control technologies located at Stickney (IL) and Alsip (IL). These technologies reduce the risk of transfer of ANS between basins in both directions. Additionally, the nonstructural measures discussed in Section 3.2 of this report would also be implemented as part of this alternative.

At both Stickney (IL) and Alsip (IL), a new GLMRIS Lock would be constructed on the CSSC and the Cal-Sag, respectively. Approach channels from Lake Michigan and the Mississippi River directions would be built on either side of the lock and would include electric barriers to prevent fish from entering the lock chamber during lockages. An ANS Treatment Plant would provide the water for lockages to ensure ANS not affected by the electric barriers would not be allowed to transfer during lockages. These locks would remain closed at all times unless a vessel needed to cross to the other side. Additionally, if

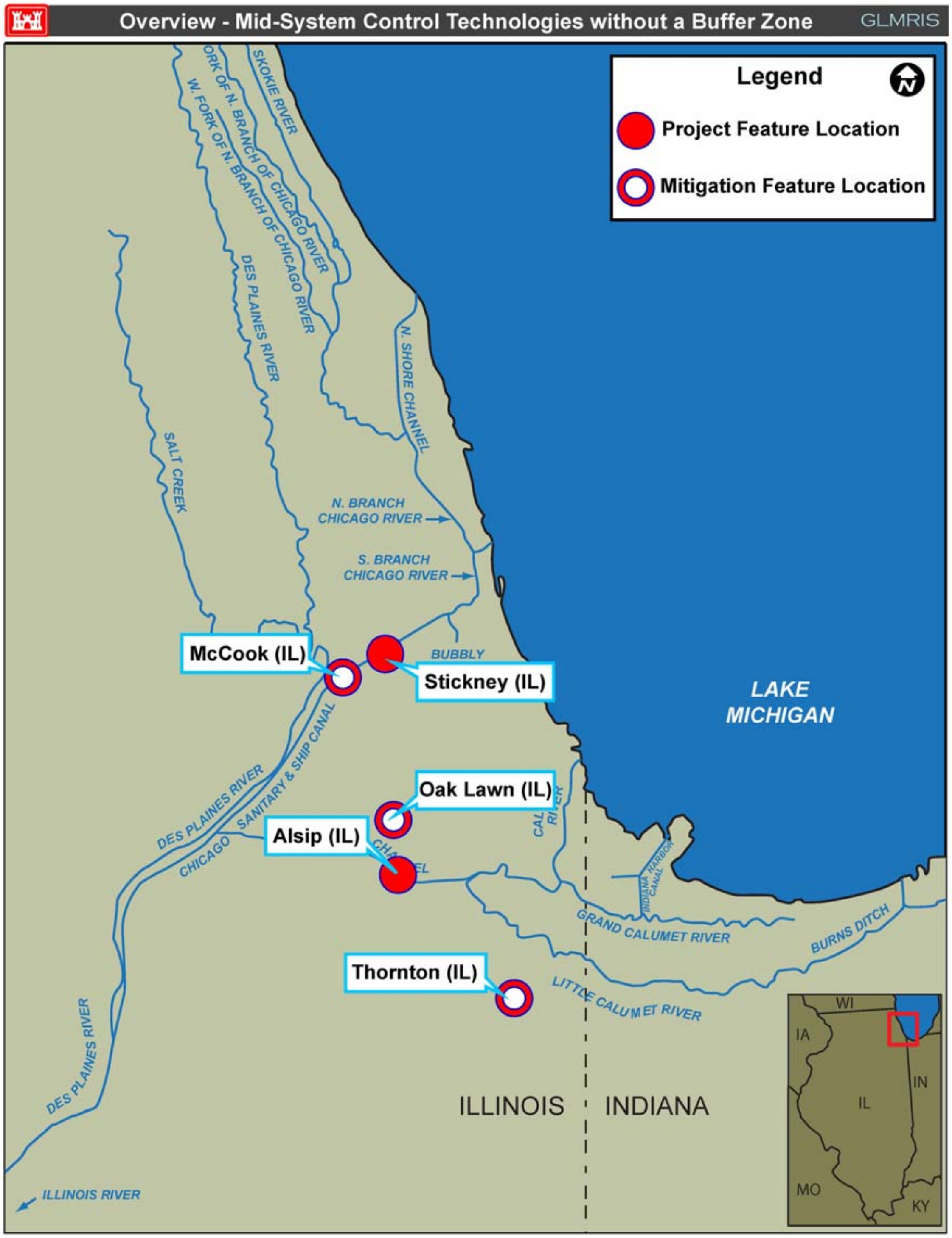
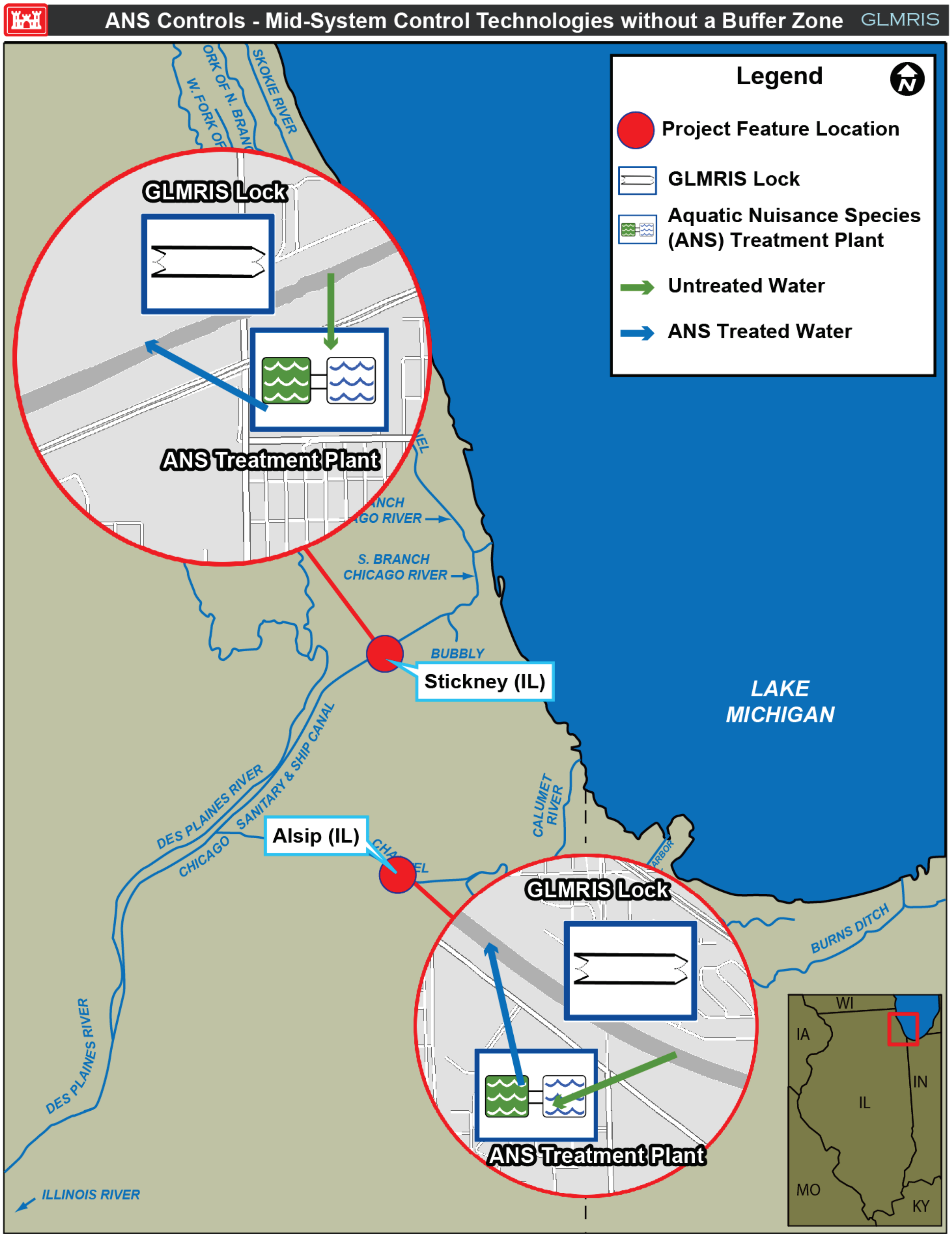


Figure 3.1 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.2 Locations of ANS Prevention Measures with Additional Details

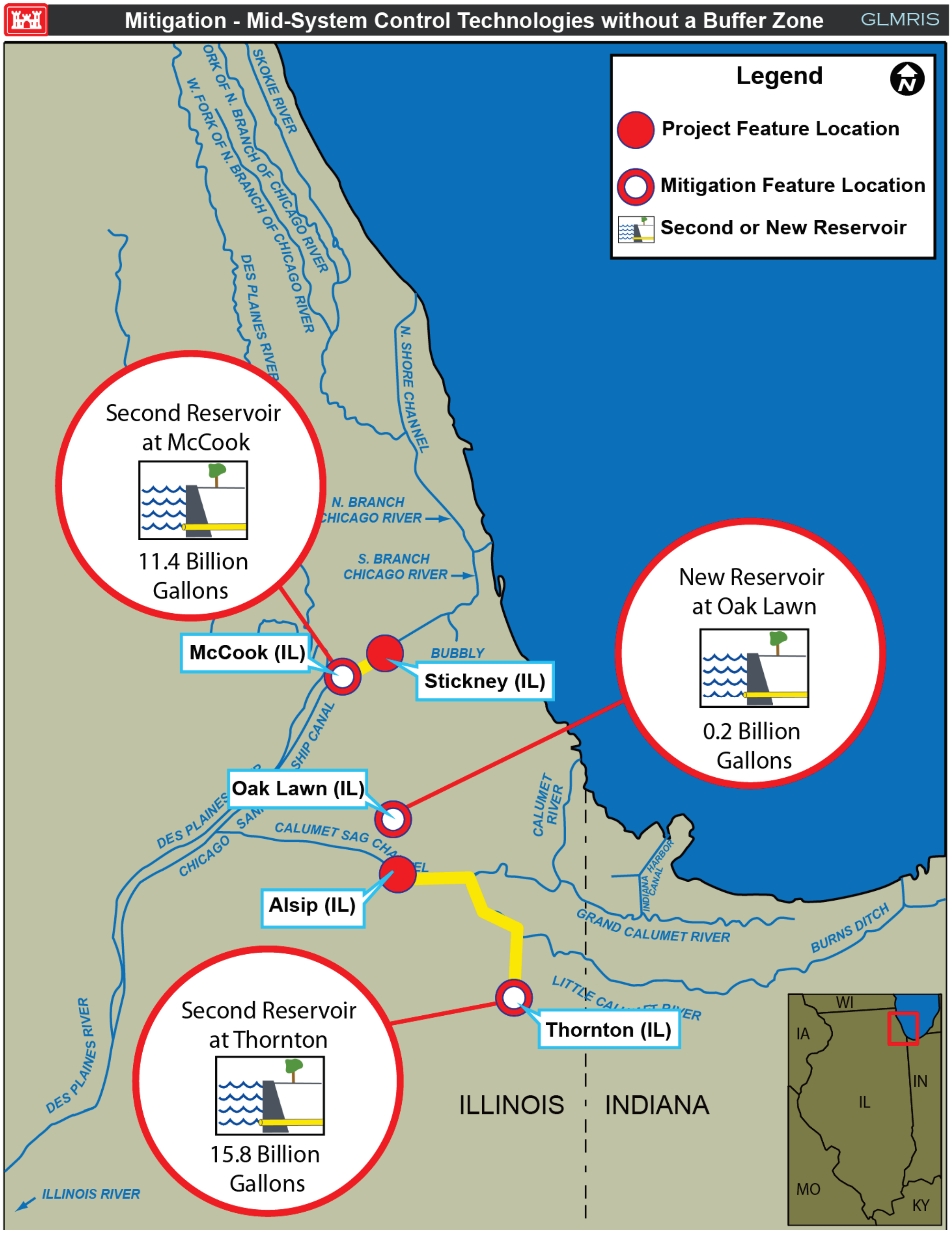


Figure 3.3 Location Details of Mitigation Measures

there were a power failure with the electric barriers or another maintenance concern, the locks would remain closed to prevent passage of ANS.

The normal flow of the CAWS would be diverted from the channel on the lakeside of the new locks, through ANS Treatment Plants at each location, and then discharged back to the riverside of the new locks.

Please refer to the Attachment Map Package Mid-System Control Technologies without a Buffer Zone for additional mapping details.

ANS Treatment Plants for ANS Control

- ANS Treatment Plant at Stickney (IL) – 700 MGD capacity, 5.6-acre footprint.
- ANS Treatment Plant at Alsip (IL) – 900 MGD capacity, 7.2-acre footprint.

CAWS Ecosystem Impacts

The construction of this alternative would not significantly alter the already homogenized aquatic habitat (e.g., substrate and geomorphology of stream channel) within the CAWS. The ANS Treatment Plant would treat all organism collected, a nonselective application of treatment. This would impact native fish and other native aquatic organisms that make up the food web of the CAWS. This disruption would impact ecosystem function and structure. A Medium impact is anticipated. A more detailed discussion of this analysis can be found as an Attachment to Appendix A.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Water Quality CAWS Impacts

Water quality impacts to the CAWS are expected to be minimal under this alternative. The ANS Control measures proposed are not expected to change the direction of flow or operation of the waterway system. Therefore, water quality impacts are expected to be similar to the future-without project condition.

Water Quality Lake Michigan Impacts

There are no negative impacts to Lake Michigan under this alternative because the ANS Control measures proposed are not expected to change the direction of flow or operation of the waterway system. Therefore, water quality impacts are expected to be similar to the future without project condition.

Flood Risk Management (FRM) Impacts

All normal flow of the CAWS would be diverted through the new ANS Treatment Plants. During storm events, the additional flow above normal would need to be stored until the CAWS would be able to receive it without FRM impacts. Also, the flow on Thorn Creek, an aquatic connection with the potential to bypass the Alsip (IL) physical barrier, would need to be captured and stored during storm events.

Without any mitigation measures, this alternative yields a net change in equivalent expected annual damages EEAD of $1,149,000 annually due to the locks at Stickney (IL) and Alsip (IL) that cannot be opened during storm events. This net change in EEAD represents the additional damages to buildings and their contents that are expected to occur on a yearly basis as a result of this alternative. In the without-project conditions, damages are expected to occur to various structures. However, the implementation of a GLMRIS plan will either increase the total damages in the Chicago area or decrease total damages in the Chicago area. Specifically, the values presented represent the difference (i.e., net change) between the without-project condition (EEAD of $231.241 million) and the with-project conditions. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

To mitigate for impacts to FRM two new reservoirs and the necessary stormwater collection system (via tunnels) would be constructed. These new reservoirs and tunnels would be very similar in nature to the existing TARP in the Chicago area. These reservoirs would store stormwater up to the 0.2% ACE event, route the water through existing wastewater treatment plants, and then discharge the water into the CAWS such that it joins the Mississippi River basin. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix J – Civil Design.

Flood Risk Management (FRM) Mitigation Measures

- Conveyance tunnel along the CSSC to McCook (IL) estimated at 5 miles long and 14 feet in diameter.
- A new 11.4 billion gallon reservoir at McCook (IL) would address FRM impacts on the North Shore Channel, Chicago River, and CSSC in the system.
- Conveyance tunnel from Alsip (IN) to Thornton (IL) estimated at 5 miles long and 16 feet in diameter.
- A new 15.8 billion gallon reservoir at McCook (IL) would address FRM impacts on the Calumet, Grand Calumet and Little Calumet Rivers in the system.
- A new 0.2 billion gallon reservoir at Oak Lawn (IL) would address FRM impacts on Thorn Creek, a potential bypass of the physical barrier in Alsip (IL) on the Cal-Sag Channel in the system.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures, construction and proposed operation of the lock structures in this alternative would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events. The FRM mitigation would act as mitigation for human safety for the induced flooding.

Construction of the electric barriers at Stickney (IL) and Alsip (IL) would also have impacts to human safety. Their installation would have to be coordinated with the U.S. Coast Guard, and restrictions on small watercraft traversing the barriers would be imposed.

Commercial Navigation Impacts

The Mid-System Control Technologies without a Buffer Zone would result in a loss of commercial cargo navigation transportation cost savings of $0.75 million annually. This alternative includes adding locks in the CAWS, so commercial cargo movements are likely to be impacted by increased lockage times. Increased lockage times translate into greater overall shipping times, which translate into decreases in transportation cost savings. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Mid-System Control Technologies without a Buffer Zone to noncommercial navigation would likely include:

- The new locks will require additional time for vessels attempting the "loop" around North America.
- Passenger and government vessels will experience additional costs and delay when taking a trip through the location of the new locks.
- Vessels under 20 feet will not be able to pass through the electronic barriers (current U.S. Coast Guard restriction).

The Mid-System Control Technologies without a Buffer Zone would have a low impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

3.10.2 ANS Risk Reduction

This alternative includes nonstructural measures assumed to be implemented quickly (T_0). An exception would be nonstructural measures dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25} and in part, are generally discussed below. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies are known, the combination of technologies and application of the technologies are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternative includes physical barriers, which have uncertainty based on the size of the design storm event. A detailed discussion of this risk assessment analysis, including a more detailed explanation regarding the measures and uncertainty for this alternative, are found in Appendix C – Risk Assessments.

This alternative would be implemented at T_{25} and would reduce the risk ratings of the following species:

ANS Potentially Invading the Great Lakes Basin

Scud (*Apocorophium lacustre*)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). This alternative would not reduce the scud's risk of establishment in the GL basin compared to the risk identified in the No New Federal Action – Sustained Activities conditions. Please see Appendix C – Risk Assessments for the scud. The scud is already present at the CAWS and can be transported via vessel movement. This alternative provides for continued vessel movement in the CAWS and would not reduce the risk of the scud.

Bighead Carp (*Hypophthalmichthys nobilis*)

The bighead carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and creates control points for this species with construction of electric barriers, ANSTPs, and GLMRIS Locks.

Nonstructural measures such as piscicides, overfishing, etc., are expected to limit the population of bighead carp below these control points. Ballast and bilge water management are expected to control the transfer of eggs, larvae, and fry through the GLMRIS Lock.

The electric barrier is expected to control swimming fish from entering the GLMRIS Lock. The pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the ANSTP and is expected to control the transfer of bighead carp eggs, larvae, and fry that may passively drift into the lock. These control points would reduce the likelihood that the species would pass through the CAWS.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of bighead carp from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Silver Carp (*Hypophthalmichthys molitrix*)

The silver carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and electric barriers, ANSTPs, and GLMRIS Locks to create control points within the system for this species.

Nonstructural measures such as piscicides, overfishing, etc., are expected to limit the population of silver carp below these control points. Ballast and bilge water management are expected to control the transfer of eggs, larvae, and fry through the GLMRIS Lock.

The electric barrier is expected to control swimming fish from entering the GLMRIS Lock. The pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the ANSTP and is expected to control the transfer of silver carp eggs, larvae, and fry that may passively drift into the lock. This control point would reduce the likelihood that the species would pass through the CAWS.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of silver carp from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

ANS Potentially Invading the Mississippi River Basin

This alternative would not reduce the risk of adverse impacts from transfer of the following ANS through the CAWS and establishment in the MR basin: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook waterflea (*Cercopagis pengoi*), and VHSv (*Novirhabdovirus* sp.). These four species are either hull foulers or may transfer via temporary vessel attachment through the GLMRIS Lock. This alternative does not include a measure that successfully addresses hull fouling or vessel attachment.

Grass Kelp (*Enteromorpha flexuosa*)

A 2003 study indicated that the closest population to the CAWS of *E. flexuosa* is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). In addition to other measures, this alternative includes nonstructural measures and GLMRIS Locks and ANSTPs to create control points within the system for this species.

The ANSTPs' UV treatment is expected to inactivate grass kelp from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. The GLMRIS Lock is not expected to control grass kelp's entry into or passage through the CAWS by vessels. Grass kelp may temporarily attach to vessels, but the GLMRIS Lock would not dislodge algae from vessel hulls.

Nonstructural measures, such as aquatic herbicides, would target reducing the abundance of grass kelp where it is found. Nonstructural measures as described in the risk assessment are expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of *E. flexuosa* from Medium to Low for time steps T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Reed sweet grass (*Glyceria maxima*)

Reed sweet grass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012).

In addition to other measures, this alternative includes nonstructural measures and GLMRIS Locks and ANSTPs to create control points within the system for this species.

The ANSTP's UV treatment is expected to inactivate reed sweet grass from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. The GLMRIS Lock is not expected to control reed sweet grasses' entry into or passage through the CAWS by vessels. Reed sweet grass may temporarily attach to vessels, but the GLMRIS Lock would not dislodge it from vessel hulls.

Though the control points containing GLMRIS Locks are not expected to be effective for reed sweet grass, nonstructural measures such as monitoring followed by aquatic herbicide treatment, if it is encountered, are expected to control its arrival to the CAWS. Nonstructural measures as described in the risk assessment are expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk rating from Medium to Low.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Bloody Red Shrimp (*Hemimysis anomala*)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). This species is not known to be a hull fouler or to temporarily attach to vessels. In addition to other measures, this alternative includes nonstructural measures and GLMRIS Locks and ANSTPs to create control points for this species.

The pump-driven filling and emptying system of the GLMRIS Lock would control its passage during lockages. The ANSTPs' UV treatment is expected to inactivate the bloody red shrimp from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from High to Low at T_{25} and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{25}. However, because the bloody red shrimp's probability of establishment is High at T_0 and T_{10}, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	High	High	High	High
GLMRIS Alternative[a]	High	High	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Threespine Stickleback (*Gasterosteus aculeatus*)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station. This alternative includes nonstructural measures and electric barriers, GLMRIS Locks, and ANSTPs to create control points within the system for this species.

The electric barrier is expected to control the entry of swimming fish into the lock, while the pump-driven filling and emptying system of the GLMRIS Lock would control the passage of eggs, larvae, and fry. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the MR basin side of the control point for water quality purposes and maintenance of current hydrologic conditions. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures would reduce the likelihood the threespine stickleback would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{25}. However, because the threespine stickleback's probability of establishment is High at T_0 and T_{10}, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Ruffe (*Gymnocephalus cernuus*)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). This alternative includes nonstructural measures, and electric barriers, GLMRIS Locks, and ANSTPs to create control points within the system for this species.

The electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae, and fry during lockages. The water treated by the ANSTP would flush the GLMRIS Lock and would be discharged to the MR basin side of the control point for water quality purposes and maintenance of hydrologic conditions in the CAWS. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Tubenose Goby (*Proterorhinus semilunaris*)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011). This alternative includes nonstructural measures and electric barriers, GLMRIS Locks, and ANSTPs to create control points within the system for this species.

The tubenose goby is an active swimmer but is able to disperse more quickly through ballast water transfer. The management of ballast/bilge water in ships that travel in waters where tubenose gobies occur is expected to delay the time it would take this species to arrive at the CAWS pathway and reduces the likelihood it will arrive at the CAWS at T_{10}. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected this species can swim from its current location to the CAWS by T_{25}.

The electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae, and fry during lockages. The water treated by the ANSTP would flush the GLMRIS Lock and would be discharged to the MR basin side of the control point for water quality purposes and maintenance of current hydrologic conditions. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{10}, $T_{25,}$ and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

3.10.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.5) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Table 3.5 Costs of Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative

Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative[a]	
ANS Control Measures Costs	$4,032,000,000
CAWS Ecosystem Mitigation Measures Costs	$44,000,000
Water Quality Mitigation Measures Cost	NA
FRM Mitigation Measures Cost	$9,140,000,000
Design/Construction Management	$2,257,000,000
LERRDs	$70,000,000
OMRR&R Cost (annual)	$145,500,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$15,543,000,000**

[a] Costs are shown as 2014 program-year dollars.

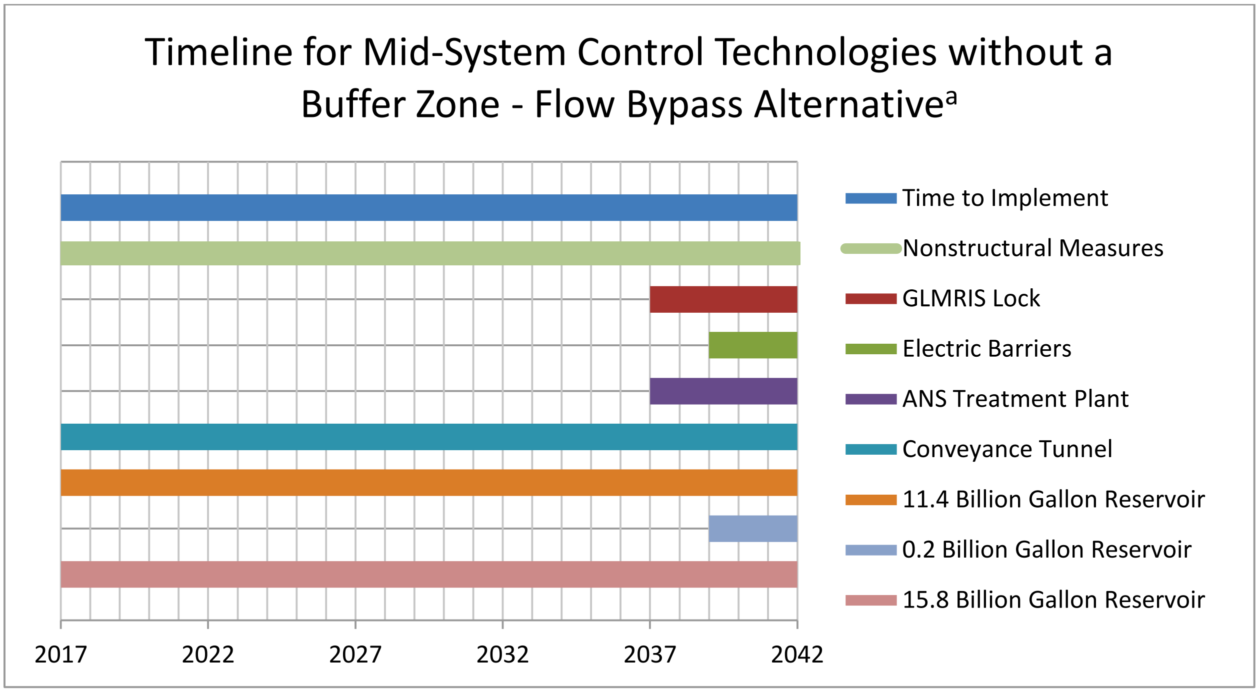
USACE recognizes that while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.6) identifies who may be financial responsible for measures in this alternative.

Table 3.6 Financial Responsibilities for Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative

Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
GLMRIS Lock @ Stickney (IL)	CAWS Ecosystem Restoration		Nonstructural
Electric Barrier × 2 @ Stickney (IL)	Conveyance Tunnel		
ANS Treatment Plant @ Stickney (IL)	New 11.4 Billion Gallon Reservoir @ McCook (IL)		
GLMRIS Lock @ Alsip (IL)	New 0.2 Billion Gallon Reservoir @ Oak Lawn (IL)		
Electric Barrier × 2 @ Alsip (IL)	Conveyance Tunnel		
ANS Treatment Plant @ Alsip (IL)	New 15.8 Billion Gallon Reservoir @ Thornton (IL)		

3.10.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.4 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.



[a] The mitigation measures must be implemented prior to the completion of the ANS Control measures, such as the GLMRIS Lock, to minimize impacts to CAWS uses and users. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.4 Timeline for Mid-System Control Technologies without a Buffer Zone – Flow Bypass Alternative

3.10.5 Complexity of Regulatory Compliance

The Mid-System Control Technologies without a Buffer Zone is anticipated to have a medium level of complexity associated with regulatory compliance. Implementation of the project features will require a high degree of coordination with federal, state, and local regulators. In-water construction will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the State of Illinois. Additional electric barriers will require coordination with the U.S. Coast Guard on potential safety regulations for navigation through the barriers. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.

3.11 Alternative Plan 4: Control Technology Alternative with a Buffer Zone

3.11.1 Alternative Plan Description

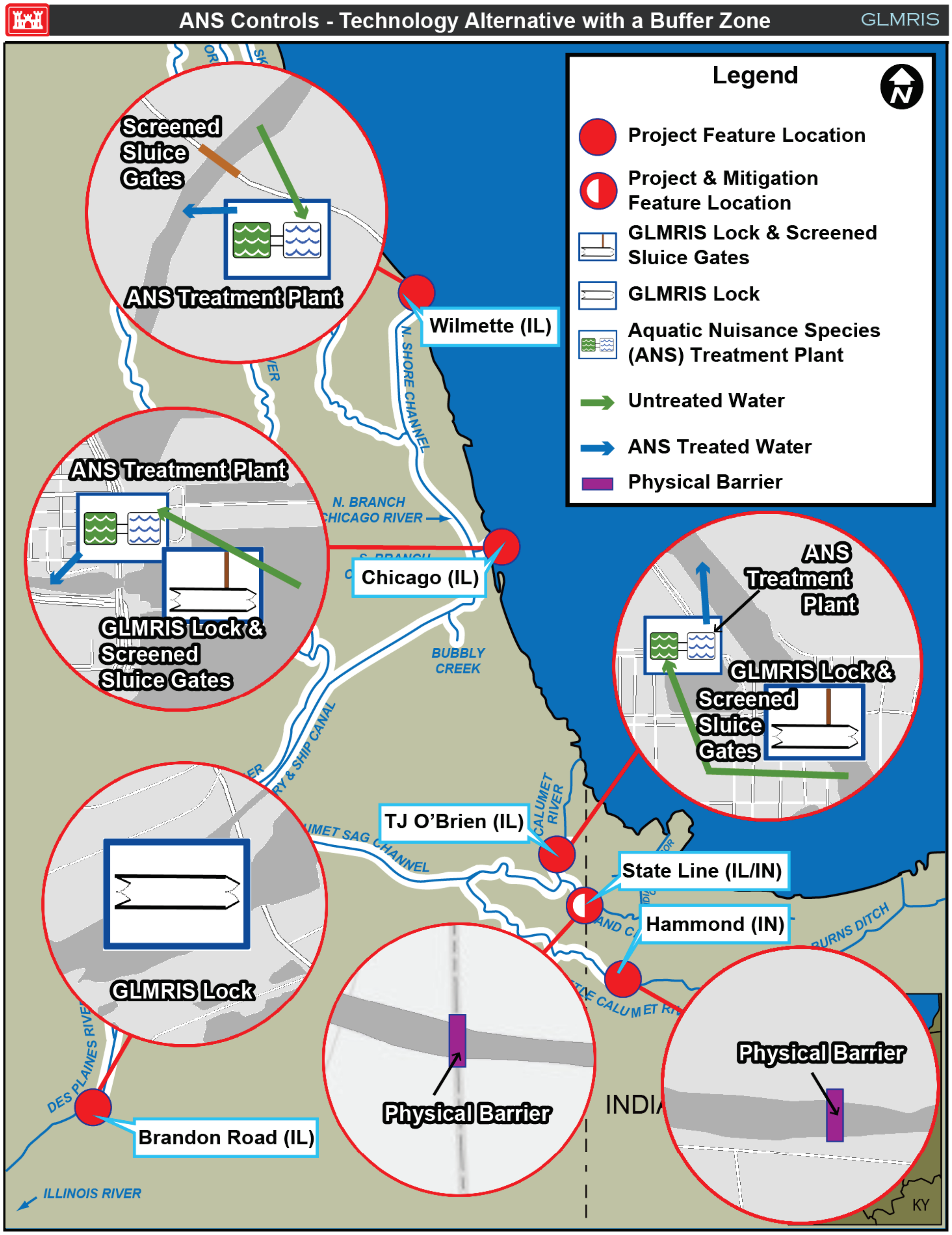
Table 3.7 summarizes the measures included in the Control Technology Alternative with a Buffer Zone, the type of measures and the locations of the measures, which are depicted in Figures 3.5-3.7.

Table 3.7 Technology Alternative with Buffer Zone – CAWS Buffer Zone

Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative		
Location	**Measure**	**Type of Measure**
Basin-wide	Nonstructural	ANS Control
To Be Determined within Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
Wilmette (IL)	Screened Sluice Gates	ANS Control
	ANS Treatment Plant	WQ Mitigation
Chicago (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	
	ANS Treatment Plant	
	Screened Sluice Gates	
TJ. O'Brien (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	
	ANS Treatment Plant	
	Screened Sluice Gates	
Stateline (IL/IN)	Physical Barrier	ANS Control
	0.3 Billion Gallon Reservoir	FRM Mitigation
Hammond (IN)	Physical Barrier	ANS Control
Thornton (IL)	4.4 Billion Gallon Reservoir	FRM Mitigation
	Conveyance Tunnel	
Brandon Road (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	

This alternative creates an ANS-free Buffer Zone by installing ANS control measures along all five aquatic connections between the CAWS and Lake Michigan and by installing ANS control measures at the single downstream point of the CAWS at Brandon Road (IL) (Figures 3.5 and 3.6). This is achieved by modifying or replacing the existing structures at Wilmette (IL), Chicago (IL), T.J. O'Brien (IL), and Brandon Road (IL) and by constructing physical barriers along the uncontrolled pathways of the Grand Calumet River and Little Calumet River at Stateline (IL/IN) and Hammond (IN). Additionally, the nonstructural measures outlined in Section 3.9 – Alternative Plan 2: Nonstructural Control Technologies would be implemented as part of this alternative.

Figure 3.5 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.6 Locations of ANS Prevention Measures with Additional Details

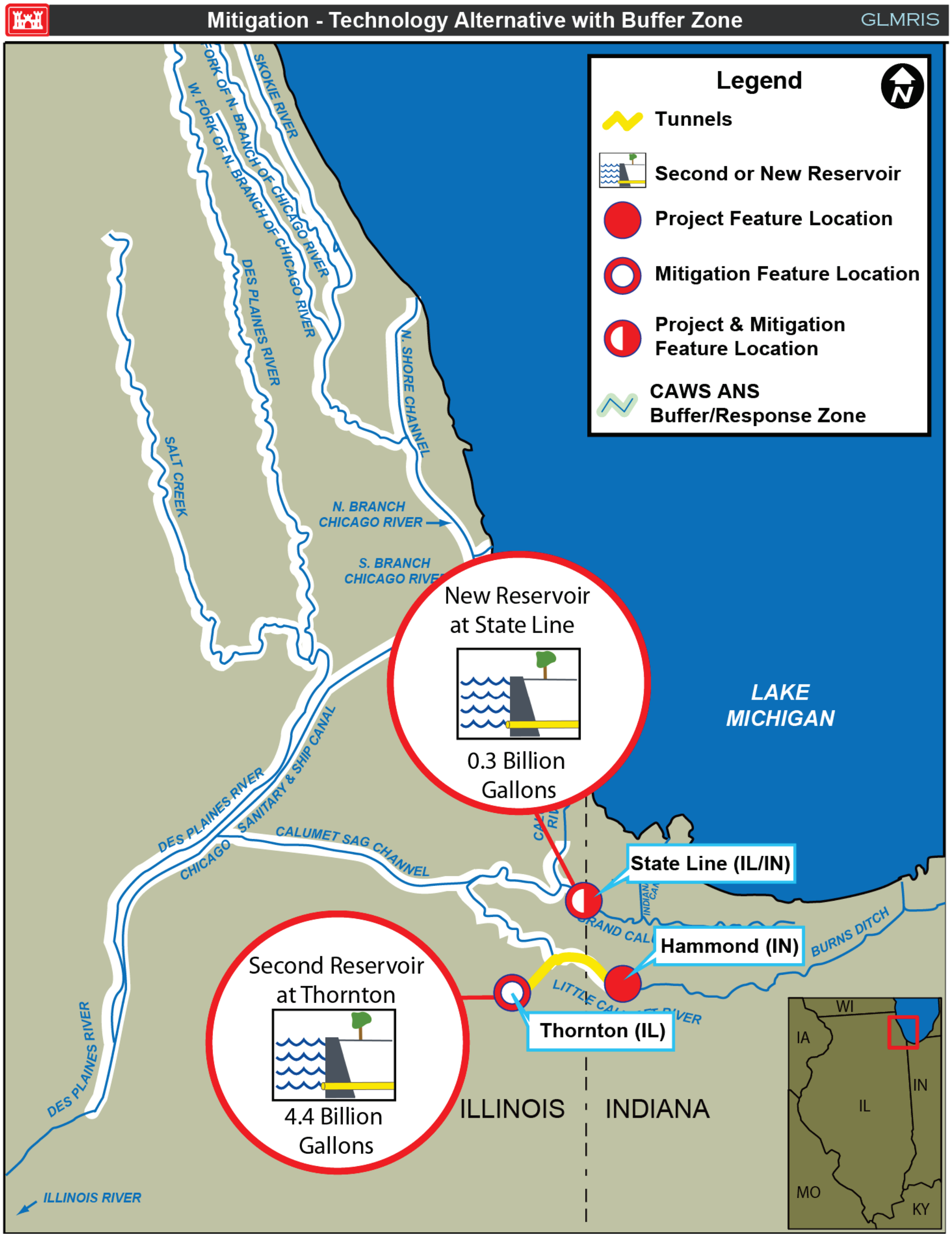


Figure 3.7 Locations of Mitigation Measures with Additional Details

At Wilmette (IL), new screened sluice gates would be installed that are designed to prevent ANS from Lake Michigan from entering the CAWS while still allowing water to flow from the CAWS into Lake Michigan when necessary for FRM.

At Chicago (IL), the existing single-chamber lock would be replaced with a new double-chamber GLMRIS Lock with a shallow chamber and a deep chamber that is at the existing depth. The GLMRIS Lock would have a water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone. A new approach channel from Lake Michigan would include an electric barrier to prevent fish from entering the lock chamber during lockages. An ANS Treatment Plant would provide the water for lockages to ensure ANS not affected by the electric barriers would not be allowed to transfer into the CAWS from Lake Michigan. Screened sluice gates would be installed that are designed to prevent ANS from Lake Michigan from entering the CAWS while still allowing water to flow from the CAWS into Lake Michigan when necessary for FRM.

At T.J. O'Brien (IL), the same ANS control measures at Chicago (IL) would be implemented with the exception of the lock replacement. At T.J. O'Brien (IL), the existing single-chamber lock would be replaced with a new single chamber GLMRIS Lock at the existing depth. The GLMRIS Lock would have a water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone.

At Brandon Road (IL), a new approach channel from the Mississippi River direction would include an electric barrier to prevent fish from entering the lock chamber during lockages. The existing lock would be rehabilitated to install a new water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone and release the water downstream to the Mississippi River Basin and prevent ANS not affected by the electric barrier from entering the lock chamber.

The GLMRIS Locks would remain closed at all times unless a vessel needed to cross to the other side. Additionally, if there were a power failure with the electric barriers or another maintenance concern, the locks would remain closed to prevent passage of ANS.

CAWS Ecosystem Impacts

The Control Technology Alternative with a Buffer Zone would remove aquatic habitat at or near Lake Michigan. The two physical separation barriers along the Grand Calumet and Little Calumet Rivers would impede the dispersal of native species within their respective rivers. The result could be the extirpation of vulnerable native species and disruption of the food web. This is anticipated to be a High impact.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Water Quality CAWS Impacts

The GLMRIS Lock and ANS Treatment Plant are novel technology applications that enable the Technology with a Buffer Zone Alternative to prevent ANS transfer between basins while maintaining lock operations for navigation. This alternative impacts water quality in the CAWS because it precludes the use of untreated Lake Michigan water to ameliorate water quality in the CAWS. Absence of Lake Michigan diversion water in the CAWS system would result in low flows, stagnant zones, and low dissolved oxygen concentrations.

In addition to their role as an ANS control measure, the proposed ANS Treatment Plants at Wilmette (IL), Chicago (IL), and T.J. O'Brien (IL) would also function to mitigate water quality impacts. The ANS Treatment Plants would withdraw water from the Lake Michigan side of the physical barriers, treat the water to remove or inactivate ANS, and then discharge the ANS-treated water on the Mississippi River side of the physical barriers. The treatment technologies proposed for the ANSTPs include screening and UV radiation. The ANSTPs would allow the discretionary diversion of Lake Michigan water allocated to MWRD to continue and the CAWS hydrology to remain similar to current conditions. With this mitigation, water quantity and quality are expected to be essentially equivalent for the future with-project and without-project conditions. For additional information on mitigation. refer to Appendix F.

Water Quality CAWS Mitigation Measures

- ANS Treatment Plant at Wilmette (IL) – 200 MGD capacity, 0.7-acre footprint.
- ANS Treatment Plant at Chicago (IL) – 1,750 MGD total capacity, 5.7-acre footprint.
  - 450 MGD capacity for water quality mitigation.
  - 1,300 MGD capacity to supply the GLMRIS Lock.
- ANS Treatment Plant at T.J. O'Brien (IL) – 1,250 MGD total capacity, 4.1-acre footprint.
  - 450 MGD capacity for water quality mitigation.
  - 800 MGD capacity to supply the GLMRIS Lock.

Water Quality Lake Michigan Impacts

Under this alternative, water quantity and quality are expected to be essentially equivalent for the future with-project and without-project conditions; therefore, there are no impacts to the water quality of Lake Michigan as a result of this alternative.

Flood Risk Management (FRM) Impacts

Under existing conditions, the Grand Calumet River and Little Calumet River flow toward the Mississippi River and Great Lakes basins. The physical barriers at Stateline (IL/IN) and Hammond (IN) prevent this bi-directional flow and would cause FRM impacts such as induced sewer and overbank flooding during large storm events. USACE is currently constructing a levee system on the Little Calumet River. The stage increases caused by these physical barriers would affect the level of protection on the levees. The Little Calumet River levee system is being constructed to a 0.5% ACE level (200-yr) with at least a 95% confidence for certification. With these barriers in place, the impacts to the level of protection (LOP) is substantial for several levee sections as summarized below (LOP where 95% confidence is achieved):

- Reach 4 Hammond East North 100-yr
- Reach 5b Griffith South 50-yr
- Reach 6a Gary North 100-yr
- Reach 7 Gary South 100-yr

Without any mitigation measures, this alternative yields a net change in equivalent expected annual damages EEAD of $570,000 annually due to the physical barriers at Stateline (IL\IN) and Hammond (IN). To mitigate for impacts to FRM, two new reservoirs and the necessary stormwater collection system (via tunnels) would be constructed. These new reservoirs and tunnels would be very similar in nature to the existing TARP in the Chicago area. These reservoirs would store stormwater up to the 0.2% ACE event, route the water through existing wastewater treatment plants, and then discharge the water into the CAWS such that it joins the Mississippi River Basin.

Flood Risk Management (FRM) Mitigation Measures

- New 0.3 billion gallon reservoir at Stateline (IL) would address FRM impacts on the Grand Calumet River in the system.
- A new 4.4 billion gallon reservoir at Thornton (IL) would address FRM impacts on the Little Calumet River in the system.
- Conveyance tunnel from Hammond (IN) to Thornton (IL) estimated to be 7 miles long and 14 feet in diameter.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures (Figure 3.7), construction of physical barriers would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events. The FRM mitigation would act as mitigation for these human safety impacts.

Construction of the electric barriers at Chicago (IL), T.J. O'Brien (IL), and Brandon Road (IL) would also have impacts to human safety. Their installation would have to be coordinated with the U.S. Coast Guard, and restrictions on small watercraft traversing the barriers would be imposed.

Commercial Navigation Impacts

The Control Technology Alternative with a Buffer Zone would result in a loss of commercial cargo navigation transportation cost savings of $0.5 million annually. This alternative includes adding locks in the CAWS or modifying existing locks; commercial cargo movements could be impacted by increased lockage times. Increased lockage times translate into greater overall shipping times, which translate into decreases in transportation cost savings. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Control Technology Alternative with a Buffer Zone Impacts to noncommercial navigation would likely include:

- Police/fire/other government vessels will need to incur additional expense in order to maintain the same level of service. Emergency response vessels will be impacted, which is a safety issue.

- There will be additional cost to non-cargo lock users as they attempt to maintain previous usage, find alternate means of reaching their destination, and/or find alternate destinations for boat repairs, fishing, or other recreational activity.
- The physical barriers may increase the frequency of high water events on the CAWS.

- The value of the recreational experience for tour boat passengers, recreational anglers, and recreational boaters may decrease. Vessels under 20 feet will not be able to pass through the electronic barriers (current U.S. Coast Guard restriction).

The Control Technology Alternative with a Buffer Zone would have a medium impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

3.11.2 ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{10} and in part, are generally discussed below. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies involved in these alternatives are known, the combination of technologies and application of the technologies are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternative includes physical barriers, which has uncertainty based on the size of the design storm event. A detailed discussion of this risk assessment analysis including a more detailed explanation regarding the measures and uncertainty for each of the 13 High and Medium risk species for this alternative are found in Appendix C –Risk Assessments. This alternative would be implemented at T_{10} and would reduce the risk ratings of the following species:

ANS Potentially Invading the Great Lakes Basin

Scud (*Apocorophium lacustre*)

The scud (*Apocorophium lacustre*) has been reported from the Mississippi River, Ohio River, and Illinois River (Grigorovich et al. 2008; USGS 2011). This ANS has been found in the Illinois River less than 32.2 km (20 mi) from Brandon Road Lock and Dam; however, the last survey for this species was conducted in 2008, so it may currently be even closer to this dam (USGS 2011; Grigorovich et al. 2008). This alternative would not reduce the scud's the risk of establishment in the GL basin compared to the risk identified in the No New Federal Action – Sustained Activities conditions. Please see Appendix C – Risk Assessments. The scud is already present at the CAWS and can be transported via vessel movement. This alternative does not impact vessel movement in the CAWS.

Bighead Carp (*Hypophthalmichthys nobilis*)

The bighead carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and electric barriers and GLMRIS Locks to create control points within the system for this species.

Nonstructural measures such as piscicides, overfishing, etc., are expected to limit the population of bighead carp below the barrier. Ballast and bilge water management are expected to control the transfer of eggs, larvae, and fry through the GLMRIS Lock.

The electric barrier is expected to control swimming fish from entering the GLMRIS Lock. The pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the CAWS Buffer Zone and is expected to control the passage of bighead carp eggs, larvae, and fry that may passively drift into the lock. This control point would reduce the likelihood that the species would pass through the CAWS.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of bighead carp from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Silver Carp (*Hypophthalmichthys molitrix*)

The silver carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and creates control points for this species with construction of GLMRIS Locks and electric barriers.

Nonstructural measures such as piscicides, overfishing, etc., are expected to limit the population of silver carp below the barrier. Ballast and bilge water management are expected to control the transfer of eggs, larvae, and fry through the GLMRIS Lock.

The electric barrier is expected to control swimming fish from entering the GLMRIS Lock. The pump-driven filling and emptying system of the GLMRIS Lock would flush the lock with water from the CAWS Buffer Zone and is expected to control the transfer of silver carp eggs, larvae, and fry that may passively drift into the lock. This control point would reduce the likelihood that the species would pass through the CAWS.

The comprehensive implementation of this alternative as identified in this risk assessment would reduce the risk of silver carp from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

ANS Potentially Invading the Mississippi River Basin

This alternative would not reduce the risk of adverse impacts from transfer of the following ANS through the CAWS and establishment in the MR basin: diatom (*Stephanodiscus binderanus*), red algae (*Bangia atropurpurea*), fishhook waterflea (*Cercopagis pengoi*), and VHSv (*Novirhabdovirus* sp.). These four species are either hull foulers or may transfer via temporary vessel attachment through the GLMRIS Lock. This alternative does not include a measure that successfully addresses hull fouling or vessel attachment.

Grass Kelp (*Enteromorpha flexuosa*)

A 2003 study indicated that the closest population to the CAWS of *E. flexuosa* is in Muskegon Lake in Michigan, as well as in two nearby inland lakes and lagoons (Sturtevant 2011). In addition to other measures, this alternative includes nonstructural measures and GLMRIS Locks and ANSTPs to create control points within the system for this species.

The ANSTPs' UV treatment is expected to inactivate grass kelp from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. The GLMRIS Lock is not expected to control grass kelp's passage through the CAWS by vessels. Grass kelp may temporarily attach to vessels, but the GLMRIS Lock would not dislodge algae from vessel hulls.

Nonstructural measures, such as aquatic herbicides, would target reducing the abundance of grass kelp where it is found. Nonstructural measures as described in the risk assessment are expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk of *E. flexuosa* from Medium to Low for time steps T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Reed sweet grass (*Glyceria maxima*)

Reed sweet grass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012). In addition to other measures, this alternative includes GLMRIS Locks and ANSTPs at control points within the system for this species.

The ANSTP's UV treatment is expected to inactivate reed sweet grass from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. The GLMRIS Lock is not expected to control reed sweet grasses' entry into or passage through the CAWS by vessels. Reed sweet grass may temporarily attach to vessels, but the GLMRIS Lock would not dislodge it from vessel hulls.

Though the control points containing GLMRIS Locks are not expected to be effective for reed sweet grass, nonstructural measures such as monitoring followed by aquatic herbicide treatment, if it is encountered, are expected to control its arrival to the CAWS. Nonstructural measures as described in the risk assessment are expected to control this species' dispersion beyond its current locations. Thus, these measures would reduce the likelihood this species would arrive at the CAWS and establish in the MR basin.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the T_{50} risk rating from Medium to Low.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Bloody Red Shrimp (*Hemimysis anomala*)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). This species is not known to be a hull fouler or known to temporarily attach to vessels. In addition to other measures, this alternative includes GLMRIS Locks and ANSTPs to create control points for this species.

The pump-driven filling and emptying system of the GLMRIS Lock would control its passage during lockages. The ANSTPs' UV treatment is expected to inactivate the bloody red shrimp from Lake Michigan water. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the CAWS for water quality purposes and maintenance of current hydrologic conditions. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from High to Low at T_{10}, T_{25}, and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{10}. However, because the bloody red shrimp's probability of establishment is High at T_0, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0 – T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	High	High	High	High
GLMRIS Alternative[a]	High	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Threespine Stickleback (*Gasterosteus aculeatus*)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station. This alternative includes nonstructural measures and electric barriers, GLMRIS Locks, and ANSTPs to create control points within the system for this species.

In addition to other measures, this alternative includes nonstructural measures and GLMRIS Locks and ANSTPs to create control points within the system for this species. The electric barrier is expected to control the entry of swimming fish into the lock, while the pump-driven filling and emptying system of the GLMRIS Lock would control the passage of eggs, larvae, and fry. The water treated by the ANSTP would be used to flush the GLMRIS Lock and would be diverted to the MR basin side of the control point for water quality purposes and maintenance of hydrologic conditions in the CAWS. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures would reduce the likelihood the threespine stickleback would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{10}, T_{25}, and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{10}. However, because the threespine stickleback's probability of establishment is High at T_0, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Ruffe (*Gymnocephalus cernuus*)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). In addition to other measures, this alternative includes nonstructural measures, and GLMRIS Locks and ANSTPs to create control points within the system for this species.

The electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae, and fry during lockages. The water treated by the ANSTP would flush the GLMRIS Lock and would be discharged to the MR basin side of the control point for water quality purposes and maintenance of hydrologic conditions in the CAWS. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Tubenose Goby (*Proterorhinus semilunaris*)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011). The tubenose goby is an active swimmer but due to its benthic nature is able to disperse more quickly through ballast water transfer. This alternative includes nonstructural measures, electric barriers, GLMRIS Locks, and ANSTPs to create control points within the system for this species.

The tubenose goby is an active swimmer but is able to disperse more quickly through ballast water transfer. The management of ballast/bilge water in ships that travel in waters where tubenose gobies occur is expected to delay the time it would take for this species to arrive at the CAWS pathway and reduces the likelihood it will arrive at the CAWS at T_{10}. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is expected this species can swim from its current location to the CAWS by T_{25}.

The electric barrier is expected to control the entry of swimming fish into the CAWS, while the pump-driven filling and emptying system of the GLMRIS Lock is expected to control the passage of eggs, larvae, and fry during lockages. The water treated by the ANSTP would flush the GLMRIS Lock and would be discharged to the MR basin side of the control point for water quality purposes and maintenance of hydrologic conditions in the CAWS. The ANSTP is expected to screen or inactivate all life stages of fish from the water. These measures will reduce the likelihood this species would pass through the CAWS.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

3.11.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.8) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K.

USACE recognizes that while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.9) identifies who may be financial responsible for measures in this alternative.

Table 3.8 Costs for Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative

Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative[a]	
ANS Control Measures Costs	$3,175,000,000
CAWS Ecosystem Mitigation Measures Costs	$25,000,000
Water Quality Mitigation Measures Cost	$1,559,000,000
FRM Mitigation Measures Cost	$1,980,000,000
Design/Construction Management	$1,037,000,000
LERRDs	$30,000,000
OMRR&R Cost (annual)	$150,500,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$7,806,000,000**

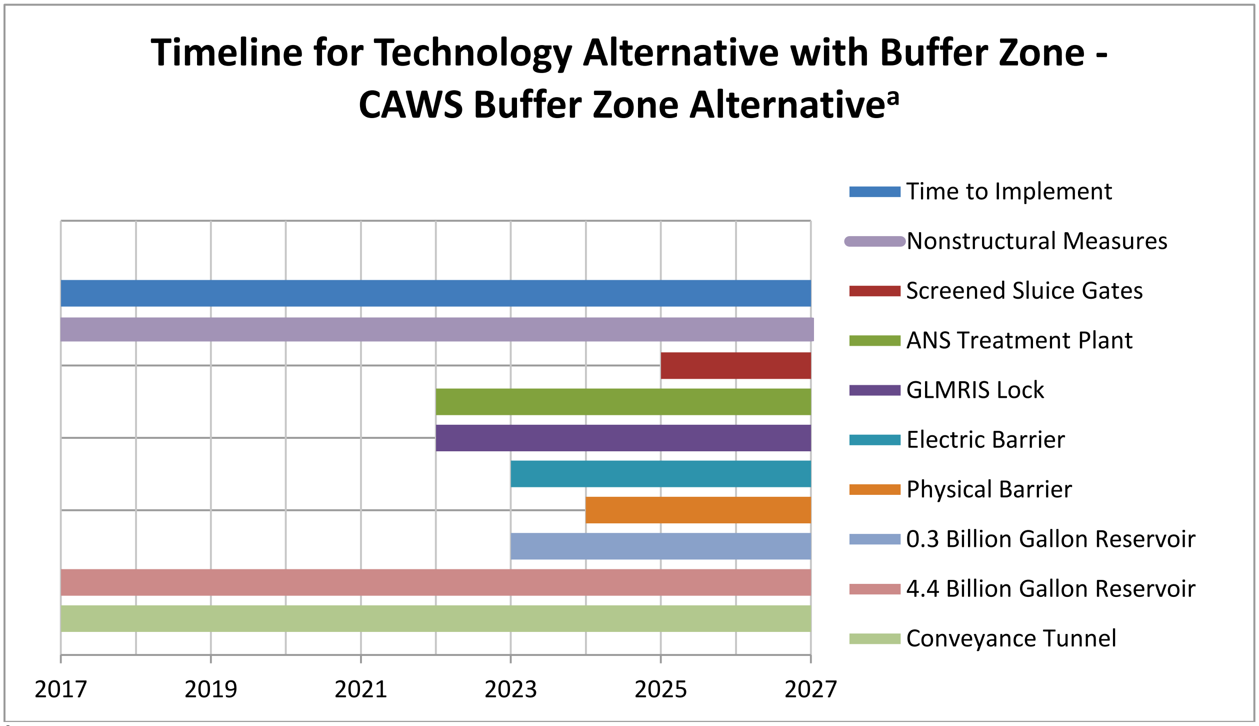
[a] Costs are shown as 2014 program-year dollars.

Table 3.9 Financial Responsibilities for Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative

Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
Screened Sluice Gates @ Wilmette (IL)	CAWS Ecosystem Restoration		Nonstructural
GLMRIS Lock @ Chicago (IL)	ANS Treatment Plant @ Wilmette (IL)		
Electric Barrier @ Chicago (IL)	New 0.3 Billion Gallon Reservoir @ Stateline (IL/IN)		
ANS Treatment Plant @ Chicago (IL)	New 4.4 Billion Gallon Reservoir @ Thornon (IL)		
Screened Sluice Gates @ Chicago (IL)	Conveyance Tunnel		
GLMRIS Lock @ T.J. O'Brien (IL)			
Electric Barrier @ T.J. O'Brien (IL)			
ANS Treatment Plant @ T.J. O'Brien (IL)			
Screened Sluice Gates @ T.J. O'Brien (IL)			
Physical Barrier @ Stateline (IL/IN)			
Physical Barrier @ Hammond (IN)			
GLMRIS Lock @ Brandon Road (IL)			
Electric Barrier @ Brandon Road (IL)			

3.11.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.8 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.



[a] The mitigation measures must be implemented prior to the completion of the ANS control measures, such as the GLMRIS Lock, to minimize impacts to CAWS users and uses. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.8 Timeline for Technology Alternative with Buffer Zone – CAWS Buffer Zone Alternative

3.11.5 Complexity of Regulatory Compliance

The Control Technology Alternative with a Buffer Zone will have a medium level of complexity associated with regulatory compliance. Implementation of the project features will require a high degree of coordination with federal, state, and local regulators. In-water construction will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the States of Illinois and Indiana.. Additional electric barriers will also require coordination with the U.S. Coast Guard on potential safety regulations for navigation through the barriers. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.

3.12 Alternative Plan 5: Lakefront Hydrologic Separation

3.12.1 Alternative Plan Description

Table 3.10 summarizes the measures included in the Lakefront Hydrologic Separation Alternative, the type of measures and the locations of the measures. Additional location details are found in Figures 3.9-3.11.

Table 3.10 Lakefront Hydrologic Separation

Lakefront Hydrologic Separation		
Location	**Measure**	**Type of Measure**
Basin Wide	Nonstructural	ANS Control
To Be Determined within the Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
	Recreational Vessel Dry Dock Storage	Noncommercial Navigation Mitigation
Wilmette (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
Chicago (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
McCook (IL)	Conveyance Tunnel	FRM Mitigation
	6.5 Billion Gallon Reservoir	
Calumet City (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
Hammond (IN)	Physical Barrier	ANS Control
Thornton (IL)	13.5 Billion Gallon Reservoir	FRM Mitigation
	Conveyance Tunnel × 2	

This alternative includes four physical barriers located at Wilmette (IL), Chicago (IL), Calumet City (IL), and Hammond (IN). Additionally, the nonstructural measures discussed in Section 3.2 of this report would also be implemented as part of this alternative.

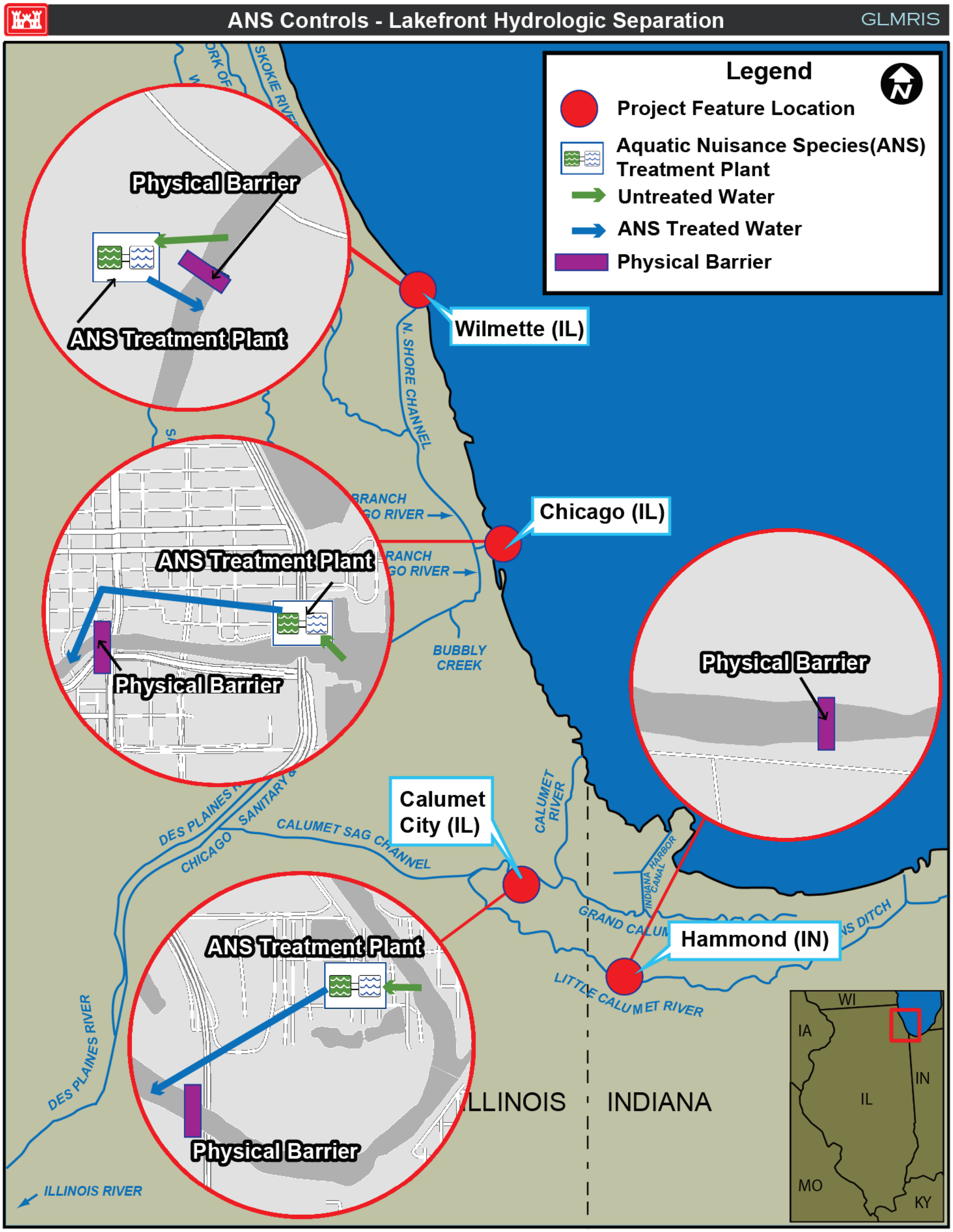
CAWS Ecosystem Impacts

The Lakefront Hydrologic Separation Alternative would remove aquatic habitat at or near Lake Michigan. The separation of the CAWS at Lake Michigan would also impede native species from moving between the Lake and the Chicago River. This is anticipated as a High impact.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Figure 3.9 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.10 Location Details of ANS Prevention Measures

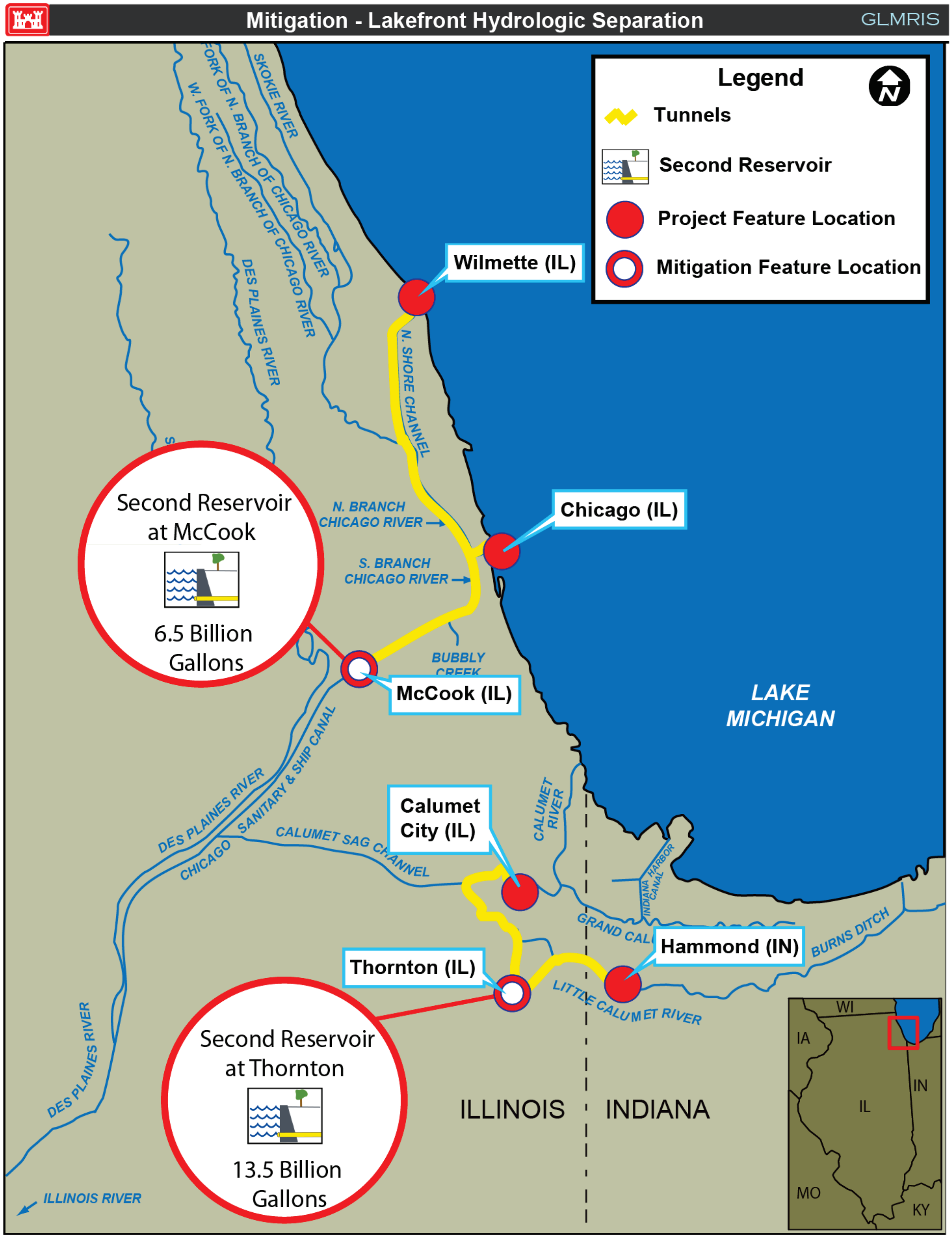


Figure 3.11 Further Location Details of Mitigation Measures

Water Quality CAWS Impacts

Water quality modeling, described in Appendix F, indicates that stagnant conditions and low dissolved oxygen concentrations would develop near the dead-end reaches of the system, if the proposed barriers are installed at the lakefront. The number of hours exceeding water quality benchmarks in the CAWS is expected to increase above the expected future without-project conditions.

This represents a High impact to water quality in the CAWS.

To mitigate water quality impacts to the CAWS, ANS Treatment Plants would be constructed at Wilmette (IL), Chicago (IL), and Calumet City (IL). The ANS Treatment Plants would withdraw water from the Lake Michigan side of the physical barriers, treat the water to remove or inactivate ANS, and then discharge the ANS-treated water on the Mississippi River side of the physical barriers. The treatment technologies proposed for the ANSTPs include screening and UV radiation. These ANS Treatment Plants would allow the discretionary diversion of Lake Michigan water allocated to MWRD to continue, and CAWS hydrology would remain similar to current conditions. With this mitigation, water quantity and quality are expected to be essentially equivalent for the future with-project and without-project conditions. For additional information on mitigation, refer to Appendix F.

Water Quality CAWS Mitigation Measures

- ANS Treatment Plant at Wilmette (IL) – 200 MGD capacity, 0.7-acre footprint.
- ANS Treatment Plant at Chicago (IL) – 450 MGD capacity, 1.5-acre footprint.
- ANS Treatment Plant at Calumet City (IL) – 450 MGD capacity, 1.5-acre footprint.

Water Quality Lake Michigan Impacts

There are no negative impacts to Lake Michigan under this alternative, but only positive impacts. The Lakefront Separation Alternative results in improvements to water quality in Lake Michigan. Flood Risk Management (FRM) mitigation measures will capture all backflows from the CAWS to Lake Michigan during large storms up to and including the 0.2% ACE event. This mitigation will prevent combined sewage-stormwater backflows to Lake Michigan. Frequency and duration of historical backflow events are described in Appendix E.

Flood Risk Management (FRM) Impacts

Under existing conditions, much of the flow of water in the CAWS would backflow into Lake Michigan during a 0.2% ACE event. This backflow volume would need to be captured to prevent an increase in stage levels on the CAWS and avoid any induced flooding, basement or overbank, in the Chicago area. This backflow volume was determined from USACE's H&H model and is the basis of the reservoir sizes in this alternative. The physical barriers at Calumet City (IL) and Hammond (IN) prevent bi-directional flow and would cause FRM impacts. USACE is currently constructing a levee system on the Little Calumet River. The stage increases caused by these physical barriers would affect the level of protection on the levees. The Little Calumet River levee system is being constructed to a 0.5% ACE level (200-yr) with at least a 95% confidence for certification. With these barriers in place, the impacts to the level of protection (LOP) is substantial for several levee sections, as summarized below (LOP where 95% confidence is achieved):

- Reach 4 Hammond East North 100-yr
- Reach 5b Griffith South 50-yr
- Reach 6a Gary North 100-yr
- Reach 7 Gary South 100-yr

Without mitigation measures, this alternative yields a net change in EEAD of $65,963,000 annually due to physical barriers at Wilmette (IL), Calumet City (IL), Chicago (IL), and Hammond (IN). This net change in EEAD represents the additional damages to buildings and their contents that are expected to occur on a yearly basis as a result of this alternative. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

To mitigate for impacts to FRM, two new reservoirs and the necessary stormwater collection system (via tunnels) would be constructed. These new reservoirs and tunnels would be very similar in nature to the existing TARP in the Chicago area. These reservoirs would store storm water up to the 0.2% ACE event, route the water through existing wastewater treatment plants, and then discharge the water into the CAWS such that it joins the Mississippi River basin. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix J – Civil Design.

Flood Risk Management (FRM) Mitigation Measures

- New 6.5 billion gallon reservoir at McCook (IL) would address FRM impacts on the CSSC, Chicago River, and North Shore Channel of the system.

- Conveyance tunnel from Wilmette (IL) to Chicago (IL) estimated at 13 miles long and 22 feet in diameter.

- Conveyance tunnel from Chicago (IL) to McCook (IL) estimated at 13 miles long and 42 feet in diameter.

- A new 13.5 billion gallon reservoir at Thornton (IL) would address FRM impacts on the Cal-Sag Channel and Calumet, Grand Calumet, and Little Calumet Rivers in the system.

- Conveyance tunnel from Calumet City (IL) to Thornton (IL) estimated at 6 miles long and 30 feet in diameter.

- Conveyance tunnel from Hammond (IN) to Thornton (IL) estimated at 7 miles long and 14 feet in diameter.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures, construction of physical barriers would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events.

The FRM mitigation would act as mitigation for human safety for the Lakefront Hydrologic Separation Alternative.

Commercial Navigation Impacts

The Lakefront Hydrologic Separation Alternative would result in a loss of commercial cargo navigation transportation cost savings of $211.77 million annually. In this alternative, both shallow-draft and deep-draft commodity movements could no longer occur on the CAWS and would need to switch to truck or rail, find alternative sources for input, sell their output in different markets, or shut down. Since the tonnage moving past the Lakefront Hydrologic Separation barriers is less than the tonnage moving past the Mid-System Hydrologic Separation barriers, this alternative has less of an impact to commercial cargo transportation cost savings. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. This conclusion was based on a survey of the shippers, docks, and carriers that utilize the CAWS. For many of the shippers, their margins are too slim for them to stay competitive with the additional cost of transloading. Most respondents replied that they would shift modes to either truck or rail for the entire length of the transit, find new sources for production inputs, or shut down permanently. Additionally, a multi-modal facility owned by CenterPoint Properties currently operates in Joliet, Illinois. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Lakefront Hydrologic Separation Impacts to noncommercial navigation would likely include:

- Police/fire/other government vessels will need to incur additional expense in order to maintain the same level of service. Emergency response vessels will be impacted, which is a safety issue.

- There will be additional cost to non-cargo lock users as they attempt to maintain previous usage, find alternate means of reaching their destination, and/or find alternate destinations for boat repairs, fishing, or other recreational activity.

- The physical barriers may increase the frequency of high water events on the CAWS.

- The value of the recreational experience for tour boat passengers, recreational fishermen, and recreational boaters may decrease.

The Lakefront Hydrologic Separation Alternative would have a High impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Noncommercial Navigation (includes recreational navigation) Mitigation Measures

- Creation of dry dock storage with direct access to Lake Michigan for up to 5,000 recreational vessels.

Hydropower Impacts

Results of the hydrology and hydraulics analysis in Appendix E indicate that the impacts of this alternative on the hydrologic conditions at Lockport Powerhouse would be negligibly small, resulting in no quantifiable impact to hydropower generation.

Unmitigated impacts

While the proposed mitigation measures are expected to minimize any effects on the downstream Mississippi River Basin outside of the CAWS, the impacts of reduced flow in the Illinois Waterway downstream of the project areas were not extensively studied in GLMRIS. See Appendix A – Effect of Mid-System Separation on Low Flows in Downstream Waterway for additional details.

3.12.2 ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. When compared to alternatives that do not rely solely on hydrologic separation, the hydrologic separation alternatives were assessed as having lower uncertainty when comparing the impact the alternative had on ANS passage through the CAWS. A detailed discussion of this risk assessment analysis including uncertainty for each of the 13 High and Medium risk species for this alternative can be found in Appendix C –Risk Assessments.

This alternative would be implemented at T_{25} and would reduce the risk ratings of the following species:

ANS Potentially Invading the Great Lakes Basin

Scud (*Apocorophium lacustre*)

A. lacustre was first reported from freshwater in North America in 1987-1988 from the lower Mississippi River between 510 and 515 river miles (820 and 829 km) (Grigorovich et al. 2008). By 2003, *A lacustre* had invaded the Illinois River and expanded its range into the upper reaches of the Ohio and Illinois Rivers. This alternative includes nonstructural measures and construction of a physical barrier in the CAWS at more than one location to separate the Great Lakes and Mississippi River basins. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event).

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}. However, because the scud's probability of establishment is High at T_0 and T_{10}, there is a High probability that it may have transferred to and established in the GL basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Bighead Carp (*Hypophthalmichthys nobilis*)

The bighead carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and construction of a physical barrier in the CAWS at more than one location to separate the Great Lakes and Mississippi River basins. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event).

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Silver Carp (*Hypophthalmichthys molitrix*)

The silver carp have been found in the Des Plaines River in Rock Run Rookery (ACRCC 2013). The rookery is approximately 4 miles downstream from the Brandon Road Lock and Dam. This alternative includes nonstructural measures and construction of a physical barrier in the CAWS at more than one location to separate the Great Lakes and Mississippi River basins. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event).

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	Medium
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

ANS Potentially Invading the Mississippi River Basin

Grass Kelp (*Enteromorpha flexuosa*)

A 2003 study indicated that the closest population of *E. flexuosa* is in Muskegon Lake in Michigan, and it was found in 2 of 11 nearby inland lakes and lagoons (Sturtevant 2011). Because there are nonstructural measures, such as aquatic herbicides, that would target reducing the abundance of grass kelp in these lakes, the comprehensive implementation of this alternative as described in the risk assessment would reduce the opportunities for the species to disperse beyond their current locations. This alternative would reduce the risk of grass kelp's adverse impacts by controlling its arrival at and movement through the CAWS, and thus its establishment in the MR basin. In addition, the physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTP would also reduce the probability of passage of this species to Low.

The comprehensive implementation of nonstructural measures, physical barriers, and the ANSTP reduces the probability of establishment rating from Medium to Low for time steps T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Red Algae (*Bangia atropurpurea*)

Red alga was first recorded from Lake Erie in 1964 (Edwards and Harrold 1970). In the Great Lakes, it spread from Lake Erie to southern Lake Michigan within a decade (Lin and Blum 1977). Based on recent data from Lake Michigan, red algae (Division Rhodophyta) is rarely found in the Lake Michigan watershed (Whitman 2012). This alternative includes nonstructural measures and construction of a physical barrier in the CAWS and ANSTP at more than one location to separate the Great Lakes and Mississippi River basins. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event).

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}. However, because the red algae's probability of establishment is Medium at T_0 and T_{10}, there is a Medium probability that it may have transferred to and established in the MR Basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Diatom (*Stephanodiscus binderanus*)

S. binderanus was first recorded in Lake Michigan in 1938 and appeared in Lake Ontario in the late 1940s to early 1950s (Kipp 2011). While *S. binderanus* is common in the Great Lakes, it has fluctuated in abundance; its population has declined as nutrient inputs into the Great Lakes declined (Kipp 2011). This alternative includes nonstructural measures and construction of a physical barrier in the CAWS at more than one location to separate the Great Lakes and Mississippi River basins. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event).

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}. However, because the diatom's probability of establishment is Medium at T_0 and T_{10}, there is a Medium probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Reed sweet grass (*Glyceria maxima*)

Reed sweet grass is established in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). In 2006, a small, localized population was discovered growing at Illinois Beach State Park, north of Waukegan, Illinois. The population was treated with herbicides and eradicated, and monitoring for this species in the vicinity has been implemented (Howard 2012). Nonstructural measures for this species would include monitoring followed by aquatic herbicide treatment if it is encountered. The nonstructural measures in this alternative would reduce the risk of reed sweet grass's adverse impacts by controlling its arrival to and movement through the CAWS and thus its establishment in the MR basin.

In addition, the physical barriers in this alternative would eliminate the aquatic pathway or untreated water except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTPs would inactivate reed sweet grass from water diverted from Lake Michigan to the CAWS for water quality purposes.

The implementation of hydrologic separation to include nonstructural measures reduces the probability of establishment from Medium to Low for time step T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Fishhook Waterflea (*Cercopagis pengoi*)

The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTPs would inactivate fishhook waterflea from water diverted from Lake Michigan to the CAWS for water quality purposes.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from High to Low at T_{25} and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Medium	High
GLMRIS Alternative[a]	Low	Low	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Bloody Red Shrimp (*Hemimysis anomala*)

The species is established within Lake Michigan having been documented offshore of Jackson Harbor in 2007 and Waukegan Harbor in 2006 (Kipp et al. 2011). The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTPs would inactivate bloody red shrimp from water diverted from Lake Michigan to the CAWS for water quality purposes.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from High to Low at T_{25} and T_{50}, assuming no prior establishment of the bloody red shrimp in the MR basin prior to T_{25}. However, because the bloody red shrimp's probability of establishment is High at T_0 and T_{10}, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	High	High	High	High
GLMRIS Alternative[a]	High	High	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Threespine Stickleback (*Gasterosteus aculeatus*)

The threespine stickleback is considered established in southern Lake Michigan, and it has been found in the North Shore Channel, which connects to the Wilmette Pumping Station. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTPs would inactivate threespine stickleback from water diverted from Lake Michigan to the CAWS for water quality purposes.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25}, and T_{50}, assuming no prior establishment of the threespine stickleback in the MR basin prior to T_{25}. However, because the threespine stickleback's probability of establishment is High at T_0 and T_{10}, there is a High probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

Ruffe (*Gymnocephalus cernuus*)

The ruffe is not widespread, and there are no high-density populations in Lake Michigan outside of Green Bay (Bowen and Goehle 2011). The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTP would also reduce the probability of passage of this species to Low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Low	Low	Medium
GLMRIS Alternative[a]	Low	Low	Low	***Low***

[a] The shaded cell and bold italics indicate there is a reduction in the risk rating.

Tubenose Goby (*Proterorhinus semilunaris*)

The tubenose goby has spread throughout Lake St. Clair in Michigan and its tributaries (Jude et al. 1992), as well as the Detroit River system, and is commonly collected in the Duluth-Superior harbor of Lake Superior (Kocovsky et al. 2011). A population of tubenose gobies has become established and self-sustaining in the western basin of Lake Erie (Kocovsky et al. 2011).

The nonstructural measures in this alternative include management of ballast/bilge water of ships that travel in waters where tubenose gobies occur and could delay the time it would take for this species to arrive at the CAWS pathway for T_{10}. Because the tubenose goby is an active swimmer, even with ballast/bilge water management, it is anticipated that this species can swim from its current location to the CAWS by T_{25}. The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTP would also reduce the probability of passage of this species to Low.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{10}, T_{25}, and T_{50}.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Low	Medium	Medium	Medium
GLMRIS Alternative[a]	Low	***Low***	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

VHSv (*Novirhabdovirus sp.*)

VHSv was first reported in the Great Lakes in 2003 from Lake St. Clair (Elsayed et al. 2006), and by 2010 it had spread to all five Great Lakes (MNDR 2010). Benthic macroinvertebrates sampled in Lake Michigan have tested positive for the virus (Faisal et al. 2012). The physical barriers in this alternative would eliminate the aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE event). The ANSTPs would inactivate VHSv from water diverted from Lake Michigan to the CAWS for water quality purposes.

The comprehensive implementation of this GLMRIS Alternative as identified in the risk assessment would reduce the risk rating from Medium to Low at T_{25} and T_{50}. However, because the VHSv's probability of establishment is Medium at T_0 and T_{10}, there is a Medium probability that it may have transferred to and established in the MR basin prior to the implementation of this alternative.

	Risk of Adverse Impacts from Movement through the CAWS and Establishment in the MR Basin at T_0–T_{50}			
Alternative	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action – Sustained Activities	Medium	Medium	Medium	Medium
GLMRIS Alternative[a]	Medium	Medium	***Low***	***Low***

[a] The shaded cells and bold italics indicate there is a reduction in the risk rating.

3.12.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.11) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

USACE recognizes that while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.12) identifies who may be financial responsible for measures in this alternative.

Table 3.11 Lakefront Hydrologic Separation Costs

Lakefront Hydrologic Separation[a]	
ANS Control Measures Costs	$446,000,000
CAWS Ecosystem Mitigation Measures Costs	$47,000,000
Water Quality Mitigation Measures Cost	$534,000,000
FRM Mitigation Measures Cost	$14,451,000,000
Navigation Mitigation Measures Cost	$129,000,000
Design/Construction Management	$2,704,000,000
LERRDs	$78,000,000
OMRR&R Cost (annual)	$87,000,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$18,389,000,000**

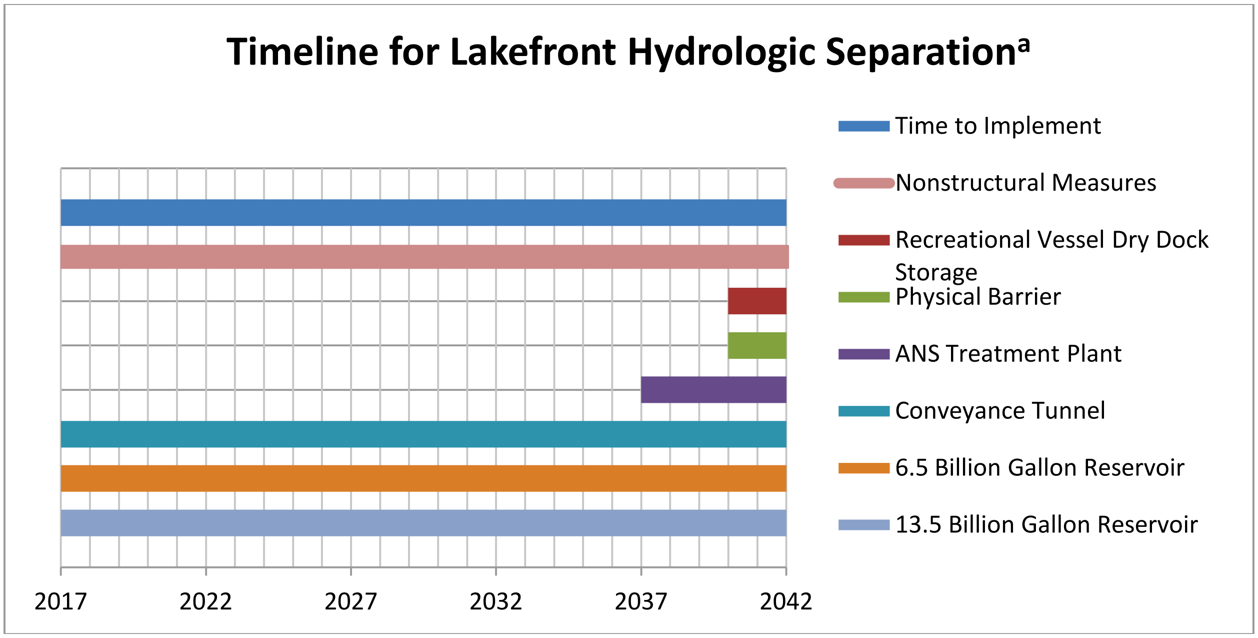
[a] Costs are shown as 2014 program-year dollars.

Table 3.12 Financial Responsibilities for the Lakefront Hydrologic Separation Alternative

Lakefront Hydrologic Separation			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
Physical Barrier @ Wilmette (IL)	CAWS Ecosystem Restoration	Recreational Vessel Dry Dock Storage	Nonstructural
Physical Barrier @ Chicago (IL)	ANS Treatment Plant @ Wilmette (IL)		
Physical Barrier @ Calumet City (IL)	ANS Treatment Plant @ Chicago (IL)		
Physical Barrier @ Hammond (IN)	Conveyance Tunnel		
	New 6.5 Billion Gallon Reservoir @ McCook (IL)		
	ANS Treatment Plant @ Calumet City (IL)		
	New 13.5 Billion Gallon Reservoir @ Thornton (IL)		
	Conveyance Tunnel × 2		

3.12.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.12 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.



[a] The mitigation measures must be implemented prior to the completion of the ANS control measures, such as physical barriers, to minimize impacts to CAWS uses and users. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.12 Timeline for Lakefront Hydrologic Separation Alternative

3.12.5 Complexity of Regulatory Compliance

Lakefront Hydrologic Separation would have a high level of complexity associated with regulatory compliance. In addition to construction of physical barriers, which will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the States of Illinois and Indiana, the mitigation actions to address potential flood risks and navigation impacts will likely require extensive coordination with state regulators. Potential changes to diversion, though relatively minor, may require coordination with Canada and all Great Lakes states. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.

3.13 Alternative Plan 6: Mid-System Hydrologic Separation

3.13.1 Alternative Plan Description

Table 3.13 summarizes the measures included in the Mid-System Hydrologic Separation Alternative, the types of measures and the locations of the measures. More details about the locations can be found in Figures 3.13-3.16.

Table 3.13 Mid-System Hydrologic Separation

Mid-System Hydrologic Separation		
Location	**Measure**	**Type of Measure**
Basin Wide	Nonstructural	ANS Control
	Sediment Remediation	WQ Mitigation
To Be Determined within the Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
Stickney (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
	WRP Outfall Tunnel	
McCook (IL)	Conveyance Tunnel	WQ Mitigation
	8.1 Billion Gallon Reservoir	
Oak Lawn (IL)	0.2 Billion Gallon Reservoir	FRM Mitigation
Alsip (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
	WRP Outfall Tunnel	
Thornton (IL)	5.2 Billion Gallon Reservoir	WQ Mitigation
	Conveyance Tunnel	

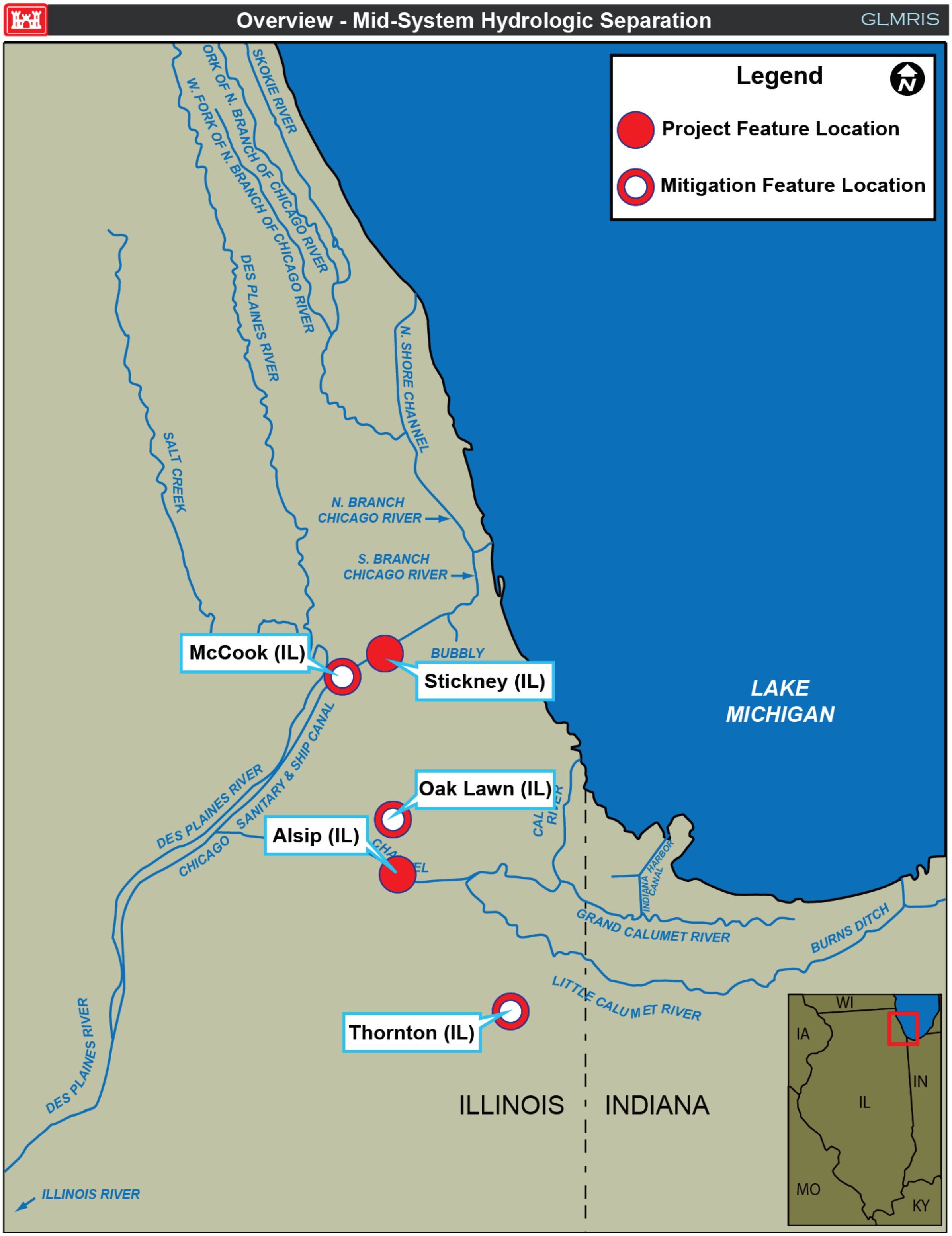
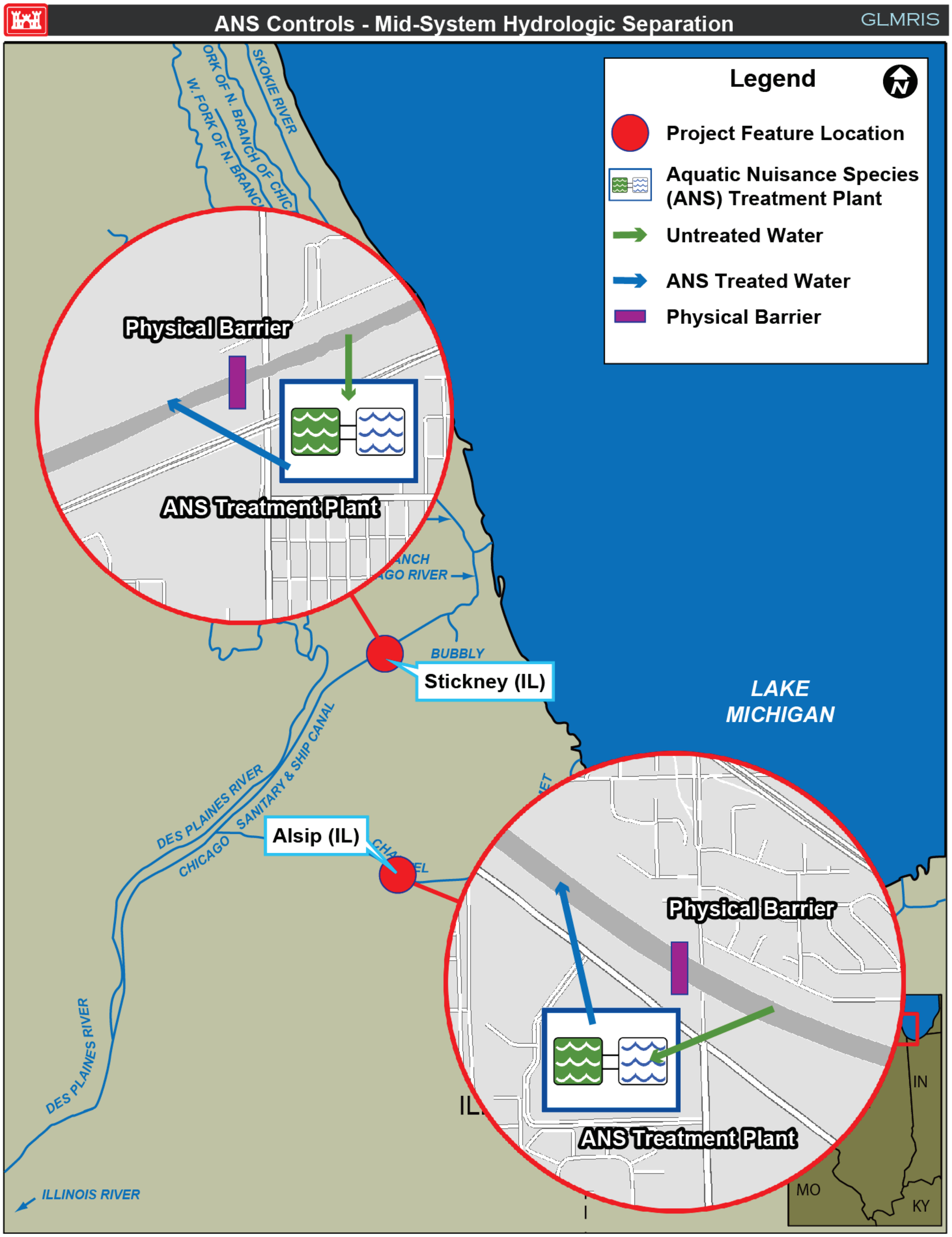


Figure 3.13 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.14 Location Details Regarding ANS Prevention Measures

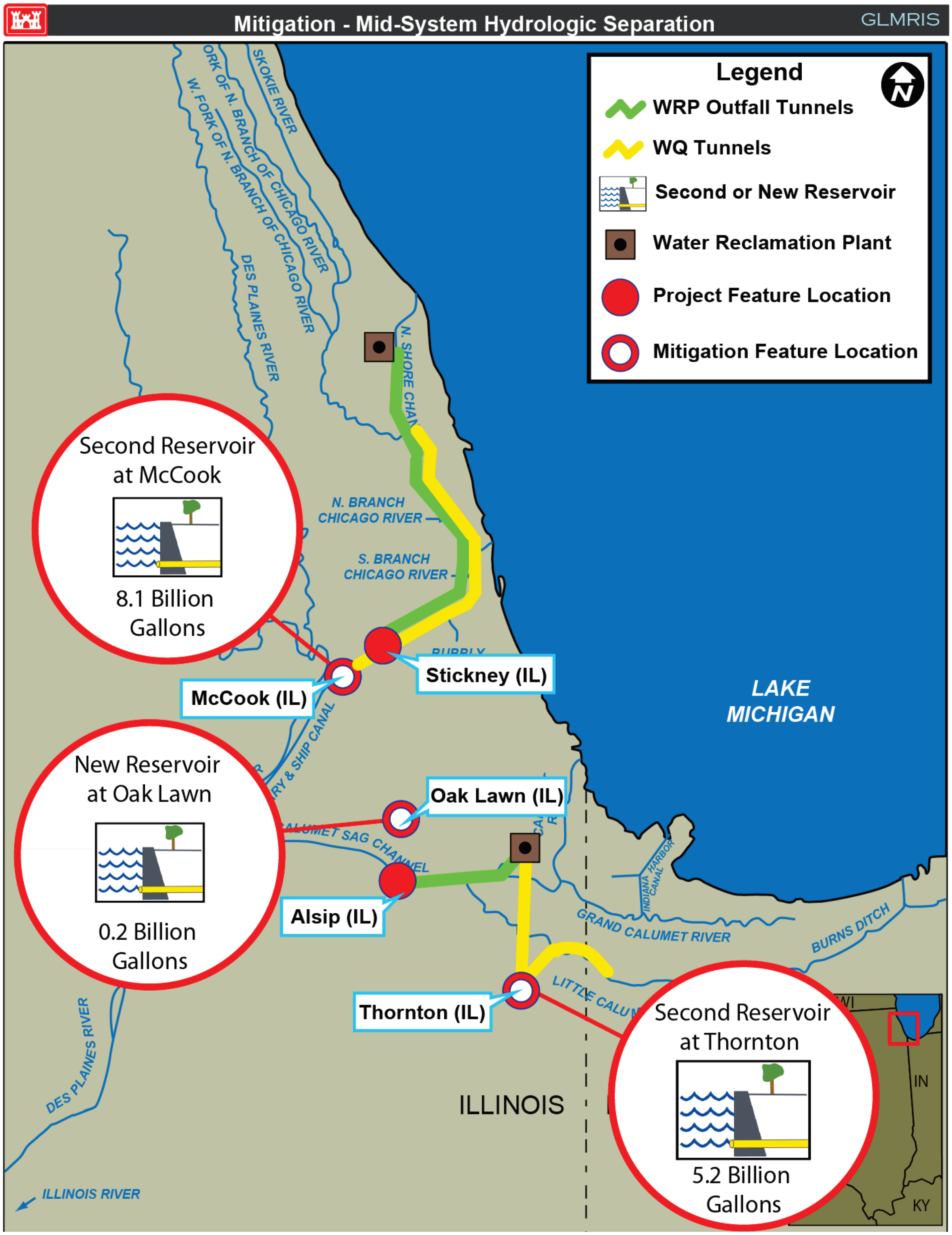


Figure 3.15 More Location Details Concerning Mitigation Measures

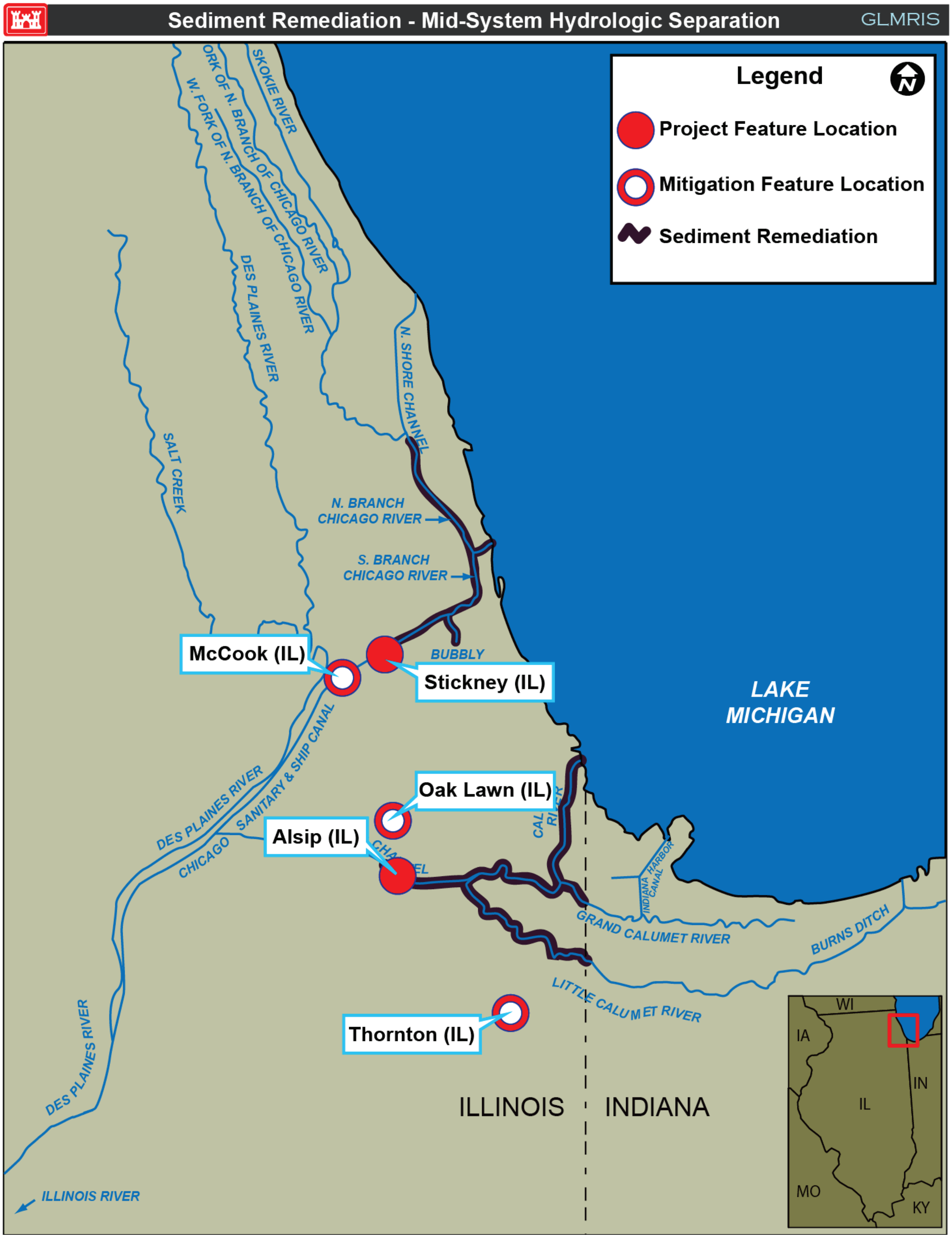


Figure 3.16 Further Location Details Concerning Sediment Remediation Measures

This alternative has two physical barriers located at Stickney (IL) and Alsip (IL). Additionally, the nonstructural measures discussed in Section 3.2 of this report would also be implemented as part of this alternative.

CAWS Ecosystem Impacts

The Stickney (IL) and Alsip (IL) physical barriers are located close to the historical separation point between the Mississippi River and Great Lakes basins. The Mid-System Hydrologic Separation Alternative would result in the loss of low-quality aquatic habitat around the footprint of the physical barriers. This location will impact the ability of native aquatic species to disperse between basins and therefore between populations, but it is ultimately reversing an environmental impact from previous human activities. This is anticipated to be a Low impact.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Water Quality CAWS Impacts

Water quality modeling, described in Appendix F, indicates that stagnant conditions and low dissolved oxygen concentrations would develop in the CAWS, if the proposed barriers are constructed at Stickney (IL) and Alsip (IL). The number of hours exceeding water quality standards and benchmarks for the CAWS is expected to increase above the expected future without-project conditions. Numeric water quality standards are not defined for several parameters studied in GLMRIS water quality modeling. As a result of interagency coordination, EPA and IEPA collaborated to provide candidate benchmarks against which to measure expected future water quality conditions. Candidate benchmarks are included in Appendix F.

This represents a High impact to water quality in the CAWS.

To mitigate water quality impacts to the CAWS, ANS Treatment Plants would be constructed at Stickney (IL) and Alsip (IL). The ANS Treatment Plants would withdraw water from the Lake Michigan side of the physical barriers, treat the water to remove or inactivate ANS, and then discharge the ANS-treated water on the Mississippi River side of the physical barriers. The treatment technologies proposed for the ANSTPs at Stickney and Alsip include screening, filtration, and UV radiation. For additional information on mitigation, refer to Appendix F.

Water Quality CAWS Mitigation Measures

- ANS Treatment Plant at Stickney (IL) – 650 MGD capacity, 5.2-acre footprint.
- ANS Treatment Plant at Alsip (IL) – 450 MGD capacity, 3.6-acre footprint.

Water Quality Lake Michigan Impacts

The most significant impacts of the Mid-System Hydrologic Separation Alternative are the short-term and cumulative contaminant loads to Lake Michigan. As a result of the Mid-System Separation Alternative, treated effluent for the O'Brien and Calumet WRPs, hundreds of combined sewer overflows, dozens of storm sewer flows, and effluent from five CSO pumping stations will all be directed toward Lake Michigan on a continuous basis. Urban storm runoff and contaminated sediment, while not assessed by the water quality models, will also contribute to the water quality impacts of this project alternative to Lake Michigan. Water quality modeling results of the effect of continued discharge of these inputs to Lake Michigan can be found in Appendix F.

Lake Michigan is the drinking water source for Chicago and many surrounding municipalities and has stricter water quality regulations in comparison to the CAWS. Anti-degradation rules prohibit actions that would result in the deterioration of water quality in Lake Michigan and specifically prohibit new or increased loading of bioaccumulative chemicals of concern (BCCs) (35 Ill. Adm. Code 302.105). Conventional physical and biological wastewater treatment processes will not remove dissolved constituents such as chloride and BCCs present in municipal wastewater. Advanced treatment processes such as microfiltration and reverse osmosis will remove dissolved constituents like chloride and BCCs, but these technologies are typically reserved for drinking water applications in water-scarce environments due to the high energy costs associated with their operation. In addition, reverse osmosis has never been implemented at the scale required for the Chicago area, and there is uncertainty as to whether reverse osmosis facilities of the required size would be available within the required timeframe for project implementation.

Preliminary cost estimates show that a more cost-effective way to meet regulatory standards in the CAWS and Lake Michigan for the Mid-System Hydrologic Separation Alternative is to relocate the WRP outfalls to the river side of the hydrologic separation barriers. Additional mitigation for water quality impacts to Lake Michigan will include a tunnel and reservoir system to capture all CSO events and prevent their discharge to the CAWS. The reservoir water would then be pumped out to existing wastewater treatment facilities to make it suitable for discharge to the waterways. Although end-of-pipe treatments to address CSOs were considered, prior studies determined that end-of-pipe treatment could not be implemented at 65 of the 170 existing outfalls, and bacteria standards would still be violated regularly due to the 65 untreated outfalls. The final element of mitigation for water quality impacts to Lake Michigan includes sediment remediation on the lake side of the barriers. A more detailed discussion of the mitigation measures for water quality impacts can be found in Appendix F.

Urban stormwater runoff transports road salt, oil and grease, fertilizers, herbicides, and bacteria into the waterways. No agency is empowered with the authority to effectively regulate non-point pollutant discharges to the waterways. While stormwater Best Management Practices may be voluntarily adopted by municipal governments, it is anticipated that the Mid-System Hydrologic Separation Alternative will result in some unmitigated impacts to water quality in Lake Michigan resulting from stormwater runoff.

Water Quality Lake Michigan Mitigation Measures

- On the Chicago River system, a tunnel 13 feet in diameter and 12.5 miles long is proposed to deliver the O'Brien WRP effluent to the river side of the proposed physical barrier in Stickney (IL).
- A pump station would be required at the downstream end in order to return the plant effluent to the elevation of the Chicago Sanitary and Ship Canal.
- On the Calumet River system, a tunnel 13 feet in diameter and 5.3 miles long would be needed to deliver the Calumet WRP effluent to the river side of the proposed physical barrier in Alsip (IL).
- A pump station would be required at the downstream end in order to return the plant effluent to the elevation of the Cal-Sag Channel.
- A new 8.1 billion gallon reservoir at McCook (IL) would address water quality impacts on the CSSC, Chicago River, and North Shore Channel of the system.
- A conveyance tunnel along the North Shore Channel to McCook (IL) estimated at 13 miles long and 32 feet diameter.
- A new 5.2 billion gallon reservoir at Thornton (IL) would address water quality impacts on the Cal-Sag Channel and Calumet, Grand Calumet, and Little Calumet Rivers in the system.
- The water in the reservoirs would be routed through existing wastewater treatment plants and then discharged into the CAWS such that it joins the Mississippi River basin.
- A conveyance tunnel from Hammond (IN) to Thornton (IL) estimated at 7 miles long and 14 feet in diameter.
- Sediment remediation of the Chicago and Calumet River systems east of the physical barriers.
- Stormwater Best Management Practices (BMPs) would be coordinated within the CAWS.

Flood Risk Management (FRM) Impacts

The Mid-System Hydrologic Separation Alternative was developed to have minimal impacts on FRM impacts. Any additional stormwater that would need to be captured to mitigate for FRM impacts would be captured in the tunnels and reservoirs designed to capture the stormwater during CSO events, with the exception of the flow on Thorn Creek, an aquatic connection with the potential to bypass the Alsip (IL) physical barrier.

Without mitigation measures, this alternative yields a net change in EEAD of $1,149,000 annually due to physical barriers at Stickney (IL) and Alsip (IL). This net change in EEAD represents the additional damages to buildings and their contents that is expected to occur on a yearly basis as a result of this alternative. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

The water quality mitigation of tunnels and reservoirs would also act as FRM mitigation. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix J – Civil Design.

Flood Risk Management Impacts and Mitigation Measures

- A new 0.2 billion gallon reservoir at Oak Lawn (IL) would address FRM impacts on Thorn Creek, a potential bypass of the physical barrier in Alsip (IL) on the Cal-Sag Channel in the system.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures, construction of physical barriers would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events.

The water quality mitigation would act as mitigation for human safety for the Mid-System Hydrologic Separation Alternative.

Commercial Navigation Impacts

The Mid-System Hydrologic Separation Alternative would result in a loss of commercial cargo navigation transportation cost savings of $251.76 million annually. In the mid-system separation alternatives, shallow-draft commercial cargo movements are impacted by barriers on the Chicago Sanitary and Ship Canal (CSSC) and the Cal-Sag Channel. However, deep-draft commercial cargo movements mostly travel between the Great Lakes and the Calumet River or Lake Calumet, so they are lake side of the barriers and would not be affected. Since the tonnage moving past the Mid-System Hydrologic Separation barriers is greater than the tonnage moving past Lakefront Hydrologic Separation barriers, this alternative has a greater impact on commercial cargo transportation cost savings. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. This conclusion was based on a survey of the shippers, docks, and carriers that utilize the CAWS. For many of the shippers, their margins are too slim for them to stay competitive with the additional cost of transloading. Most respondents replied that they would shift modes to either truck or rail for the entire length of the transit, find new sources for production inputs, or shut down permanently. Additionally, a multi-modal facility owned by CenterPoint Properties currently operates in Joliet, Illinois. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Mid-System Hydrologic Separation impacts to noncommercial navigation would likely include:

- Impacts to vessels attempting to do the “loop” around North America.
- Some government agencies may have to duplicate some services, if their jurisdictions extend beyond the barriers.
- Passenger vessels and government vessels may be affected by additional high-water events.

The Mid-System Hydrologic Separation Alternative would have a medium impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Hydropower Impacts

Results of the hydrology and hydraulics analysis in Appendix E indicate that the impacts of this alternative on the hydrologic conditions at Lockport Powerhouse would be negligibly small, resulting in no quantifiable impact to hydropower generation.

Unmitigated Impacts

Installation of physical barriers on the CAWS at Alsip (IL) and Stickney (IL) will bring significant impacts to water quality in both the CAWS and Lake Michigan. Many of these impacts can be mitigated by the mitigation measures described previously. Other impacts that are expected as a result of the Mid-System Separation Alternative will be more difficult to correct. Currently, non-point source discharges of pollutants to the waterways remain largely unregulated, and thus the Mid-System Hydrologic Separation Alternative may result in some unmitigated impacts to water quality in Lake Michigan resulting from stormwater runoff.

Additionally, while the proposed mitigation measures are expected to minimize any effects on the downstream Mississippi River Basin outside of the CAWS, the impacts of reduced flow in the Illinois Waterway downstream of the project areas were not extensively studied in GLMRIS. See Appendix A – Effect of Mid-System Separation on Low Flows in Downstream Waterway – for additional details.

3.13.2 ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures that are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. When compared to alternatives that do not rely solely on hydrologic separation, the hydrologic separation alternatives were assessed as having lower uncertainty when comparing the impact the alternative had on ANS passage through the CAWS. A detailed discussion of this risk assessment analysis including uncertainty for each of the 13 High and Medium risk species for this alternative can be found in Appendix C –Risk Assessments.

The results of the with-project risk assessments of this alternative are the same as the Lakefront Hydrologic Separation Alternative. Please see Section 3.12.2 for the discussion of ANS risk reduction provided by this alternative.

3.13.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.14) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Table 3.14 Mid-System Hydrologic Separation Costs

Mid-System Hydrologic Separation[a]	
ANS Control Measures Costs	$223,000,000
CAWS Ecosystem Mitigation Measures Costs	$42,000,000
Water Quality Mitigation Measures Cost	$12,886,000,000
FRM Mitigation Measures Cost	$24,000,000
Design/Construction Management	$2,257,000,000
LERRDs	$80,000,000
OMRR&R Cost (annual)	$67,000,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$15,512,000,000**

[a] Costs are shown as 2014 program-year dollars.

USACE recognizes that, while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.15) identifies who may be financial responsible for measures in this alternative.

Table 3.15 Mid-System Hydrologic Separation Financial Responsibility

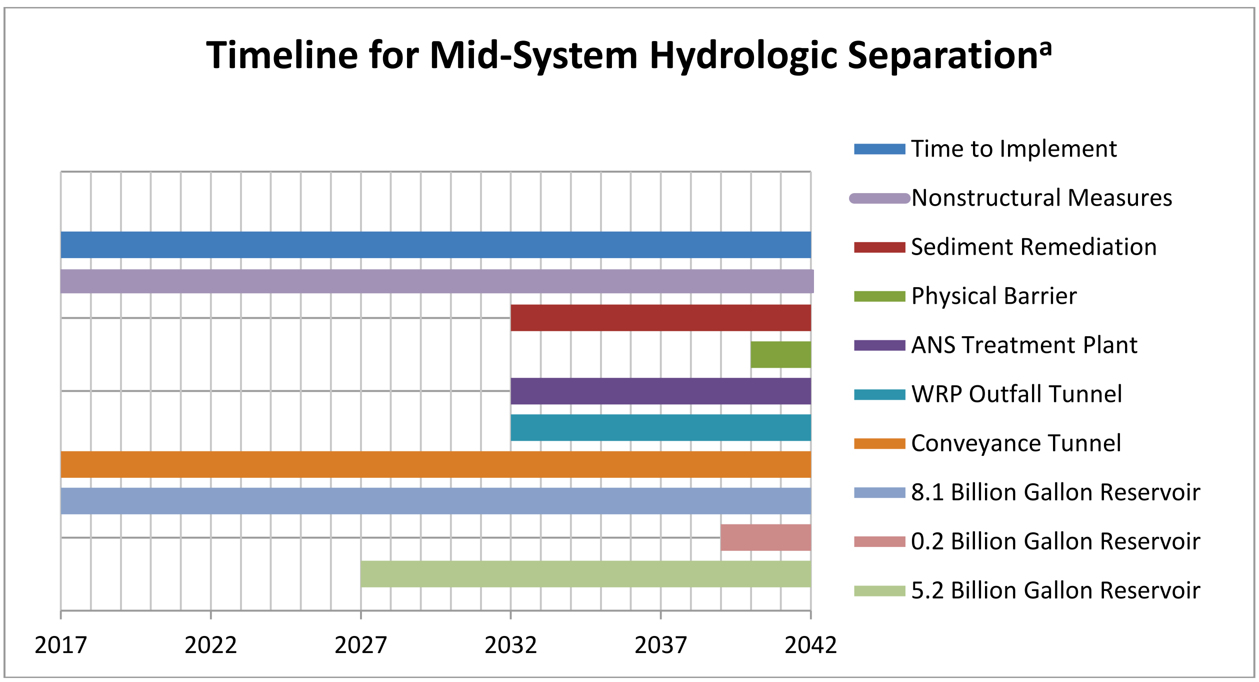
Mid-System Hydrologic Separation			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
Physical Barrier @ Stickney (IL)	CAWS Ecosystem Restoration	Sediment Remediation	Nonstructural
Physical Barrier @ Alsip (IL)	ANS Treatment Plant @ Stickney (IL)	WRP Outfall Tunnel	
	New 8.1 Billion Gallon Reservoir @ McCook (IL)	WRP Outfall Tunnel	
	New 0.2 Billion Gallon Reservoir @ Oak Lawn (IL)	Conveyance Tunnel	
	ANS Treatment Plant @ Alsip (IL)	Conveyance Tunnel	
	New 5.2 Billion Gallon Reservoir @ Thornton (IL)		

3.13.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.17 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.

3.13.5 Complexity of Regulatory Compliance

The Mid-System Hydrologic Separation would have a high level of complexity associated with regulatory compliance. In addition to construction of physical barriers, which will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the States of Illinois and Indiana, the mitigation actions to address potential water quality, flood risk, and navigation impacts will likely require extensive coordination with federal and state regulators. Potential changes to diversion, though relatively minor, may require coordination with Canada and all Great Lakes states. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.



[a] The mitigation measures must be implemented prior to the completion of the ANS control measures, such as physical barriers, to minimize impacts to CAWS uses and users. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.17 Mid-System Hydrologic Separation Timeline

3.14 Alternative Plan 7: Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone

3.14.1 Alternative Plan Description

Table 3.16 summarizes the measures included in the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone, the types of measures and the locations of the measures. Details about the measures may be found in Figures 3.18-3.21.

Table 3.16 Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative

Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative		
Location	**Measure**	**Type of Measure**
Basin-wide	Nonstructural	ANS Control
	Sediment Remediation	WQ Mitigation
To Be Determined within the Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
Stickney (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
	WRP Outfall Tunnel	
McCook (IL)	Conveyance Tunnel	WQ Mitigation
	8.1 Billion Gallon Reservoir	
T.J. O'Brien (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	
	ANS Treatment Plant	
	Screened Sluice Gates	
Stateline (IL/IN)	Physical Barrier	ANS Control
	0.3 Billion Gallon Reservoir	FRM Mitigation
Hammond (IN)	Physical Barrier	ANS Control
Thornton (IL)	4.4 Billion Gallon Reservoir	FRM Mitigation
	Conveyance Tunnel	
Brandon Road (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	

This alternative includes three physical barriers located at Stickney (IL), Stateline (IL/IN), and Hammond (IN) that will hydrologically separate four of the five aquatic pathways between the CAWS and Lake Michigan. Along the remaining aquatic pathway a Buffer Zone would be established by the construction of ANS control measures at T.J. O'Brien (IL) and Brandon Road (IL). Additionally, the nonstructural measures described in Section 3.2 would be implemented as part of this alternative.

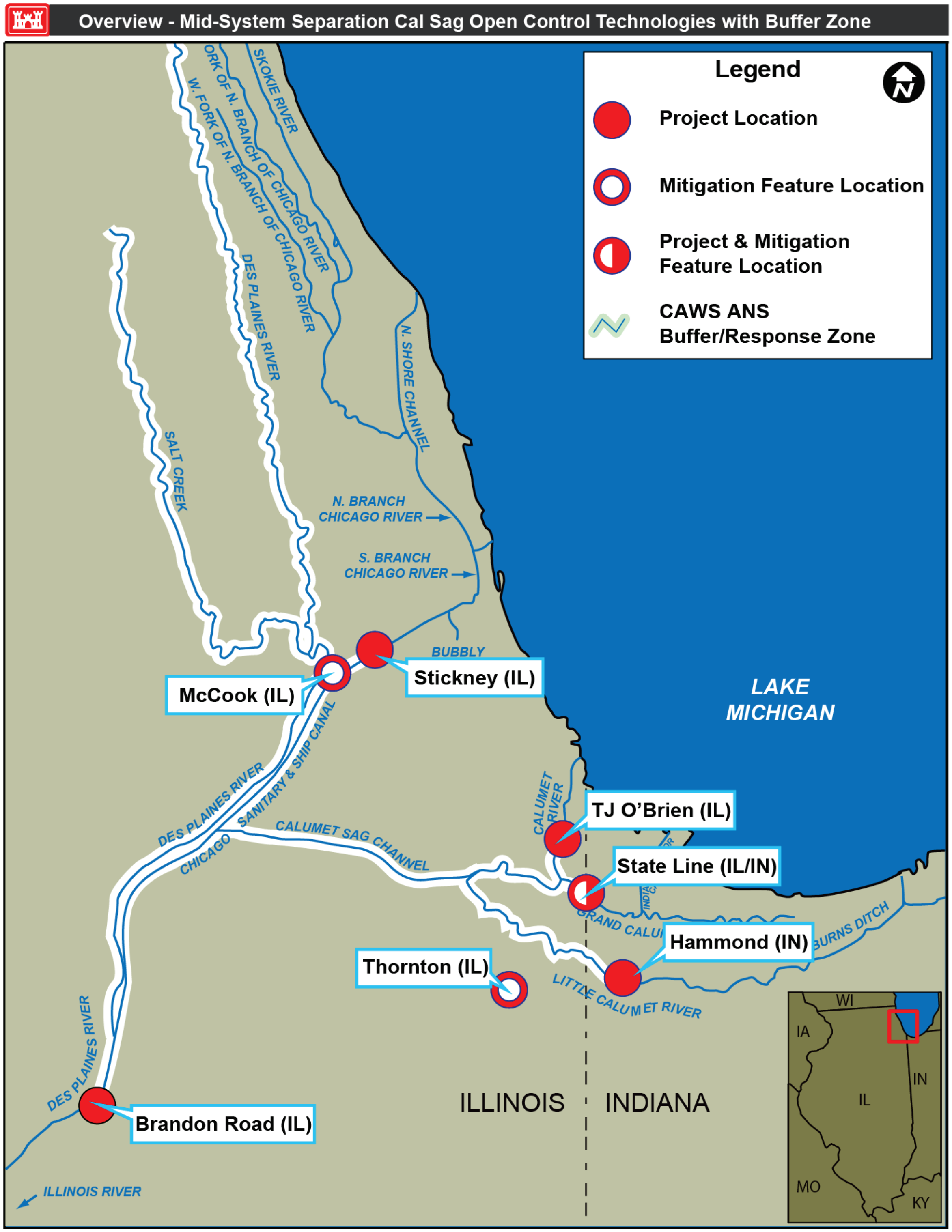
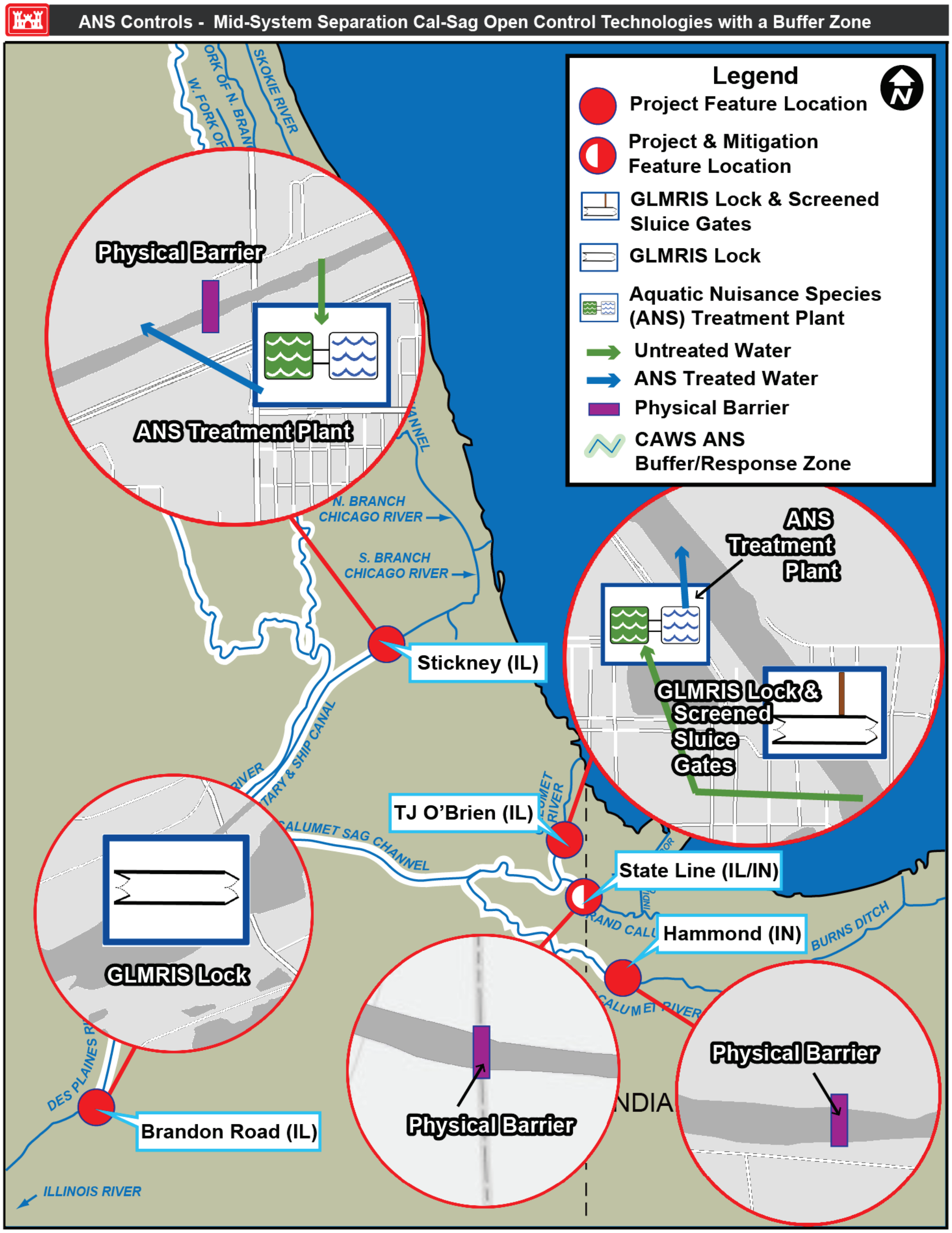


Figure 3.18 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.19 Location Details of ANS Prevention Measures

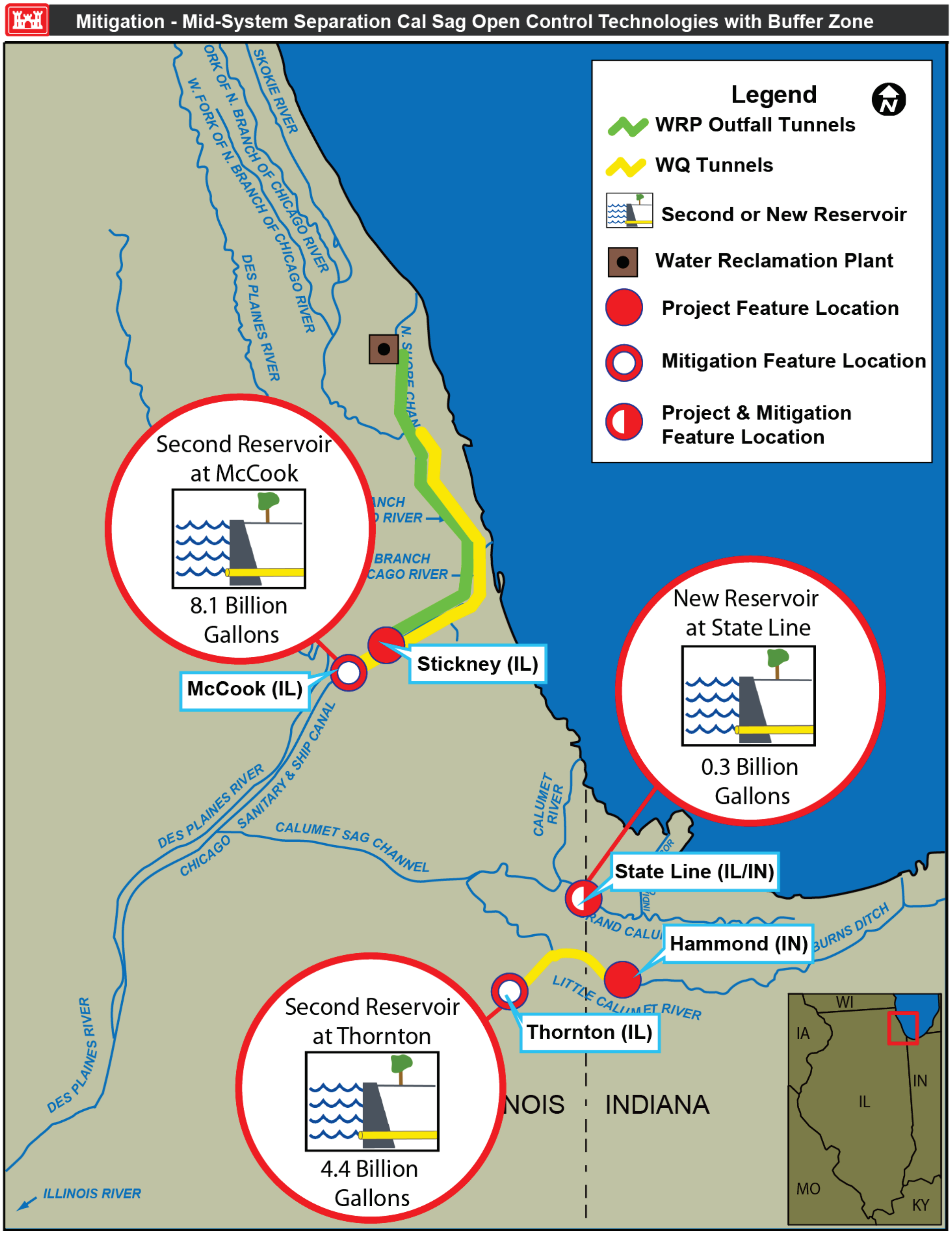


Figure 3.20 Location Details of Mitigation Measures

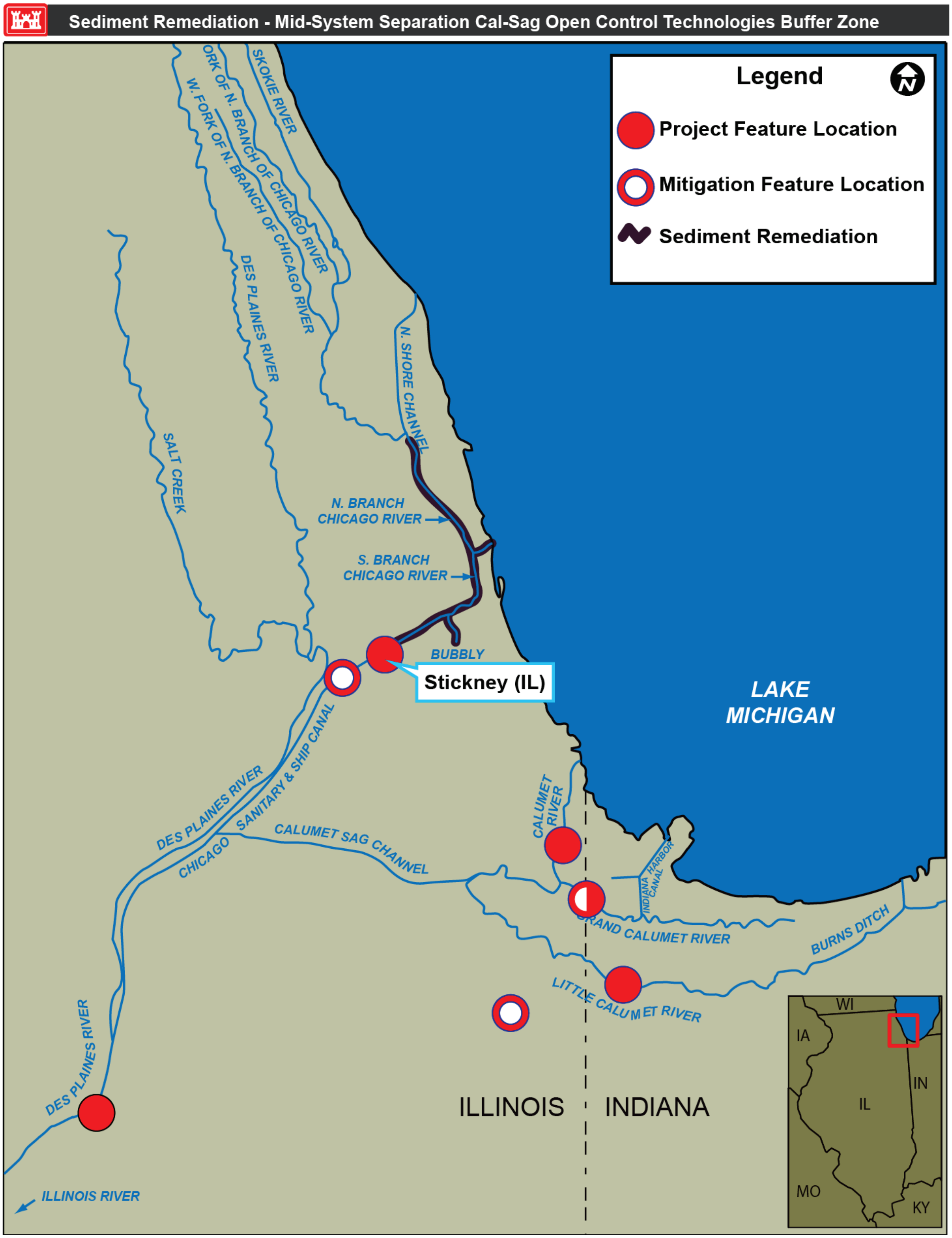


Figure 3.21 Location Details of Sediment Remediation Measures

At T.J. O'Brien (IL), the existing single-chamber lock would be replaced with a new single-chamber GLMRIS Lock with a shallow chamber and a deep chamber that is at the existing depth. The GLMRIS Lock would have a water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone. A new approach channel from Lake Michigan would include an electric barrier to prevent fish from entering the lock chamber during lockages. An ANS treatment plant would provide the water for lockages to ensure ANS not affected by the electric barriers would not be allowed to transfer into the CAWS from Lake Michigan. Screened sluice gates would be installed that are designed to prevent ANS from Lake Michigan from entering the CAWS while still allowing water to flow from the CAWS into Lake Michigan when necessary.

At Brandon Road (IL), a new approach channel from the Mississippi River direction would include an electric barrier to prevent fish from entering the lock chamber during lockages. The existing lock would be rehabilitated to install a new water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone and release the water downstream to the Mississippi River Basin and prevent ANS not affected by the electric barrier from entering the lock chamber.

The GLMRIS Locks would remain closed at all times unless a vessel needed to cross to the other side. Additionally, if there were a power failure with the electric barriers or another maintenance concern, the locks would remain closed to prevent passage of ANS.

CAWS Ecosystem Impacts

The two physical separation barriers along the Grand Calumet and Little Calumet Rivers would impede the dispersal of native species within their respective rivers. The result could be the extirpation of vulnerable native species and disruption of the food web. The Stickney (IL) physical barrier is located close to the historical separation point between the Mississippi River and Great Lakes Basins. This location will impact the ability of native aquatic species to disperse between basins and therefore between populations, but it is ultimately reversing an environmental impact from previous human activities. This is anticipated to be a High impact.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Water Quality CAWS Impacts

The Stickney (IL) physical barrier presents significant threats to water quality on the river side of the physical barrier. Water quality modeling, described in Appendix F, indicates that hours out of compliance with water quality benchmarks would increase on the SBCR and the CSSC due to the physical blockage of flows by the barrier.

This represents a Medium impact to water quality in the CAWS.

To mitigate water quality impacts to the CAWS, an ANS Treatment Plant would be constructed at Stickney (IL). The ANS Treatment Plant would withdraw water from the Lake Michigan side of the physical barrier, treat the water to remove or inactivate ANS, and then discharge the ANS-treated water on the Mississippi River side of the physical barrier. The treatment technologies proposed for the ANSTP at Stickney include screening, filtration, and UV radiation.

In addition to its role as an ANS control measure, the proposed ANS Treatment Plant at T.J. O'Brien (IL) would also function to mitigate water quality impacts. The ANSTP would allow the discretionary diversion of Lake Michigan water allocated to MWRD to continue and the hydrology along the Cal-Sag Channel to remain similar to current conditions. For additional information on mitigation, refer to Appendix F.

Water Quality CAWS Mitigation Measures

- ANS Treatment Plant at Stickney (IL) – 650 MGD capacity, 5.2-acre footprint.
- ANS Treatment Plant at T.J. O'Brien (IL) – 1,250 MGD total capacity, 4.1-acre footprint.
- 450 MGD capacity for water quality mitigation.
- 800 MGD capacity to supply the GLMRIS Lock.

Water Quality Lake Michigan Impacts

The most significant impacts of the Stickney (IL) physical barrier are the short-term and cumulative contaminant loads to Lake Michigan. As a result of the Stickney (IL) physical barrier, treated effluent from the O'Brien WRPs, hundreds of combined sewer overflows, dozens of storm sewer flows, and effluent from CSO pumping stations will all be directed toward Lake Michigan on a continuous basis. Urban storm runoff and contaminated sediment, while not assessed by the water quality models, will also contribute to the water quality impacts of this project alternative to Lake Michigan. Further detailed discussion of these analyses can be found in Appendix F – Water Quality Analyses.

To mitigate for water quality impacts to Lake Michigan, WRP effluent would be diverted to the river side of the physical barriers, a tunnel and reservoir system designed to capture all CSO events before they entered the Chicago River and North Shore Channel would be constructed, and contaminated sediment on the lake side of the Stickney (IL) physical barrier would be dredged and capped. For additional information on the mitigation measures refer to Appendix F – Water Quality Analyses.

Water Quality Lake Michigan Mitigation Measures

- On the Chicago River system, a tunnel 13 feet in diameter and 12.5 miles long is proposed to deliver the O'Brien WRP effluent to the river side of the proposed physical barrier in Stickney (IL).

- A pump station would be required at the downstream end in order to return the plant effluent to the elevation of the Chicago Sanitary and Ship Canal.

- New 8.1 billion gallon reservoir at McCook (IL) would address water quality impacts on the CSSC, Chicago River, and North Shore Channel of the system.

- The water in the reservoirs would be routed through existing wastewater treatment plants and then discharged into the CAWS such that it joins the Mississippi River basin.

- A conveyance tunnel along the North Shore Channel to McCook (IL) estimated at 13 miles long and 32 feet in diameter.

- Sediment remediation of the Chicago and Calumet River systems east of the physical barriers.

- Stormwater BMPs would be coordinated within the CAWS.

Flood Risk Management (FRM) Impacts

Under existing conditions, the Grand Calumet River and Little Calumet River flow toward the Mississippi River and Great Lakes basins. The physical barriers at Stateline (IL/IN) and Hammond (IN) prevent this bi-directional flow and would cause FRM impacts such as induced sewer and overbank flooding during large storm events. USACE is currently constructing a levee system on the Little Calumet River. The stage increases caused by these physical barriers would affect the level of protection on the levees. The Little Calumet River levee system is being constructed to a 0.5% ACE level (200-yr) with at least a 95% confidence for certification. With these barriers in place, the impacts to the level of protection (LOP) is substantial for several levee sections as summarized below (LOP where 95% confidence is achieved):

- Reach 4 Hammond East North 100-yr
- Reach 5b Griffith South 50-yr
- Reach 6a Gary North 100-yr
- Reach 7 Gary South 100-yr

Without mitigation measures, this alternative yields a net change in EEAD of $28,081,000 annually due to physical barriers at Stickney (IL), Stateline (IL/IN), and Hammond (IN). This net change in EEAD represents the additional damages to buildings and their contents that is expected to occur on a yearly basis as a result of this alternative. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

To mitigate for impacts to FRM two new reservoirs, and the necessary stormwater collection system (via tunnels) would be constructed. These new reservoirs and tunnels would be very similar in nature to the existing TARP in the Chicago area. These reservoirs would store stormwater up to the 0.2% ACE event, route the water through existing wastewater treatment plants, and then discharge the water into the CAWS such that it joins the Mississippi River basin. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix J – Civil Design.

Flood Risk Management (FRM) Mitigation Measures

- New 0.3 billion gallon reservoir at Stateline (IL) would address FRM impacts on the Grand Calumet River in the system.

- A new 4.4 billion gallon reservoir at Thornton (IL) would address FRM impacts on the Little Calumet River in the system.

- A conveyance tunnel from Hammond (IN) to Thornton (IL) estimated at 7 miles long and 14 feet in diameter.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures, construction of physical barriers would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events. The FRM mitigation would act as mitigation for these human safety impacts.

Construction of the electric barriers at Chicago (IL), T.J. O'Brien (IL), and Brandon Road (IL) would also have impacts to human safety. Their installation would have to be coordinated with the U.S. Coast Guard, and restrictions on small watercraft traversing the barriers would be imposed.

Commercial Navigation Impacts

The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone would result in a loss of commercial cargo navigation transportation cost savings of $7.30 million annually. In this alternative, some of the shallow draft movements could no longer move on the CAWS and would need to switch to truck or rail, find alternative sources for input, sell their output in different markets, or shut down. Some shallow draft movements that could still occur would need to take new routes in order to avoid the physical barriers. Since not all movements are forced off the waterway, the loss in transportation cost savings is less than the alternatives recommending complete hydrological separation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses, and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone impacts to noncommercial navigation would likely include:

- Additional safety restrictions to vessels that must travel through electric barriers.

- Some government agencies may have to duplicate services, if their jurisdictions extend beyond the barriers.

- Passenger vessels and government vessels may be affected by additional high water events.

- Vessels under 20 feet will not be able to pass through the electronic barriers (current U.S. Coast Guard restriction).

The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone would have a high impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Unmitigated Impacts

Installation of a physical barrier on the CAWS at Stickney (IL) will bring significant impacts to water quality in both the CAWS and Lake Michigan. Many of these impacts can be mitigated by the mitigation measures described previously. Other impacts that are expected as a result of the Mid-System Separation Alternative will be more difficult to correct. Currently, non-point source discharges of pollutants to the waterways remain largely unregulated, and thus the Mid-System Hydrologic Separation Alternative may result in some unmitigated impacts to water quality in Lake Michigan resulting from stormwater runoff.

Additionally, while the proposed mitigation measures are expected to minimize any effects on the downstream Mississippi River Basin outside of the CAWS, the impacts of reduced flow in the Illinois Waterway downstream of the project areas were not extensively studied in GLMRIS. See Appendix A – Effect of Mid-System Separation on Low Flows in Downstream Waterway for additional details.

3.14.2 ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies involved in these alternatives are known, the combination of technologies and application of the technologies are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternative includes physical barriers, which has uncertainty based on the size of the design storm event. A detailed discussion of this risk assessment analysis including uncertainty for each of the 13 High and Medium risk species for this alternative can be found in Appendix C –Risk Assessments.

The results of the with-project risk assessments of this alternative are the same as the Mid-System Control Technology without a Buffer Zone Alternative. Please see Section 3.10.2 for the discussion of ANS risk reduction provided by this alternative.

3.14.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.17) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

USACE recognizes that while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.18) identifies who may be financial responsible for measures in this alternative.

Table 3.17 Costs of Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative

Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative[a]	
ANS Control Measures Costs	$2,716,000,000
CAWS Ecosystem Mitigation Measures Costs	$44,000,000
Water Quality Mitigation Measures Cost	$8,280,000,000
FRM Mitigation Measures Cost	$1,863,000,000
Design/Construction Management	$2,152,000,000
LERRDs	$42,000,000
OMRR&R Cost (annual)	$110,200,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$15,097,000,000**

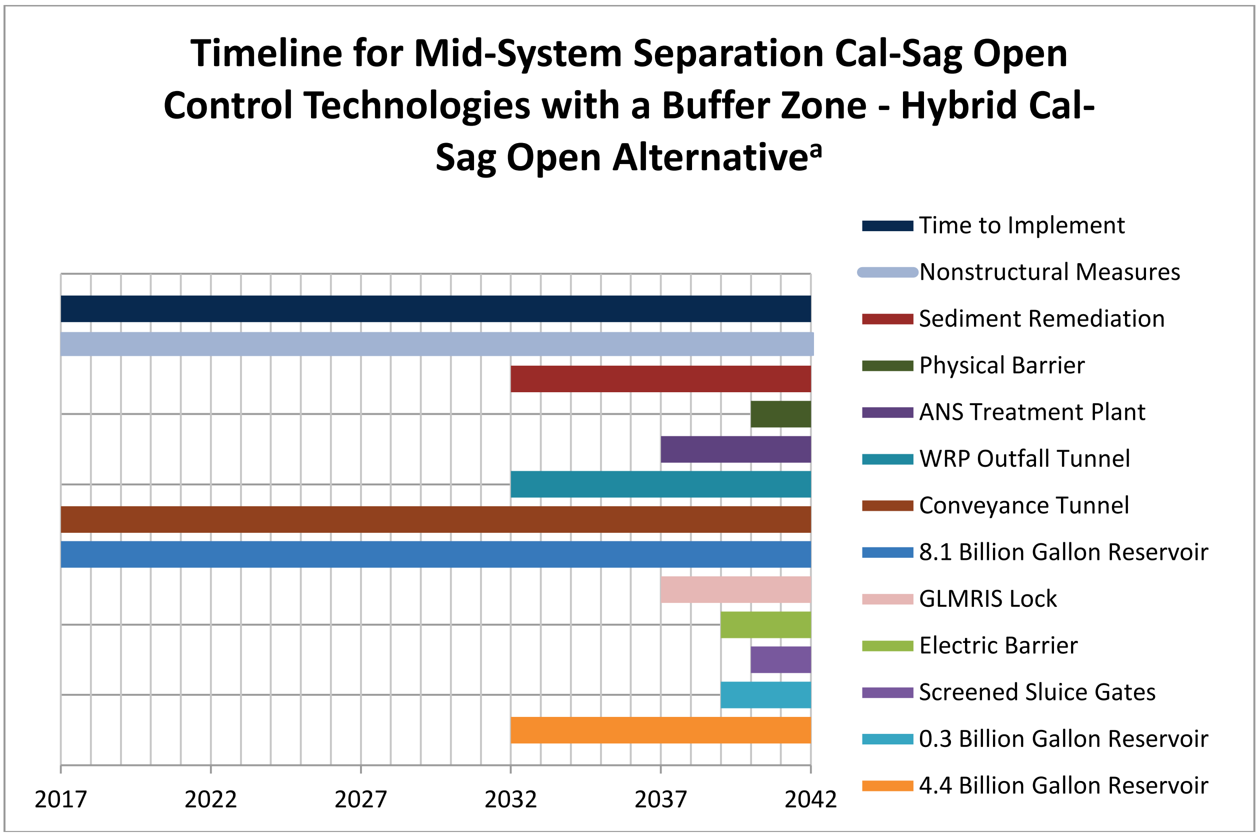
[a] Costs are shown as 2014 program-year dollars.

Table 3.18 Financial Responsibilities for Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative

Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
Physical Barrier @ Stickney (IL)	CAWS Ecosystem Restoration	Sediment Remediation	Nonstructural
GLMRIS Lock @ T.J. O'Brien (IL)	ANS Treatment Plant @ Stickney (IL)	WRP Outfall Tunnel	
Electric Barrier @ T.J. O'Brien (IL)	New 8.1 Billion Gallon Reservoir @ McCook (IL)	Conveyance Tunnel	
ANS Treatment Plant @ T.J. O'Brien (IL)	New 0.3 Billion Gallon Reservoir @ Oak Lawn (IL)		
Screened Sluice Gates @ T.J. O'Brien (IL)	New 4.4 Billion Gallon Reservoir @ Thornton (IL)		
Physical Barrier @ Stateline (IL/IN)	Conveyance Tunnel		
Physical Barrier @ Hammond (IN)			
GLMRIS Lock @ Brandon Road (IL)			
Electric Barrier @ Brandon Road (IL)			

3.14.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.22 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.



[a] The mitigation measures must be implemented prior to the completion of the ANS control measures, such as the GLMRIS Lock, to minimize impacts to CAWS uses and users. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.22 Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone – Hybrid Cal-Sag Open Alternative Timeline

3.14.5 Complexity of Regulatory Compliance

The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone will have a high level of complexity associated with regulatory compliance. In addition to construction of physical barriers, which will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the States of Illinois and Indiana, the mitigation actions to address potential water quality, flood risk, and navigation impacts will likely require extensive coordination with federal and state water quality regulators. Potential changes to diversion, though relatively minor, may require coordination with Canada and all Great Lakes states. Additional electric barriers will also require coordination with the U.S. Coast Guard on potential safety regulations for navigation through the barriers. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.

3.15 Alternative Plan 8: Mid-System Separation CSSC Open Control Technologies with a Buffer Zone

3.15.1 Alternative Plan Description

Table 3.19 summarizes the measures included in the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone, the type of measures and the locations of the measures. More information about the measures can be found in Figures 3.23-3.26.

This alternative includes a physical barrier located at Alsip (IL) hydrologically separating three of the five aquatic pathways between the CAWS and Lake Michigan. Along the two remaining aquatic pathways a Buffer Zone is would be established by installing ANS control measures at Wilmette (IL), Chicago (IL), and Brandon Road (IL). Additionally, the nonstructural measures described in Section 3.2 would be implemented as part of this alternative.

At Wilmette (IL), new screened sluice gates would be installed that are designed to prevent ANS from Lake Michigan from entering the CAWS while still allowing water to flow from the CAWS into Lake Michigan when necessary.

At Chicago (IL), the existing single-chamber lock would be replaced with a new double-chamber GLMRIS Lock with a shallow chamber and a deep chamber that is at the existing depth. The GLMRIS Lock would have a water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone. A new approach channel from Lake Michigan would include an electric barrier to prevent fish from entering the lock chamber during lockages. An ANS Treatment Plant would provide the water for lockages to ensure ANS not affected by the electric barriers would not be allowed to transfer into the CAWS from Lake Michigan. Screened sluice gates would be installed that are designed to prevent ANS from Lake Michigan from entering the CAWS while still allowing water to flow from the CAWS into Lake Michigan when necessary.

At Brandon Road (IL), a new approach channel from the Mississippi River direction would include an electric barrier to prevent fish from entering the lock chamber during lockages. The existing lock would be rehabilitated to install a new water flushing system that would fill the lock with ANS-free water from the CAWS Buffer Zone and release the water downstream to the Mississippi River basin and prevent ANS not affected by the electric barrier from entering the lock chamber.

Table 3.19 Mid-System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative

Mid System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative		
Location	**Measure**	**Type of Measure**
Basin-wide	Nonstructural	ANS Control
	Sediment Remediation	WQ Mitigation
To Be Determined within the Chicago Area	CAWS Ecosystem Mitigation	To Be Determined
Wilmette (IL)	Screened Sluice Gates	ANS Control
	ANS Treatment Plant	WQ Mitigation
Chicago (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	
	ANS Treatment Plant	
	Screened Sluice Gates	
Oak Lawn (IL)	0.2 Billion Gallon Reservoir	FRM Mitigation
Alsip (IL)	Physical Barrier	ANS Control
	ANS Treatment Plant	WQ Mitigation
	WRP Outfall Tunnel	
Thornton (IL)	5.2 Billion Gallon Reservoir	WQ Mitigation
	Conveyance Tunnel	
Brandon Road (IL)	GLMRIS Lock	ANS Control
	Electric Barrier	

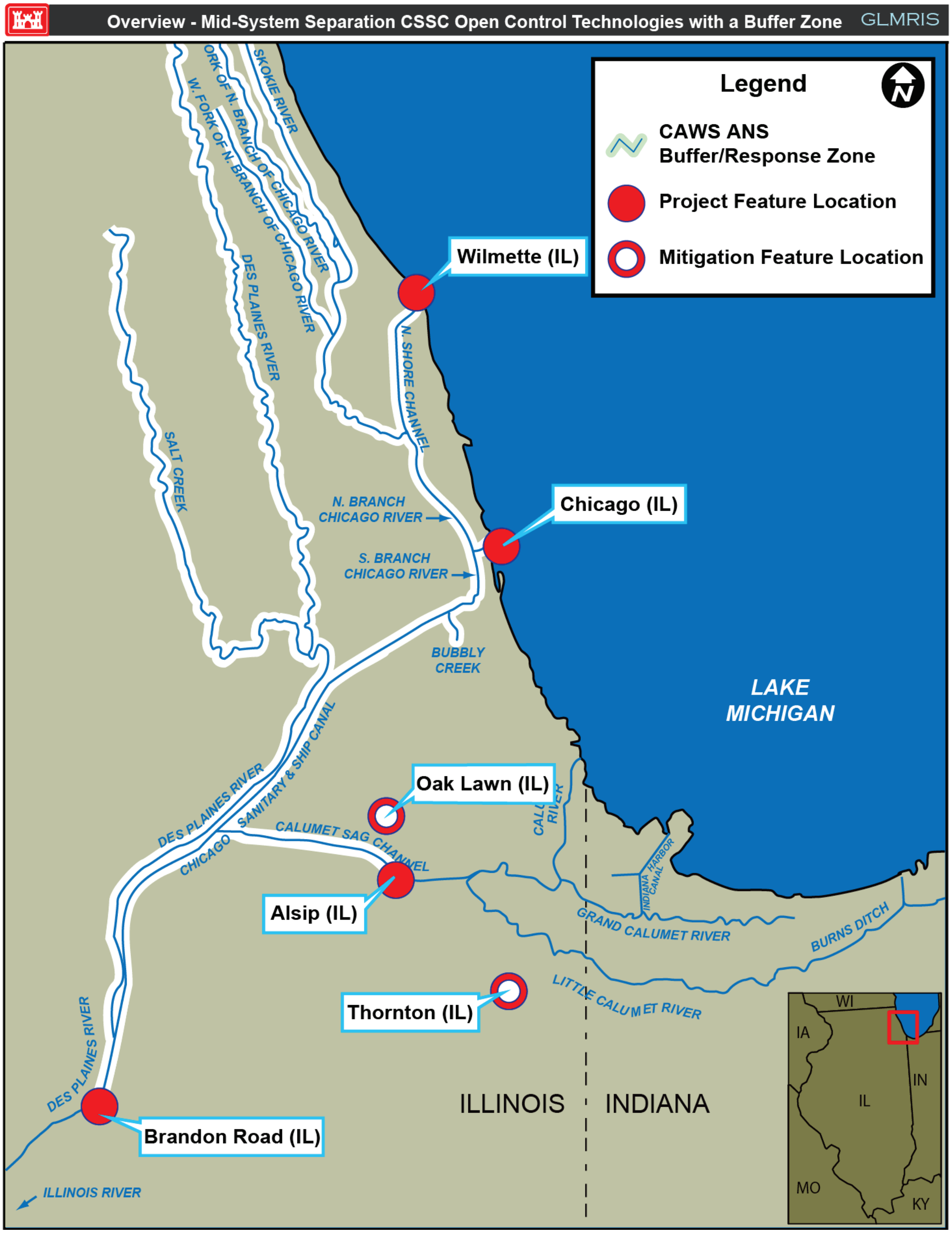
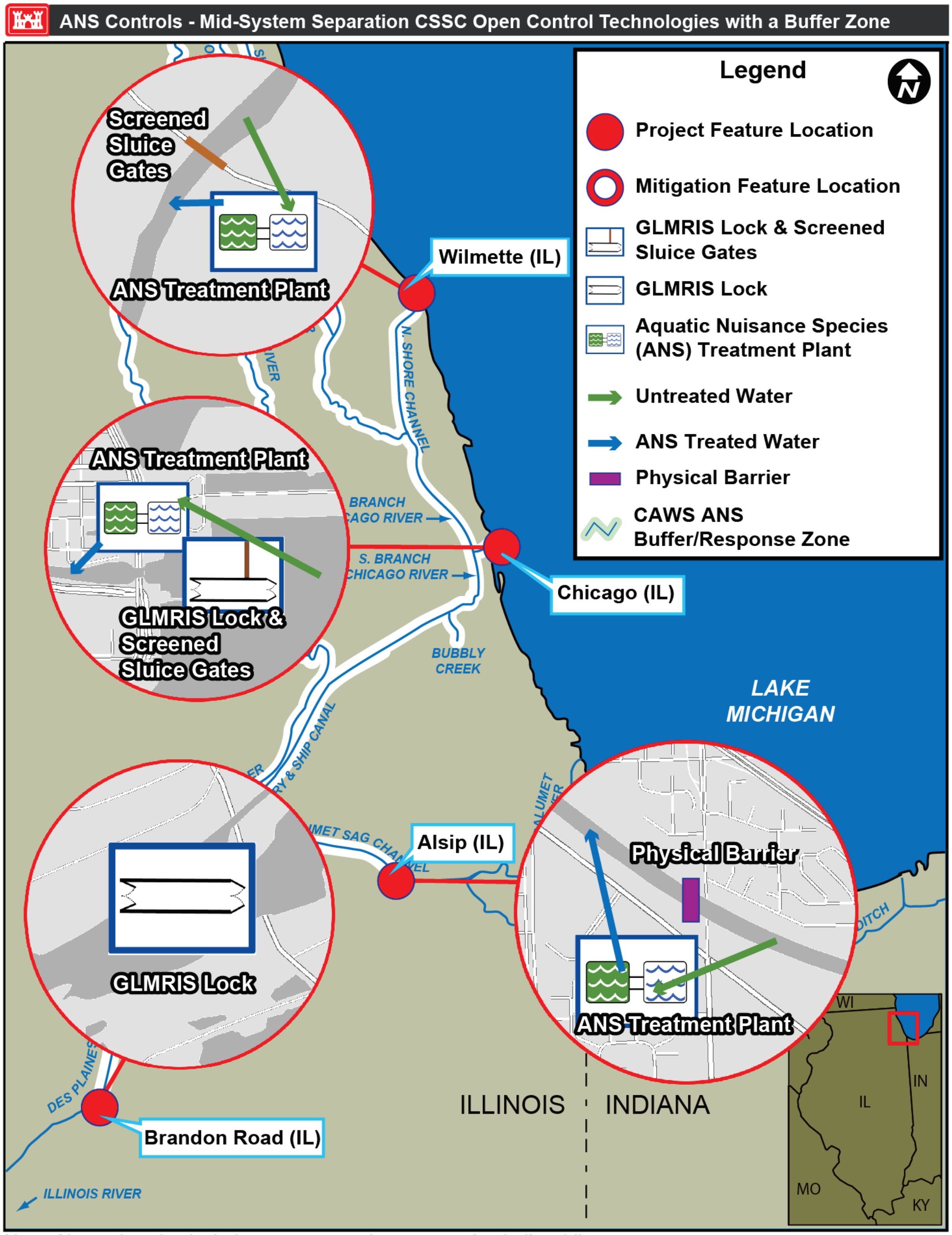


Figure 3.23 Locations of ANS Prevention and Mitigation Measures within the CAWS



Note: Alternative also includes nonstructural measures, i.e. ballast bilge management, etc.

Figure 3.24 Location Details of ANS Prevention Measures

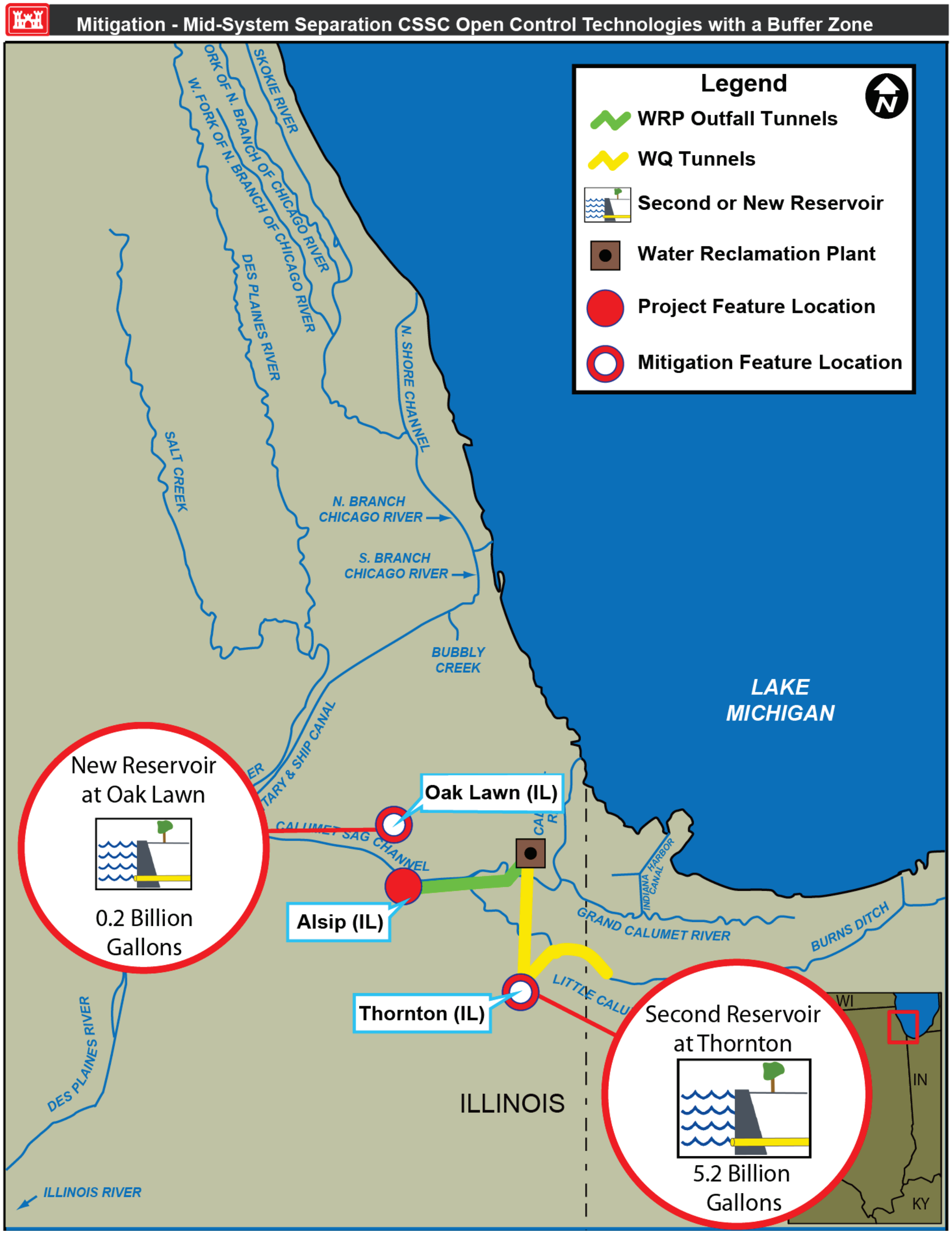


Figure 3.25 Location Details of Mitigation Measures

Figure 3.26 Location Details of Sediment Remediation Measures

The GLMRIS Locks would remain closed at all times unless a vessel needed to cross to the other side. Additionally, if there were a power failure with the electric barriers or another maintenance concern, the locks would remain closed to prevent passage of ANS.

CAWS Ecosystem Impacts

The physical barrier at Alsip (IL) will fragment the Cal-Sag Channel such that native aquatic species will no longer be able to freely move within the channel; however, the barrier is located close to the original divide between basins. This is a reversal of a previous negative environmental impact, and the effects will be a temporary period of adjustment for native aquatic species. The alternative would also remove aquatic habitat at or near Lake Michigan. This is anticipated to be a Medium impact.

CAWS Ecosystem Mitigation Measures

CAWS ecosystem mitigation measures may be required for impacts to significant natural resources as a result of plan implementation. Since site-specific designs have not been completed, impacts have not been assessed and mitigation measures have not been developed; however, the GLMRIS Team identified placeholder costs for ecosystem mitigation measures that are at a commensurate level of detail for each alternative. Further analysis and design for any selected alternative would include an assessment of plan impacts and identification of mitigation requirements as required under NEPA. These evaluations would be fully coordinated with the appropriate resource agencies.

Water Quality CAWS Impacts

The Alsip (IL) physical barrier presents significant threats to water quality on the river side of the physical barrier. Water quality modeling, described in Appendix F, indicates that hours out of compliance with water quality benchmarks would increase on the Cal-Sag Channel due to the physical blockage of flows by the barrier.

This represents a High impact to water quality in the CAWS.

To mitigate water quality impacts to the CAWS, an ANS Treatment Plant would be constructed at Alsip (IL). The ANS Treatment Plant would withdraw water from the Lake Michigan side of the physical barrier, treat the water to remove or inactivate ANS, and then discharge the ANS-treated water on the Mississippi River side of the physical barrier. The treatment technologies proposed for the ANSTP at Stickney include screening, filtration, and UV radiation.

In addition to its role as an ANS control measure, the proposed ANS Treatment Plants at Wilmette (IL) and Chicago (IL) would also function to mitigate water quality impacts. The ANSTP would allow the discretionary diversion of Lake Michigan water allocated to MWRD to continue and the hydrology along the North Shore Channel, Chicago River, and CSSC to remain similar to current conditions. For additional information on mitigation refer to Appendix F.

Water Quality CAWS Mitigation Measures

- ANS Treatment Plant at Wilmette (IL) – 200 MGD capacity, 0.7-acre footprint.
- ANS Treatment Plant at Chicago (IL) – 1,750 MGD total capacity, 5.7-acre footprint.
- 450 MGD capacity for water quality mitigation.
- 1,300 MGD capacity to supply the GLMRIS Lock.
- ANS Treatment Plant at Alsip (IL) – 450 MGD capacity, 3.6-acre footprint.

Water Quality Lake Michigan Impacts

The most significant impacts of the Alsip (IL) physical barrier are the short-term and cumulative contaminant loads to Lake Michigan. As a result of the Alsip (IL) physical barrier, treated effluent from the Calumet WRPs, hundreds of combined sewer overflows, dozens of storm sewer flows, and effluent from CSO pumping stations will all be directed toward Lake Michigan on a continuous basis. Urban storm runoff and contaminated sediment, while not assessed by the water quality models, will also contribute to the water quality impacts of this project alternative to Lake Michigan. Further detailed discussion of this analysis can be found in Appendix F – Water Quality Analyses.

To mitigate for water quality impacts to Lake Michigan, WRP effluent would be diverted to the river side of the physical barriers; a tunnel and reservoir system designed to capture all CSO events before they entered the Calumet River System would be constructed, and contaminated sediment on the lake side of the Alsip (IL) physical barrier would be dredged and capped. For additional information on the mitigation measures refer to Appendix F – Water Quality Analyses.

Water Quality Lake Michigan Mitigation Measures

- On the Calumet River System, a tunnel 13 feet in diameter and 5.3 miles long would be needed to deliver the Calumet WRP effluent to the river side of the proposed physical barrier in Alsip (IL).

- A pump station would be required at the downstream end in order to return the plant effluent to the elevation of the Cal-Sag Channel.

- A new 5.2 billion gallon reservoir at Thornton (IL) would address water quality impacts on the Cal-Sag Channel and Calumet, Grand Calumet, and Little Calumet Rivers in the system.
- The water in the reservoirs would be routed through existing wastewater treatment plants and then discharged into the CAWS such that it joins the Mississippi River basin.

- A conveyance tunnel from Hammond (IN) to Thornton (IL) estimated at 7 miles long and 14 feet in diameter.

- Sediment remediation of the Chicago and Calumet River Systems east of the physical barriers.

- Stormwater BMPs would be coordinated within the CAWS.

Flood Risk Management (FRM) Impacts

The Alsip (IL) physical barrier was developed to have minimal impacts on FRM impacts. Any additional stormwater that would need to be captured to mitigate for FRM impacts would be captured in the tunnels and reservoirs designed to capture the stormwater during CSO events with the exception of the flow on Thorn Creek, an aquatic connection with the potential to bypass the Alsip (IL) physical barrier.

Without mitigation measures, this alternative yields a lesser value of EEAD of $26,361,000 than in the without-project condition. This alternative yields a reduction in overall EEAD when compared to the without-project condition. For this alternative, a barrier would be located at Alsip (IL) on the Cal-Sag Channel and both the T.J. O'Brien Lock and Controlling Works on the Calumet River, and the Chicago River Controlling Works along the Chicago River would be opened to allow for the continual release of flood waters to Lake Michigan during infrequent storm events. Allowing discharge to Lake Michigan results in stage reductions during flood events when compared to the without-project condition, where backflows to Lake Michigan are limited. Further, the barrier at Alsip would reduce the amount of flow that currently passes westward on the Cal-Sag Channel during flood events. The barrier would limit flood flows to portions of the river that lie westward of the Alsip barrier, providing reductions in flood stages west of the barrier. In combination, the effects of allowing floodwaters to enter Lake Michigan during flood events coupled with stage reductions west of the barrier along the Cal-Sag Channel result in an overall decrease in EEAD within the CAWS region as compared to the without-project condition. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses. It is important to note that some areas within the CAWS may actually see an increase in damages to buildings and their contents. For the entire CAWS area, the damages to buildings and their contents that occur would be less than damages that occur without implementing this alternative.

The water quality mitigation of tunnels and reservoirs would also act as FRM mitigation. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix J – Civil Design.

Flood Risk Management (FRM) Mitigation Measures

- A new 0.2 billion gallon reservoir at Oak Lawn (IL) would address FRM impacts on Thorn Creek, a potential bypass of the physical barrier in Alsip (IL) on the Cal-Sag Channel in the system.

Human Safety Impacts and Mitigation Measures

Without any mitigation measures, construction of physical barriers would induce flooding of the CAWS during the 0.2% ACE event. This induced flooding would increase life safety risks associated with large storm events. The FRM mitigation would act as mitigation for these human safety impacts.

Construction of the electric barriers at Chicago (IL), T.J. O’Brien (IL), and Brandon Road (IL) would also have impacts to human safety. Their installation would have to be coordinated with the U.S. Coast Guard, and restrictions on small watercraft traversing the barriers would be imposed.

Commercial Navigation Impacts

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone would result in a loss of commercial cargo navigation transportation cost savings of $8.83 million annually. In this alternative, some of the shallow draft movements could no longer move on the CAWS and would need to switch to truck or rail, find alternative sources for input, sell their output in different markets, or shut down. Some shallow draft movements that could still occur would need to take new routes in order to avoid the physical barriers. Since not all movements are forced off the waterway, the loss in transportation cost savings is less than the alternatives recommending complete hydrological separation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Impacts to commercial navigation would not be mitigated, because no mitigation measures were identified that would effectively address the impacts. A full discussion on this topic is included in Section 2.5, Mitigation Assumptions, and in Attachment 6 (Commercial Cargo Reports) to Appendix D – Economic Analyses and Appendix A.

Noncommercial Navigation (includes recreational navigation) Impacts

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone impacts to noncommercial navigation would likely include:

- Additional safety restrictions to vessels that must travel through electric barriers.
- Some government agencies may have to duplicate services, if their jurisdictions extend beyond the barriers.
- Passenger vessels and government vessels may be affected by additional high water events.
- Vessels under 20 feet will not be able to pass through the electronic barriers (current U.S. Coast Guard restriction).

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone would have a medium impact to noncommercial navigation. A more detailed discussion of this analysis can be found in Appendix D – Economic Analyses.

Unmitigated Impacts

Installation of a physical barrier on the CAWS at Alsip (IL) will bring significant impacts to water quality in both the CAWS and Lake Michigan. Many of these impacts can be mitigated by the mitigation measures described previously. Other impacts that are expected as a result of the Mid-System Separation Alternative will be more difficult to correct. Currently, non-point source discharges of pollutants to the waterways remain largely unregulated, and thus the Mid-System Hydrologic Separation Alternative may result in some unmitigated impacts to water quality in Lake Michigan resulting from stormwater runoff.

Additionally, while the proposed mitigation measures are expected to minimize any effects on the downstream Mississippi River Basin outside of the CAWS, the impacts of reduced flow in the Illinois Waterway downstream of the project areas were not extensively studied in

GLMRIS. See Appendix A – Effect of Mid-System Separation on Low Flows in Downstream Waterway – for additional details.

3.15.2 ANS Risk Reduction

This alternative includes nonstructural measures that are assumed to be implemented quickly (T_0). An exception would be nonstructural measures which are dependent on the passage of new laws or regulations, because of the uncertainty of the time required to pass and implement new laws or regulations. The remaining structural measures are assumed to be implemented at T_{25}. This alternative includes measures, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies involved in these alternatives are known, the combination of technologies and application of the technologies are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy. As a result, the uncertainty associated with the technologies' impact on ANS passage is higher than the uncertainty of ANS passage associated with the hydrologic separation alternatives. The hydrologic separation alternative includes physical barriers, which has uncertainty based on the size of the design storm event. A detailed discussion of this risk assessment analysis including uncertainty for each of the 13 High and Medium risk species for this alternative can be found in Appendix C –Risk Assessments.

The results of the with-project risk assessments of this alternative are the same as the Mid-System Control Technology without a Buffer Zone Alternative. Please see Section 3.10.2 for the discussion of ANS risk reduction provided by this alternative.

3.15.3 Estimated Alternative Cost

The costs presented in the GLMRIS Report (Table 3.20) are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Table 3.20 Costs for Mid-System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative

Mid System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative[a]	
ANS Control Measures Costs	$2,643,000,000
CAWS Ecosystem Mitigation Measures Costs	$26,000,000
Water Quality Mitigation Measures Cost	$4,337,000,000
FRM Mitigation Measures Cost	$145,000,000
Design/Construction Management	$1,146,000,000
LERRDs	$36,000,000
OMRR&R Cost (annual)	$96,500,000
Nonstructural Costs (annual)	$68,000,000
Cost of the Alternative (Does not include annual costs)	**$8,333,000,000**

[a] Costs are shown as 2014 program-year dollars.

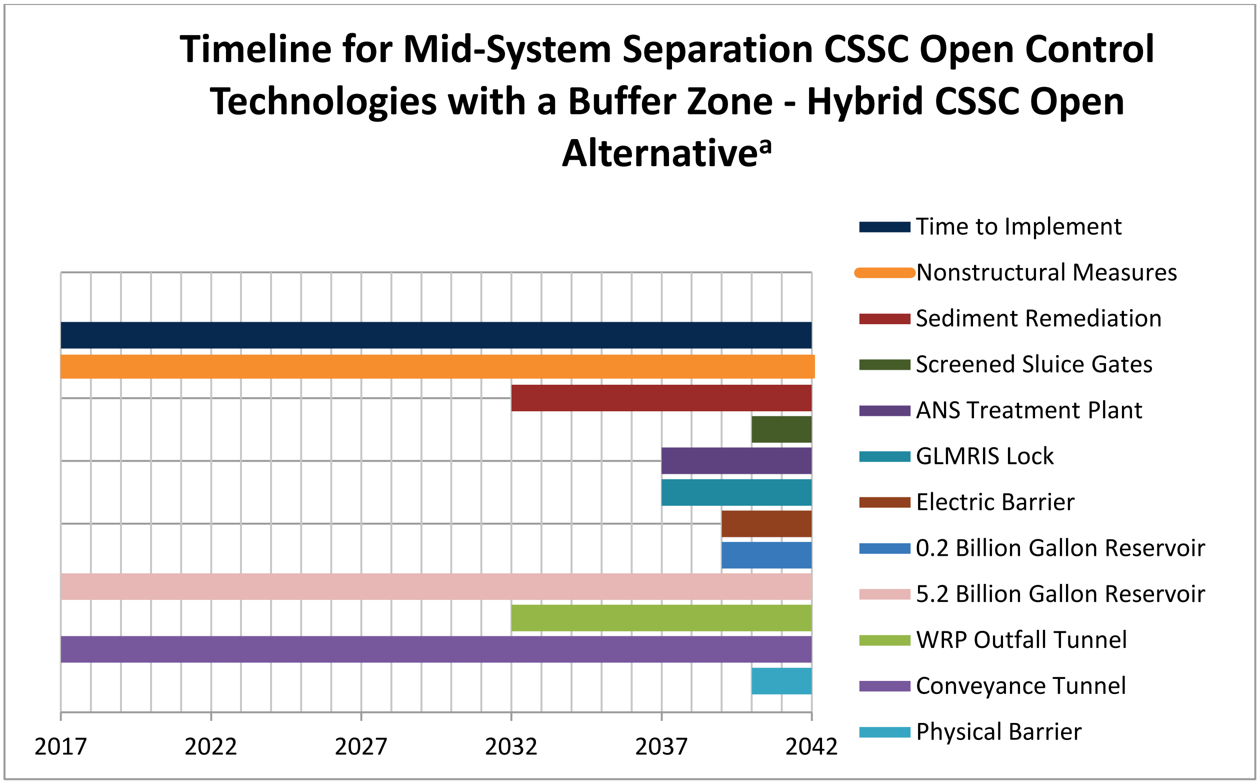
USACE recognizes that while all the measures shown in this alternative description are required to achieve the stated risk reduction, not all measures may be a financial responsibility of USACE. The following chart (Table 3.21) identifies who may be financial responsible for measures in this alternative.

Table 3.21 Financial Responsibilities for Mid-System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative

Mid System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative			
ANS Control Measures (Part of Cost of the Alternative)	**Mitigation Measures – Part of USACE Base Project (Part of Cost of the Alternative)**	**Mitigation – Paid by Others or Added to USACE Project by Congress (Part of Cost of the Alternative)**	**Mitigation – Paid by Others (Part of Cost of the Alternative)**
Screened Sluice Gates @ Wilmette (IL)	CAWS Ecosystem Restoration	Sediment Remediation	Nonstructural
GLMRIS Lock @ Chicago (IL)	ANS Treatment Plant @ Wilmette (IL)	WRP Outfall Tunnel	
Electric Barrier @ Chicago (IL)	0.2 Billion Gallon Reservoir @ Oak Lawn (IL)	Conveyance Tunnel	
ANS Treatment Plant @ Chicago (IL)	ANS Treatment Plant @ Alsip (IL)		
Screened Sluice Gates @ Chicago (IL)	5.2 Billion Gallon Reservoir @ Thornton (IL)		
Physical Barrier @ Alsip (IL)			
GLMRIS Lock @ Brandon Road (IL)			
Electric Barrier @ Brandon Road (IL)			

3.15.4 Estimated Alternative Implementation Duration

The schedule in Figure 3.27 assumes that the construction of all features is completed by the end of the implementation period. Opportunities for staged implementation to provide for earlier risk reduction may exist, but would need to be further investigated in future study. This schedule also assumes that the project has a non-federal sponsor; receives capability funding; completes required lands acquisitions; obtains required permits; and is compliant with USACE policy requirements. Lastly, the schedule assumes conditional activities required by non-USACE parties are completed as necessary to facilitate timely completion of the project. A delay associated with any of these components would likely extend the time needed for project implementation and increase costs.



[a] The mitigation measures must be implemented prior to the completion of the ANS control measures, such as the GLMRIS Lock, to minimize impacts to CAWS users and uses. Consequently, the ANS risk reduction resulting from this alternative is realized when all measures have been constructed.

Figure 3.27 Mid-System Separation CSSC Open Control Technologies with a Buffer Zone – Hybrid CSSC Open Alternative Timeline

3.15.5 Complexity of Regulatory Compliance

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone is anticipated to have a High level of complexity associated with regulatory compliance. In addition to construction of physical barriers, which will require a Clean Water Act 404(b)(1) analysis and CWA 401 water quality certifications from the State of Illinois, the mitigation actions to address potential water quality, flood risk, and navigation impacts will likely require extensive coordination with federal and state water quality regulators. Potential changes to diversion, though relatively minor, may require coordination with Canada and all Great Lakes states. Additional electric barriers will also require coordination with the U.S. Coast Guard on potential safety regulations for navigation through the barriers. Coordination with Illinois and Indiana under the Coastal Zone Management Act will also likely be required.

Chapter 4 Summary of Findings

In January 2013, the GLMRIS Team outlined the criteria that could be utilized by decision-makers to evaluate the plans that would be included in the final GLMRIS Report. The GLMRIS Report is presenting an array of potential alternatives and does not recommend a specific alternative.

4.1 Evaluation Criteria

The final evaluation criteria and associated metrics are discussed in Tables 4.1 and 4.2.

Table 4.1 Final Evaluation Criteria

Evaluation Criteria	Metric
Effectiveness at Preventing Interbasin Transfer (At time of implementation)	Qualitative Rating of one to four stars based on semi-quantitative value obtained using a ranking algorithm
Implementation (years)	# of years to full risk reduction benefits from project
Negative Environmental Impacts (CAWS)	High/Medium/Low rating based on qualitative description of alternative impacts
Negative Water Quality Impacts (CAWS)	High/Medium/Low rating based on DUFLOW (WQ Model) data and hours out of compliance of water quality standards
Negative Water Quality Impacts (Lake Michigan)	High/Medium/Low rating based on FVCOM (WQ Model) data and percent increases in loading levels of Lake Michigan
Water Quality Mitigation Measures Cost	$– Cost associated with mitigating the Water Quality Impacts to the CAWS and Lake Michigan
FRM (net change in EEAD – an annual impact)	$– Net Equivalent Expected Annual Damages of FRM impacts caused by an alternative
FRM Mitigation Measures Cost	$– Cost associated with mitigating the FRM impacts to the CAWS
Commercial Cargo Cost Impacts (annual cost)	$– Impacts to commercial cargo navigation for 50 years (2017 – 2067) discounted and amortized over the 50 year period
Non-Cargo Navigation Impacts	High/Medium/Low rating based on qualitative description of alternative impacts
Complexity of Regulatory Compliance	High/Medium/Low rating based on qualitative description of alternative impacts
Cost of the Alternative (ANS Control and Mitigation Measures)	$– Parametric cost estimate of all features (ANS prevention and mitigation) of the alternative
Nonstructural and OMRR&R Costs	$– Yearly cost of nonstructural measures and OMRR&R for project features

Table 4.2 GLMRIS Evaluation Criteria Summary

GLMRIS Alternatives	GLMRIS Alternatives Evaluation Criteria†												
			Effects of GLMRIS Alternatives										
	Effectiveness at Preventing Interbasin Transfer (at time of implementation)	Implementation (years)	Negative CAWS Environmental Impacts	Negative Water Quality Impacts (CAWS)	Negative Water Quality Impacts (Lake Michigan)	Water Quality Mitigation Measures Cost[4]	FRM (net change in EEAD – an annual impact)	FRM Mitigation Measures Cost[4]	Commercial Cargo Cost Impacts (annual cost)	Non-Cargo Navigation Impacts	Complexity of Regulatory Compliance	Cost of the ANS Control and Mitigation Measures[4]	Nonstructural & OMRR&R Costs (annual)[4]
No New Federal Action – Sustained Activities	★	The No New Federal Action – Sustained Activities Alternative assumes that any currently funded ANS prevention actions are maintained to include the operation of the existing electric barrier in Romeoville, IL. All alternatives below are actions in addition to the No New Federal Action – Sustained Activities Alternative. For complete details on this alternative, please review Section 3.8.											
Nonstructural Control Technologies	★★	0	L	L	L	N/A	$0	N/A	Likely minimal[3]	L	L	$–[5]	$68 M
Mid-System Control Technologies without a Buffer Zone – Flow Bypass[2]	★★★	25	M	L	L	N/A	$1.1 M	$9,100 M	$0.75 M	L	M	$15,500 M	$210 M
Technology Alternative with a Buffer Zone[2]	★★★	10	H	L	L	$1,600 M	$0.6 M	$2,000 M	$0.50 M	M	M	$7,800 M	$220 M
Lakefront Hydrologic Separation[2]	★★★★	25	H	M	Improves[1]	$500 M	$66.0 M	$14,500 M	$210 M	H	H	$18,300 M	$160 M
Mid-System Hydrologic Separation[2]	★★★★	25	L	H	H	$12,900 M	$1.1 M	$24 M	$250 M	M	H	$15,500 M	$140 M
Hybrid – Mid-System Separation Cal-Sag Open[2]	★★★	25	H	M	M	$8,300 M	$28.1 M	$1,900 M	$7.30 M	M	H	$15,100 M	$180 M
Hybrid – Mid-System Separation CSSC Open[2]	★★★	25	M	H	M	$4,300 M	($26.4 M)	$145 M	$8.80 M	M	H	$8,300 M	$160 M

† Evaluation Criteria Descriptions are located on the reverse side of this table.

1 Under the Lakefront Hydrologic Separation Alternative, stormwater and CSOs would no longer be able to backflow to Lake Michigan, likely reducing beach closures and contaminant loading to Lake Michigan.

2 This alternative includes the nonstructural measures identified in the Nonstructural Alternative.

3 A quantified evaluation of the impacts of the Nonstructural Alternative was unable to be completed. Based on professional judgment, the impacts are believed to be likely minimal.

4 The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. The funding stream for an alternative is assumed to be sufficient to support annual progress to meet corresponding implementation timelines. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

5 Estimated initial costs for the Nonstructural Alternative are assumed negligible and sufficiently captured by the estimate for the annual OMRR&R Costs.

Effectiveness at Preventing Interbasin Transfer. This criterion qualitatively assesses the alternative's effectiveness at preventing ANS transfer based on the number of High and Medium risk ANS of Concern whose risk of establishment can be reduced from High or Medium to Low. This criterion is also influenced by the comparative levels of uncertainty associated with the ANS Control measures proposed in each alternative. Plans are given a "star" [*] rating; with four "stars" being the most effective.

Implementation. This criterion is the total number of years it will take for the alternative to fully realize projected risk reduction benefits.

Negative CAWS Environmental Impacts. This criterion qualitatively evaluates the negative effects of an alternative on the existing environment limited to the footprint area of the alternative's construction and the alternative's impact on the connectivity of the habitats in the CAWS.

CAWS Ecosystem Mitigation Measures Costs. This criterion presents the estimated costs to mitigate some of the negative environmental impacts of an alternative.

Water Quality Impacts (CAWS). This qualitative rating is based upon the output of the CAWS DUFLOW model. DUFLOW simulates the water quality (WQ) in the CAWS under baseline, future without project, and future with project conditions. DUFLOW simulation results are used to generate a CAWS Water Quality Index for each project alternative based on the percent increase in Days Out of Regulatory Compliance for three indicator constituents (Fecal Coliform, Dissolved Oxygen, and Chloride). A detailed discussion of these analyses can be found in Appendix F – Water Quality Analyses.

Water Quality Impacts (Lake Michigan). This qualitative rating is based upon the output of the CAWS DUFLOW and Lake Michigan FVCOM models. DUFLOW calculates the loads of pollutants discharged to Lake Michigan for the baseline, future without project, and future with project conditions. DUFLOW simulation results are used to generate a Lake Michigan Water Quality Index for each project alternative, based on the mass of pollutant loads to Lake Michigan for six indicator constituents (Biochemical Oxygen Demand, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Chloride, and Fecal Coliform). A detailed discussion of these water quality analyses can be found in Appendix F – Water Quality Analyses.

Water Quality Mitigation Measures Costs. This criterion presents the estimated costs to mitigate the Water Quality Impacts to both the CAWS and Lake Michigan of an alternative. Further detailed discussion of the mitigation measures can be found in Appendix F – Water Quality, and the associated cost analyses are described in more detail in Appendix K.

Flood Risk Management (FRM). This criterion displays the FRM impacts as the equivalent expected annual damages (EEAD) associated with implementing each GLMRIS Alternative plan. In the without-project conditions, damages are expected to occur to various structures. However, the implementation of a GLMRIS plan will either increase the total damages in the Chicago area (represented as positive values in this column) or decrease total damages in the Chicago area (negative value). Specifically, the values presented represent the difference (i.e., net change) between the without-project condition (EEAD of $231.241 million) and the with-project conditions. Positive values represent induced damages in the Chicago area. Negative values represent a reduction in overall damages in the Chicago area. Values show the unmitigated impacts. A more detailed discussion of this analysis can be found in Appendix E – Hydrologic & Hydraulic Analyses and Appendix D – Economic Analyses.

FRM Mitigation Measures Costs. This criterion presents the estimated costs to mitigate the FRM impacts of an alternative. Further detailed discussion of the mitigation measures can be found in Appendices E, and J, and the associated cost analyses are described in more detail in Appendix K.

Commercial Cargo Cost Impacts. Normally, it is cheaper to move bulk commodities via waterways (waterborne transportation) than it is on land (i.e., via truck and rail). The difference between the costs of moving commodities on land and the cost of moving them on a waterway is called "transportation cost savings." This criterion displays the losses in transportation cost savings if a GLMRIS Alternative is implemented. Several of the GLMRIS Alternative plans include measures that would decrease the efficiency of moving goods on the waterway, so the cost of shipping these goods via waterways increases. Therefore, there are fewer savings associated with moving the goods via water versus land. The greater the losses in transportation cost savings, the greater the cargo navigation impacts. A more detailed discussion of these analyses can be found in Appendix D – Economic Analyses.

Non-Cargo Navigation Impacts. This criterion, based on professional judgment, qualitatively states the impact of an alternative on non-cargo navigation in the CAWS, to include recreational navigation. The alternatives will be given a ranking of "High," "Medium," or "Low." A more detailed discussion of these analyses can be found in Appendix D – Economic Analyses.

Complexity of Regulatory Compliance. This criterion qualitatively states the level of regulation that the alternative will be subject to and incorporates the complexity of the associated compliance with those regulations. The alternatives will be given a ranking of "High," "Medium," "Low," or "None." "High" means a high level of difficulty achieving regulatory compliance would be associated with the alternative. All alternatives will be fully compliant with applicable regulations.

Cost of the Alternative (ANS Controls and Mitigation). This criterion is a parametric cost estimate of each alternative. The cost estimate will include the cost of construction of the alternative measures, including any mitigation that would be required as part of the alternative. Cost estimates underwent an abbreviated risk analysis to determine an appropriate contingency percentage to be included in the cost. These estimates include costs for all work necessary to implement an alternative, although some of these costs may be borne by entities other than USACE. Cost estimates do not include final quantities. The costs presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. The funding stream for an alternative is assumed to be sufficient to support annual progress to meet corresponding implementation timelines. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

Nonstructural & OMRR&R Costs. This criterion is an estimate of the nonstructural measures and the annual operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs of an alternative. Further detailed discussion of this analysis can be found in Appendix K – Cost Engineering.

4.2 Timing of Risk Realization and Risk Reduction for 13 High and Medium Risk ANS

There are 13 species that have a Medium or High risk rating at some point in the 50-year planning horizon. Plans have been formulated with the goal of reducing these risks to a Low rating. There are several somewhat subtle facts to be aware of when considering the timing of the planned risk reductions. First, there are no time periods of zero risk for the identified 13 ANS. This means a species rated Medium or High risk at T_0 could become established in the new basin before GLMRIS Alternatives would be implemented. If a species becomes established, its risk rating becomes irrelevant. Second, because some of the risk rankings have high levels of uncertainty associated with them, it is possible that the risk is actually greater or lower than the rating reflects. Thus, the uncertainty ratings assigned to various probability elements, as set forth in Appendix C – Risk Assessments, are important to consider.

When determining whether an alternative could reduce an ANS's risk rating to low throughout the 50-year period of analysis, the following evaluation was performed:

1. What time step does the ANS have a High or Medium risk of adverse impacts in the newly invaded basin? (See Appendix C – Risk Assessment, Without Project Risk Assessments).

2. Could the alternative reduce the risk of adverse impacts from a High or Medium risk to a Low rating?

3. Can the alternative be implemented before or at the same time step when the ANS's risk rating becomes High or Medium?

For example: The fishhook waterflea has a Low risk of establishment at T_0 and T_{10} and Medium risk of establishment at T_{25}. The only alternatives that will reduce this species risk rating to Low are the Mid-System and Lakefront Hydrologic Separation Alternatives because the fishhook waterflea is a hull fouler and vessel transport continues in the other alternatives. These alternatives will be implemented by T_{25}, the same time step that fishhook becomes a Medium risk; consequently, these alternatives could reduce the risk of adverse impacts due to the fishhook waterflea becoming established to a provide for a Low risk throughout 50 years for this ANS.

Table 4.3 tabulates the results of this evaluation. The risk assessments were performed based on the currently published ANS distributions. The information regarding current ANS distributions consisted of the most recently published species surveys (some of which are quite dated) as well as information gathered directly from personal communication with researchers of these species. For some ANS, there is considerable uncertainty regarding their current distribution relative to the CAWS, as well as the potential that some ANS may already have entered the CAWS. This uncertainty arises from not knowing to what extent an ANS may have expanded its range since the most recent survey, and also from the fact that the surveys likely have not been conducted in all appropriate areas within and in the vicinity of the CAWS.

For example, the species that are rated at T_0 as having a Medium or High risk of adverse impacts through transfer and establishment in the newly invaded basin may already have transferred and established into the opposing basin. Targeted surveys to determine whether these species have already entered and/or passed through the CAWS and are now established in the newly invaded basins would inform future alternative analysis. Once the targeted surveys are completed, the GLMRIS Team would revisit the risk assessment for those species. If it has been determined that a species is already established in both basins, the species would be removed from consideration for GLMRIS Alternatives.

Table 4.3 Alternatives That Maintain the ANS Risk Rating at Low throughout the 50 Year Period of Analysis[a]

Alternatives That Maintain the ANS Risk Rating at Low throughout the 50 Year Period of Analysis						
Species	Without Project Conditions		Nonstructural Alternative	Structural Alternatives		
	Risk Rating	Time Step		Technology Alternative with a Buffer Zone[b]	Two Hybrid Alternatives and Technology w/o Buffer Alternative[b]	Lakefront and Mid-System Hydrologic Separation Alternatives[b]
			T_0	T_{10}	T_{25}	T_{25}
MR Basin						
Silver carp	M	T_{25}		X	X	X
Bighead carp	M	T_{25}		X	X	X
Scud	M	T_0				
GL Basin						
Grass kelp	M	T_{10}	X	X[c]	X[c]	X[c]
Red algae	M	T_0				
Diatom	M	T_0				
Fishhook waterflea	M	T_{25}				X
Bloody red shrimp	H	T_0				
Three spine stickleback	M	T_0				
Ruffe	M	T_{50}		X	X	X
Tubenose goby	M	T_{10}		X	X[d]	X[d]
Reed sweet grass	M	T_{50}	X	X[c]	X[c]	X[c]
Viral Hemorrhagic Septicemia	M	T_0				

M = Medium Risk Rating; H = High Risk Rating.

T_0 = Potential for establishment based on the current distribution of the ANS;

T_{10} = Potential for establishment 10 years from the present time;

T_{25} = Potential for establishment 25 years from the present time; and

T_{50} = Potential for establishment 50 years from now.

[a] See With Project Risk Assessments in Appendix C for more information. Additionally, see alternative analysis contained in Chapter 3 for a discussion of impacts due to project alternatives.

[b] Nonstructural measures are an integral component to each of the structural alternatives.

[c] The nonstructural measures are expected to control the species' arrival to the CAWS and provide for a Low risk rating over the 50 year period. The structural alternatives include nonstructural measures; consequently, even though the structural alternatives are implemented by T_{10} or T_{25}, they provide for Low risk over the entire 50-year period.

[d] The nonstructural measures are expected to maintain a Low risk level for this species at least through T_{10} but not beyond T_{25}. Structural alternatives include nonstructural measures; consequently, structural alternatives implemented by T_{25} provide for Low risk over the entire 50-year period.

The results of this time-sensitive analysis indicate that, generally, nonstructural alternatives are effective for species that are of limited distribution and abundance and whose populations are distant from the CAWS pathway. For example, nonstructural measures such as public education, monitoring, and use of aquatic herbicides are expected to delay or control the arrival of some ANS, such as the grass kelp and reed sweet grass, to the CAWS. Additionally, the implementation of ballast water management in areas where the tubenose goby is known to be established is expected to slow its arrival to the CAWS. Implementation of nonstructural measures could also slow the potential passage of some ANS through the CAWS.

In general, the structural components of the following alternatives — Control Technology without a Buffer Zone (Flow Bypass), Control Technology with a Buffer Zone, Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone (Hybrid Cal-Sag Open) and the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone (Hybrid CSSC Open) — would not be effective against the interbasin transfer of those ANS that foul hulls or temporarily attach to vessels. However, as noted in the Table 4.3, because each Alternative includes nonstructural measures, the nonstructural components of those Alternatives would reduce the risk of grass kelp and reed sweet grass, even though they are hull foulers. In developing these Alternatives, measures to address hull fouling and temporary vessel attachment would need to be further explored.

The hydrologic separation alternatives generally would control the transfer of all GLMRIS High and Medium risk species through the CAWS aquatic pathway, as long as these alternatives are constructed prior to the species transferring through the CAWS and establishing in the newly invaded basin. These alternatives could control the transfer of future ANS through the CAWS aquatic pathway except under the most extreme storm events (i.e., exceeding the 0.2% ACE events).

Please note that for risks that rise, for example from a low to a medium, in future time periods, uncertainty exists as to when that increase may occur. For example, a low risk at T_{10} that is assessed to be a medium risk by T_{25} may become a medium risk at any time after T_{10}. The dynamic nature of ANS with regard to their movement and abundance, as well as the limited knowledge of the underlying factors that lead some ANS to undergo range expansion, limit our ability to predict the time at which the probability of passage and subsequent risk may actually change. Future time period risk ratings are, to an extent, predictive ratings. These ratings are subject to both uncertainty and intervention and so future risk levels may differ from what is estimated. Prevention is the first line of defense for minimizing the introduction, spread, and establishment of ANS (National Invasive Species Council 2008). Therefore, the time period at which risks are indicated to become at least medium must be viewed with caution when considering when an alternative should be implemented.

In addition to the 13 species that are the focal point of this report, it is important to note that future ANS species may present medium to high risks. The GLMRIS alternatives may also be effective against future ANS that have similar ecological traits and would utilize similar transport mechanisms to enter and pass through the CAWS.

4.3 Summary of Findings

The transfer of ANS between basins could result in significant environmental, economic, political, and social consequences. In recent years, successful invasions of aquatic nuisance species (ANS) have severely impacted the economic and environmental resources of the Great Lakes and Mississippi River basins.

The GLMRIS Report presents “a range of options and technologies available” to prevent the transfer of ANS between the basins, and does not include a recommended plan. Consistent with the study constraints outlined in Section 1.7 of the Report, the alternatives presented do not address ANS transfer via non-aquatic pathways. Nor do the alternatives address ANS transfer from beyond the study area boundaries, i.e., transfer via Canada, the St. Lawrence Seaway, or the Gulf of Mexico.

Each of the alternatives presented in Chapter 3 and summarized in Table 4.2 are feasible and designed to meet the objectives stated in Section 1.6 of the Report. Each alternative presents a different strategy to prevent ANS transfer between the Great Lakes and Mississippi River basins through the CAWS aquatic pathways. This report includes general information on effectiveness, impacts, and costs for each type of alternative that should be considered by a decision-maker.

Study evaluation processes were consistent across all alternatives. Staged implementation and associated incremental risk reduction were not specifically considered by the GLMRIS Team for the GLMRIS Report, but could be beneficial in future analyses. For some alternatives, there are common plan elements that could provide flexibility during implementation to modify the original alternative to another alternative under certain circumstances. For example, the Technology with an ANS Buffer Zone could be staged for the implementation of ANS Control measures at Brandon Road (IL) as the first system control point. Implementation of these ANS Control measures at Brandon Road (IL) could evolve from the Technology with ANS Buffer Zone Alternative into the Mid-System Separation CSSC Open Alternative or the Mid-System Cal-Sag Open Alternative.

Technology with an ANS Buffer Zone measures at Brandon Road (IL) would allow for the timely evaluation of the implementability and efficacy of the measures in this plan, allowing minimal deviation from achievement of its ANS risk reduction in either the total implementation of this alternative or the evolution into either of the two identified hybrid alternatives.

Some alternatives may present incidental benefits to the study area apart from preventing ANS transfer. For example, under the Lakefront Hydrologic Separation Alternative, stormwater and CSOs would no longer be able to backflow to Lake Michigan, likely reducing beach closures and contaminant loading to Lake Michigan. However, in order to realize these incidental benefits, it is likely that substantial investments in infrastructure would be required before structural elements of various alternatives could be implemented.

Some risks and uncertainties are inherent in many of the complex concepts discussed in the GLMRIS Report. The costs and implementation schedules presented in the GLMRIS Report are commensurate with the five percent level of detail in design for each alternative. At the level of detail presented in the GLMRIS Report, some assumptions were made for all the alternatives to reach this comparable level of detail. Each cost and implementation schedule estimate assumes that: the necessary funding to fully efficiently complete the alternative will be provided annually; and the necessary Real Estate and necessary permits to implement the alternative can be acquired and obtained in a timely manner. These risks cannot be quantified at this time and could have impacts upon the costs and implementation schedules for each alternative in the GLMRIS Report.

There also is a risk that one or more presently identified ANS may transfer between the basins prior to alternative implementation, but these alternatives may be effective at preventing the transfer of future ANS.

After alternative implementation, there are still residual risks of adverse impacts due to ANS transfer and establishment for each GLMRIS Alternative. First, a “Low” risk rating does not indicate that “No” risk remains, but instead indicates that a low level of risk remains after alternative implementation. For instance, after implementation of the Lakefront Hydrologic Separation Alternative the tubenose goby received a "Low" risk rating because the physical barriers are constrained by the storm size they were designed to withhold. Second, residual risk of transfer remains along the Great Lakes and Mississippi River basin divide outside of the CAWS. Lastly, regardless of the implementation of any alternative, residual risk of interbasin transfer through non-aquatic pathways remains. The GLMRIS Alternatives address, 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.

In addition to a risk rating, each alternative has an uncertainty rating and discussion of the uncertainty associated with the rating. The alternatives presented in this report include measures or technologies, such as the GLMRIS Lock, which are at a conceptual level of design but use existing process engineering concepts applied to control ANS. While the technologies incorporated into the alternatives are known, the combination of technologies and application of the technologies in some instances are non-traditional. For instance, UV is frequently used for water treatment plants, and the flushing mechanism concept in the GLMRIS Lock is used in many different types of water treatment. However, these technologies have not previously been applied to control the transfer of ANS. In addition, while USACE currently operates an electric barrier, there are ongoing studies associated with improving its efficacy.

Absent further direction and pending the availability of funding, the engagement of stakeholders will be a critical next step to try to identify and build consensus toward a collaborative path forward for GLMRIS. The completion of additional detailed investigations into one or more of the conceptual alternatives presented in this document would refine current assumptions and allow the team to fill gaps in critical datasets. Future study efforts to recommend a specific alternative would need to include state, agency, and public review/comment, as well as completion of statutory requirements including Model Certification and Independent External Peer Review. Portions of alternatives that do not fall within USACE mission areas may be referred to other entities for their consideration.

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Chapter 6 List of Acronyms

ACE	annual chance exceedance
ANS	aquatic nuisance species
ANSTP	aquatic nuisance species treatment plant
ACRCC	Asian Carp Regional Coordination Council
AOC	Areas of Concern
AWQM	Ambient Water Quality Monitoring
BLF	base level flood
BAT	Best Technology Available
BOD	Biochemical Oxygen Demand
Bubbly Creek	South Fork of the South Branch of the Chicago River
(Burns) SBH	(Burns) Small Boat Harbor
CAA	Clean Air Act
Cal-Sag	Calumet-Saganashkee Channel
CAWS	Chicago Area Waterway System
CDF	confined dredged material disposal facility
CECs	Contaminants of Emerging Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CI or Cities Initiative	Great Lakes and St. Lawrence Cities Initiative
CRCW	Chicago River Controlling Works
CSO	Combined Sewer Overflow
CSSC	Chicago Sanitary & Ship Canal
CUP	Chicagoland Underflow Project
CWA	Clean Water Act
CWIS	Cooling water intake structures
DO	dissolved oxygen
DMP	Decision Management Plan
EEAD	equivalent expected annual damages
EPA	U.S. Environmental Protection Agency
ESC	Executive Steering Committee
FEMA	Federal Emergency Management Agency
FRM	flood risk management
FWOP	future without action plan (no action)
FWP	future with action plan (alternative)
GL/MR	The Great Lakes/Mississippi River
GLB	Great Lakes Basin
GLC	Great Lakes Commission
GLFC	Great Lakes Fishery Commission
GLMRIS	Great Lakes Mississippi River Interbasin Study
GRTS	USEPA Grants Reporting and Tracking System
HEC-HMS	Hydrologic Modeling System

H&H	Hydrologic and Hydraulic
HSPF	Hydrologic Simulation Program FORTRAN
HTRW	Hazardous, Toxic, and Radioactive Waste
I&M	Illinois and Michigan Canal
IL	Illinois
ILDNR	Illinois Department of Natural Resources
ILEPA	Illinois Environmental Protection Agency
IN	Indiana
INDEM	Indiana Department of Environmental Management
INDNR	Indiana Department of Natural Resources
IPCB	Illinois Pollution Control Board
L/D	Lock and Dam
LDPR	Lower Des Plaines River
LMMP	Lake Michigan Monitoring Program
LRR	Limited Reevalutation Report
LUSTs	leaking underground storage tanks
MAP-2 1	Moving Ahead for Progress in the 21st Century Act
MRB	Mississippi River Basin
MRP	monitoring and response plan
MWRD	see MWRDGC
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
MRRWG	Monitoring and Rapid Response Work Group
NAAQS	National Ambient Air Quality Standard
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NPE	no prior establishment
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
O&M	Operation and maintenance
OMRR&R	operation, maintenance, repair, replacement and rehabilitation
PAHs	polyaromatic hydrocarbons
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PDT	Project Delivery Team
PED	project preconstruction engineering and design
PM	Project Manager
RAPS	Racine Avenue Pump Station
RCRA	USEPA Resource Conservation and Recovery Act
RECs	Recognized Environmental Conditions
RM	river miles
SCALP	Special Contributing Area Loading Program

SEM/AVS	Simultaneously Extracted Metals/Acid Volatile Sulfide
SVOCs	semi-volatile organic compounds
SWMM	Storm Water Management Model
TARP	Tunnel and Reservoir Plan
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act
UMR	Upper Mississippi River
USACE	U.S. Army Corps of Engineers
USCG	United States Coast Guard
WQ	Water Quality
WQS	Water Quality Standards
WRDA	Water Resource Development Act

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