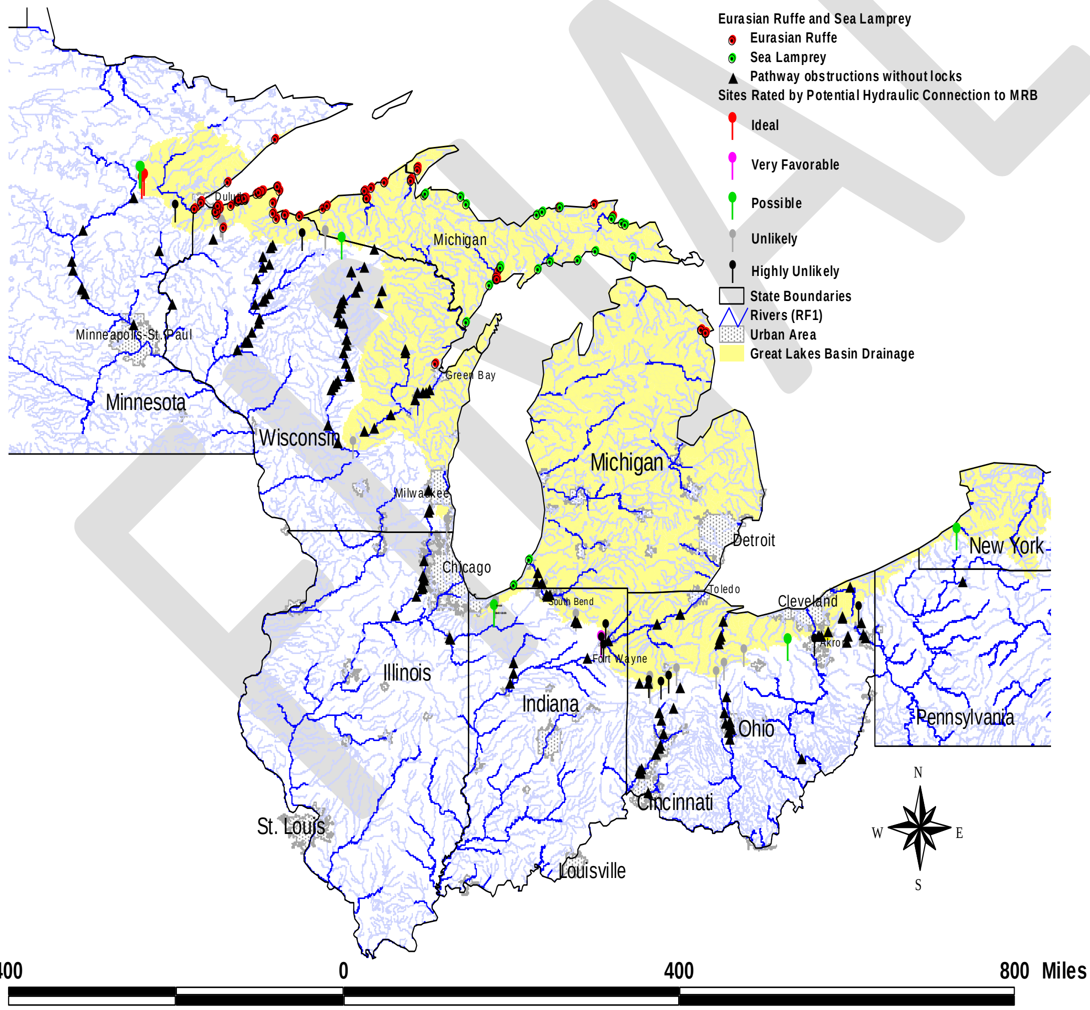
Great Lakes and Mississippi River Interbasin Study

Other Pathways Preliminary Risk Characterization

United States Army Corps of Engineers

Great Lakes and Ohio River Division



November 9, 2010

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Executive Summary

This preliminary risk characterization is an important component of a Congressionally authorized feasibility study, the Great Lakes and Mississippi River Interbasin Study (GLMRIS). GLMRIS is being led by the U.S. Army Corps of Engineers (USACE) and supported by state and other Federal resource agencies. This risk characterization describes the threats posed by the potential for aquatic nuisance species (ANS) to use surface water pathways to cross the drainage divide that separates surface water flow into the Great Lakes from surface water flow into the Mississippi River basin. The divide extends from New York to Minnesota. This report evaluates pathways other than the Chicago Area Waterway System (CAWS) which will be addressed in a separate study. The objectives of this preliminary risk characterization were to:

- Compile an inventory of all locations, outside of the CAWS, where a surface water connection exists or may form between the Great Lakes and Mississippi River Basins;
- Characterize the relative risks of ANS transfer across the basin divide and identify locations where a significant risk for interbasin transfer of ANS exists; and
- Provide detailed recommendations for prioritizing future actions at the locations deemed to pose significant risks.

Because of the size of the geographic area of consideration, the number and variety of ANS types to be considered, and the need to expeditiously identify and disseminate the information to stakeholders, the following assumptions formed the basis of the study plan.

- The compilation, review and analysis of readily available information would be sufficient to accomplish the project objective of preliminary risk characterization.
- Existing experts in hydrology and biology with local, state and Federal resource agencies would be the best available sources for relevant information and expertise.
- Stakeholder organizations with vested interests in preventing ANS migration into or out of the Great Lakes would contribute expertise and be collaborative partners.

In order to carry out the risk characterization, teams of experts in hydrology and invasive species were rapidly formed. The teams included members of the United States Geological Survey (USGS); U.S. Fish and Wildlife Service (USFWS); Natural Resources Conservation Service (NRCS); National Oceanic and Atmospheric Administration (NOAA); the Departments for Natural Resources from Minnesota, Wisconsin, Indiana, Ohio and the New York Department of Environmental Conservation; and the Great Lakes Fishery Commission. Experts with state-specific and local knowledge were critical to the effort.

Upon collection and evaluation of data, the hydrology team compiled an inventory of 36 possible aquatic pathways. Five of the locations were later deemed to pose a very remote possibility for the formation of a continuous surface water pathway across the Great Lakes Basin divide; therefore, they were dropped from further consideration and were not assigned Hydrological Risk Ratings. The results of the hydrologic characterization were presented to the team of ANS experts from the state natural resource agencies, USGS, USFWS, NOAA and USACE. The ANS experts used the hydrology characterization, ANS Fact Sheets, and distribution maps for the species of most concern to formulate opinions on the relative risk of ANS migration through each pathway location in both directions (into the Great Lakes and out of the Great Lakes). The individual ratings from the ANS experts were compiled and an ANS Transfer Risk rating was assigned to each of 31 locations for both directions, into the Great Lakes and into the Mississippi River or one of its tributaries.

Due to uncertainties associated with the available hydrologic and species information, the team carefully scrutinized available information to prevent dismissal of any location from further consideration if there was a reasonable possibility of ANS migration. Several key conclusions were reached.

- A total of 18 locations in the study area were assigned a Medium, High or Acute ANS Transfer Risk rating for species migration into or out of the Great Lakes Basin or both. The other 13 locations were all assigned Low ANS Transfer Risk ratings in both directions. The Low rating was defined in the criteria as insignificant risk and a basis for

no further consideration of the location unless the conditions change or new information is discovered to indicate otherwise.

- One location was singled out as the greatest concern, the Eagle Marsh site in Fort Wayne, IN. Interim and long-term risk reduction measures were deemed necessary to mitigate potentially imminent risk of Asian carp reaching Lake Erie through the aquatic pathway that develops at this location during a significant storm event.
- The Long Lake connection to the Ohio and Erie Canal in Summit County, OH south of Akron, OH, and the Libby Branch of the Swan River large wetlands complex in Itasca and Aitkin County, MN are also identified as High Risk locations for ANS interbasin transfer.
- With the exception of the Eagle Marsh site in Fort Wayne, the other 17 locations deemed to pose significant risk of ANS transfer require a more detailed risk characterization prior to drawing conclusions or recommendations for risk reduction measures.

This preliminary risk characterization offers seven general recommendations and a set of location specific recommendations for each location deemed to pose a Medium, High or Acute risk of ANS transfer across the Great Lakes Basin divide. Eagle Marsh in Fort Wayne, IN was identified as the highest priority location. The stakeholder team identified an interim risk reduction measure in July 2010 (construction of a mesh barrier to prevent migration of adult Asian carp into the Lake Erie drainage basin), and the Indiana DNR completed construction of the barrier prior to October 2010. Also, the USACE has initiated preparation of an expedited USACE planning study for the Eagle Marsh to identify viable long-term risk reduction measures and recommend an optimal risk reduction measure plan. That study is scheduled to be completed in less than one year. Actual implementation of the recommended measure will require identification of an appropriate Congressional authority and funding. Furthermore, most USACE authorities available for this type of project require identification of a local cost-sharing sponsor that is responsible for real estate acquisition. USACE would assist the local sponsor through design and construction, and then turn the completed facility over to the sponsor to operate and maintain.

This report recommends continued collaboration with the states and other stakeholders to complete the risk characterization at the other 17 locations and to identify measures that can be implemented at the local or state level to mitigate any significant risk at these locations. In addition, the report recommends the USACE and state DNRs develop policies and procedures to weigh the benefits of removing dams and installing fish ladders at existing dams against the increased risk of ANS migration impacts. It also recommends a more detailed evaluation of the level of ANS impedance at each dam on the streams connecting to the Great Lakes and to the Mississippi River or Ohio River from the 17 locations deemed to pose significant risk. Lastly, the report prioritizes the 17 locations based on ANS transfer risks to facilitate effective and efficient risk characterization in a resource constrained environment.

The completion of this preliminary risk characterization illustrates how the complimentary efforts of local, state and federal organizations created a synergy to rapidly accomplish a large and technically challenging task. Completion of the GLMRIS and the ultimate management of invasive species will require similarly coordinated actions at the local, state and federal levels to identify likely invasion pathways and measures to monitor, manage and control those pathways, whether by efforts to hydrologically separate the basins, application of institutional controls, increased public education and/or active eradication programs. USACE intends to use this document as the foundation for a collaborative effort among stakeholder organizations to most effectively and efficiently prevent the interbasin transfer of ANS between the Great Lakes and the Mississippi River and its tributaries.

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Date

John W. Peabody

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1 Introduction

This report is an important component of a Congressionally authorized feasibility study known as the Great Lakes and Mississippi River Interbasin Study (GLMRIS), which is being led by the U.S. Army Corps of Engineers (USACE) and supported by an array of state and Federal agencies. The report summarizes the results of a preliminary risk characterization regarding the threats posed by the potential for Aquatic Nuisance Species (ANS) to use a surface water pathway to cross the drainage divide that separates surface water flow into the Great Lakes from surface water flow into the Mississippi River basin. The drainage divide is an irregular line extending from New York to Minnesota, and it is hereafter referred to as the Divide.

The USACE Great Lakes and Ohio River Division designated the Chicago District as the Project Management District for the GLMRIS. In August 2010 the Chicago District introduced a draft Project Management Plan (PMP) for the GLMRIS to an interagency group of Stakeholders. That PMP splits the study into two distinct focus areas.

Focus Area 1 - the Chicago Area Waterways, which includes the Illinois and Des Plaines Rivers, Chicago Sanitary and Ship Canal, I&M Canal, Cal Sag Canal, Chicago River and the Grand Calumet and Little Calumet Rivers. This report does not address Focus Area 1.

Focus Area 2 is the subject of this report. It considers all the other potential aquatic pathways that exist or may form across the drainage divide between the Great Lakes and the Mississippi River (including the Ohio River and tributaries) Basins within the United States.

1.1 Purpose

As a preliminary effort, the findings, conclusions and recommendations in this report are subject to refinement and change as more information becomes available and knowledge is gained. The objective of this preliminary risk characterization was to accomplish the four

primary tasks below, and complete a draft report documenting the results within a 60 day period:

- Compile an inventory of all potential locations within Focus Area 2 where a surface water connection exists or has a reasonable probability of forming between the Great Lakes and Mississippi River Basins;
- Characterize the relative risks of ANS transfer across the basin divide at each of the locations identified;
- Expeditiously identify locations where a significant risk for interbasin transfer of ANS exists; and
- Provide detailed recommendations for prioritizing future actions within the GLMRIS PMP at the locations within Focus Area 2 deemed to pose significant risks.

1.2 Organization

To accomplish the goals of the project, the study was broken into three distinct components,

- Develop an inventory of potential surface water connection locations and an initial characterization of the hydrological conditions that may lead to the development of a surface water pathway across the Divide at each location,
- Develop an inventory and initial characterization of ANS interbasin transfer risks, and
- Perform an integrated analysis and expert elicitation of the risks of interbasin transfer through each potentially significant surface water pathway in both directions across the Divide.

The Main Report is comprised of six Sections. Section 2 defines the geographic limits of the study and the ANS to be considered in the risk characterization. Section 3 is a discussion of the methods and sources of information used, and Section 4 presents the results of the preliminary risk characterization. Sections 5 and 6 provide general and location specific conclusions and recommendations. A multi-disciplinary team of individual water resource scientists and engineers from a broad array of Federal, state, local and non-governmental

organizations was formed to complete the risk characterization, and the team was divided into three sub teams, Hydrology and Hydraulics (H&H), Aquatic Nuisance Species (ANS), and Planning.

There are eight Appendices to this report. Appendix A is the study plan that was used to guide execution of this preliminary risk characterization. A copy of the implementation guidance provided by Headquarters USACE for this project is included as Appendix B. Appendices C through G present illustrative figures, summaries of relevant and available information and notes for the hydrologic evaluation conducted for each of the sites evaluated on a state by state basis. Appendix C contains the information on the sites evaluated in Minnesota, and Appendix D contains the same for Wisconsin, as does Appendix E for Indiana, Appendix F for Ohio and Appendix G for New York. The Divide through the Commonwealth of Pennsylvania was evaluated, but no potentially viable surface water connections were identified within the state. Appendix H contains individual Fact Sheets from the USGS database for Non-indigenous Aquatic Species that were identified as species of concern to the GLMRIS for this preliminary risk characterization and distribution maps of the ANS of most concern by taxonomic group.

1.3 Authorization

The GLMRIS was authorized in Section 3061(d) of the Water Resources Development Act of 2007 (WRDA 2007), which prescribes the following authority to the Secretary of the Army and the U.S. Army Corps of Engineers (USACE).

> *"(d) 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."*

The USACE headquarters issued specific guidance to the Great Lakes and Ohio River Division Commander for execution of the project, including the following general direction to, "…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."

USACE Engineer Regulation ER 1105-2-100, Planning Guidance, provides the overall process and procedures the Corps of Engineers is required to follow in preparing feasibility studies like the GLMRIS, which are designed to support decision documents for Federal actions. An integral component of the USACE planning process is compliance with the National Environmental Policy Act (NEPA) and the preparation of an Environmental Assessment or Environmental Impact Statement and public involvement and input into the final decision document necessary to support a significant action by the Federal government.

The six step USACE planning process is an iterative process designed to assure proper consideration of all appropriate information and the necessary documentation is provided to Federal decision-makers prior to committing the Federal government to any significant action. This preliminary risk characterization is focused on the first two steps as they relate to Focus Area 2 of GLMRIS. The following internet address may be used to access USACE Engineer Regulation ER 1105-2-100, Planning Guidance to learn more about the requirements and procedures to implement the six step USACE planning process, *140.194.76.129/publications/eng-regs/**er1105-2-100**/toc.htm.*

- 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

1.4 Problem Identification

This report addresses the problem of Aquatic Nuisance Species (ANS) invading, via surface-water pathways, the Great Lakes basin from the Mississippi River basin and vice versa.

> **ANS** is defined by the Aquatic Nuisance Species Task Force as "… nonindigenous species that threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters."

> **Nonindigenous aquatic species** is defined by The U. S. Geological Survey (USGS) Nonindigenous Aquatic Species (NAS) information resource (http://nas.er.usgs.gov/about/default.aspx) as "…a species that enters a body of water or aquatic ecosystem outside of its historic or native range."

Adjectives such as nonindigenous, nuisance, invasive, alien and exotic are commonly used interchangeably in the biological invasion literature to describe undesirable species. Based on discussions between the USACE, USGS and the U.S. Fish and Wildlife Service (USFWS) the following definitions were established for the purposes of the GLMRIS. All non-indigenous aquatic species, (per the USGS definition above), that are present in the Great Lakes but not known to be present in the Mississippi River and its tributaries are defined as ANS of concern. Likewise, all non-indigenous aquatic species present in the Mississippi River or its tributaries but not known to be present in the Great Lakes are defined as ANS of concern for the GLMRIS. Therefore, the term ANS is synonymous with the term non-indigenous aquatic species in this report.

Although, there are many vectors by which ANS could and do move between basins, the GLMRIS authority is limited to a study of the range of options and technologies available to prevent the spread of ANS between the Great Lakes and Mississippi River Basins through an aquatic pathway.

ANS invasions can produce severe economic impacts (Leigh 1998), ecological impacts (including extinctions, Ricciardi and Rasmussen 1999) or both (OTA 1993, Dettmers et al. 2008). More than 180 aquatic species have invaded and become established in the Laurentian Great

Lakes since 1840 (Ricciardi 2006) making this one of the most invaded ecosystems on the planet (Vander Zanden et al. 2010). Many of these species invaded the Great Lakes through ballast water releases of transoceanic ships originating from wide ranging ports of call (Holeck et al. 2004). Because a large number of transcontinental ANS invaders have become established in the Great Lakes this ecosystem has become, in many cases, a staging area for further invasion of continental waters (Vander Zanden et al. 2010).

In fact, there are numerous organisms including bacteria and viruses, algae, plants, invertebrates, fish, and mammals that are threatening to invade susceptible ecosystems. Once established in a new ecosystem many of these species can produce negative impacts either on the ecology of the system, the economy or both. There are several well recognized mechanisms that aid or facilitate the rapid distribution of ANS. These include human facilitated and natural vectors of transport.

ANS such as the Asian carp in the Mississippi River basin threaten to invade the Great Lakes basin via aquatic pathways (Hill and Pegg 2008). The best known of these pathways is the Chicago Sanitary and Ship Canal (CSSC), part of the Chicago Area Waterway System (CAWS), which comprise Focus Area 1. The bighead carp have extended their open-water range in the last 25 years from the first collection in the Arkansas River in 1986, to being distributed throughout most of the Mississippi River system. The Silver carp range is almost as extensive as the Bighead carp, and a report published in 2008 indicated that the La Grange Pool of the Illinois River, which is downstream of the CAWS, "…may contain the greatest ambient densities of wild silver carp in the world." (Sass 2008).

While the CSSC is a primary concern to the GLMRIS, many other potential hydraulic connections exist along the Divide between New York and Minnesota. Successfully meeting the intent of the Congressional Authorization for the GLMRIS requires a thorough evaluation of all potential surface water pathways that exist or may form across the Divide. Likewise, while Asian carp are the species of most significant concern today, the ecological and economic impacts already caused by them and other aquatic invaders such as the zebra mussel illustrate the need for an aquatic resource management approach that attempts to predict the identity

and impact of future biological invaders (Ricciardi and Rasmussen 1998). This preliminary risk characterization is intended to inform the development of just such an approach.

1.5 Study Team

Consistent with the goals of the GLMRIS stakeholder conference held on 3-4 August, 2010, an interdisciplinary team of senior experts in hydrology, ANS and Civil Works planning was formed from an array of Great Lakes stakeholder organizations to conduct the preliminary risk characterization for the GLMRIS Focus Area 2. The team was tasked with gathering and evaluating a very large amount of available information, developing an ANS Risk Rating for each potential surface water pathway based on expert opinion, and documenting the results in a draft report in 60 days.

Because of the size of the geographic area of consideration, the number and variety of ANS types to be considered, and the need to expeditiously identify and disseminate the information to stakeholders, the following assumptions formed the basis of the study plan.

- The compilation, review and analysis of readily available information would be sufficient to accomplish the project objective of preliminary risk characterization.
- Existing experts in hydrology and biology with the local, state and Federal resource agencies would be the best available sources for procuring and contributing relevant information and expertise.
- The local, state and federal agencies responsible for water resource management have a vested interest in preventing ANS migration across the drainage divide into or out of the Great Lakes and would contribute expertise and be collaborative partners.

The United States Geological Survey (USGS); U.S. Fish and Wildlife Service (USFWS); Natural Resources Conservation Service (NRCS); National Oceanic and Atmospheric Administration (NOAA); the Departments for Natural Resources from Minnesota, Wisconsin, Indiana, Ohio and the New York Department of Environmental Conservation; the Great Lakes

Fishery Commission and others contributed information and expertise to identify potential aquatic pathways and complete the risk characterization. Over 60 talented professionals from these organizations directly participated in the information gathering and assessment in an open and collaborative manner.

A Hydraulics and Hydrology (H&H) Team was formed and divided into sub teams, generally by state. Two USACE representatives (hydrologist and/or civil engineer specializing in H&H) were placed on each team, one from a Great Lakes District (Chicago, Detroit or Buffalo) and one from the respective Mississippi or Ohio River District (Saint Paul, Rock Island, Louisville, Huntington or Pittsburgh) at each potential surface-water connection along the Divide. One of the USACE representatives at each location was appointed as the Team Leader for that location, and was responsible for soliciting and coordinating the input from the rest of the H&H team for that location.

The USGS provided at least one individual from their respective Water Science Centers in each state to participate on the H&H Teams within each state. Likewise, the Department of Natural Resources (DNR) in each state was contacted and in nearly all cases, the state DNR was able (Department of Environmental Conservation in New York and Fish and Boat Commission in Pennsylvania) to provide a representative to participate on each H&H Team to support the fast-track schedule for this preliminary ANS risk characterization. In several locations, local water management agency representatives also provided input into the hydrologic characterization.

The USFWS helped define the scope of the ANS to be considered for this study by developing a list of non-indigenous aquatic species in the Great Lakes not yet observed in the Mississippi River or its tributaries, and a list of non-indigenous aquatic species in the Mississippi River or its tributaries not yet observed in the Great Lakes. The USGS prepared illustrative maps indicating the spatial distribution of ANS of most significant concern to aid the team in characterizing ANS transfer risks at each potentially significant surface water connection identified, and the USGS database was the source for individual ANS fact sheets used in the risk characterization.

2 Study Area

This study of GLMRIS Focus Area 2 includes an examination of the potential surface-water connections along the Divide, through parts of New York, Pennsylvania, Ohio, Indiana, Wisconsin and Minnesota. Focus Area 2 encompasses all natural and man-made aquatic pathways and hydraulic connections that exist or may form between the Great Lakes and Mississippi River basins except for the Chicago Area Waterways. The focus of this investigation is the Divide which delineates the Great Lakes Basin drainage from the drainage of the Mississippi River basin. The Divide lies within the states of New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, and Minnesota (Figure 1).

A shaded relief map of the subject drainage basins, shown with the 2-digit Hydrologic Unit Codes (HUCs), is provided in Figure 2. The bold red line delineates the boundary between the Great Lakes Basin (HUC = 04) and the Mississippi River Basin (HUC = 07) and between the Great Lakes Basin (HUC = 04) and the Ohio River Basin (HUC = 05). This figure depicts the topography along the divide and identifies the drainage basins adjacent to the divide. The ends of the bold red line demarcating the Divide are referred to as triple points, because there are 3 first order drainage basins adjacent to the point. For instance, the point at the end of the bold red line in New York has the Chesapeake Bay Basin (HUC = 02) to the east, the Great Lakes Basin to the north (HUC = 04) and the Ohio River Basin (HUC = 05) to the east. Likewise, the point at the end of the bold red line in Figure 2 in Minnesota demarcates the boundary between the Hudson Bay Basin (HUC = 09), Mississippi River Basin (HUC = 07) and the Great Lakes Basin (HUC = 04).

The USGS established the HUC as a nested hierarchal system for subdividing large river basins into progressively smaller drainage areas, and it was a primary tool used to define the location of the Divide and the hydrologic conditions in the vicinity of potential surface water pathways across the Divide.

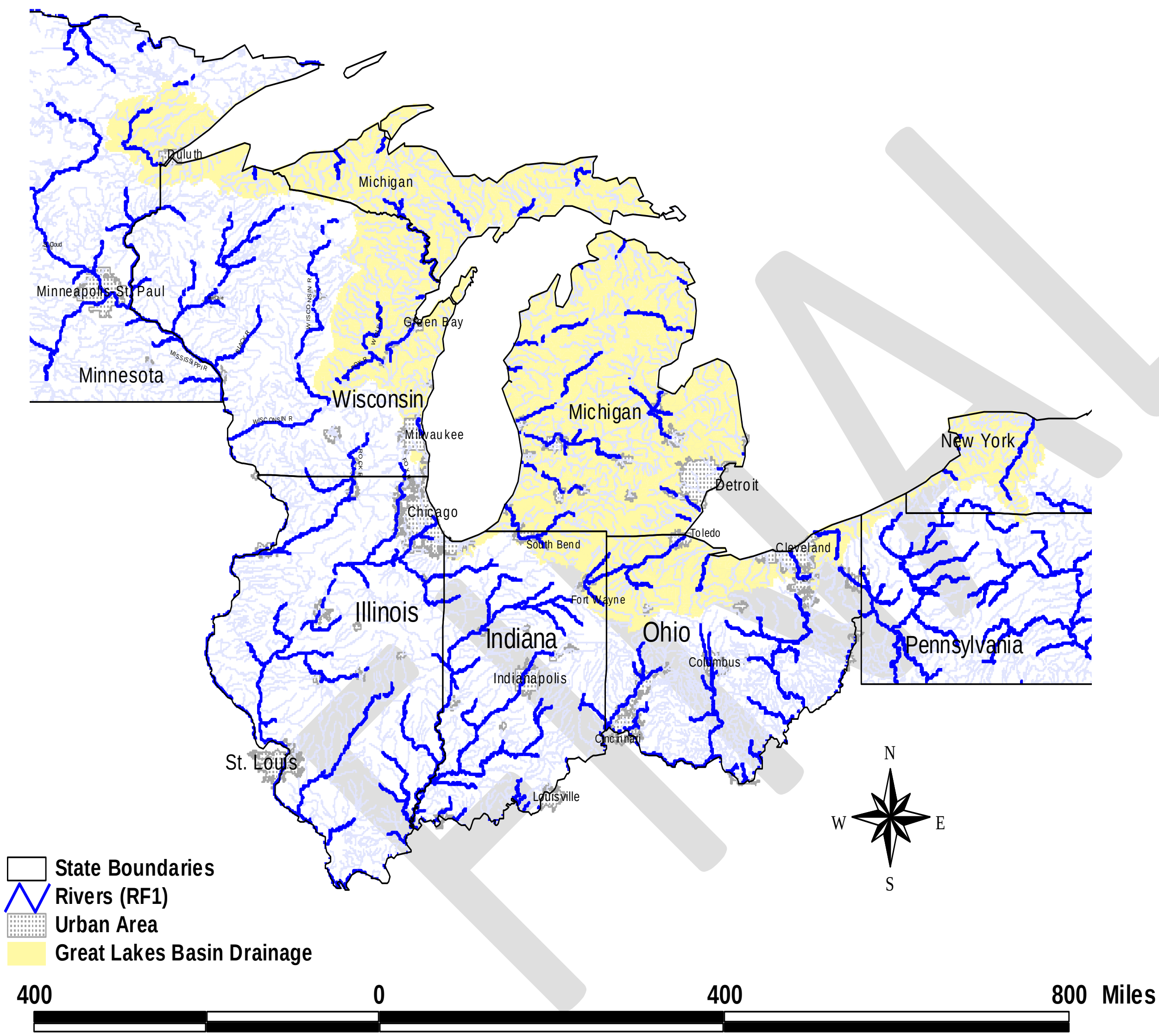

Figure 1. Great Lakes and Mississippi River Interbasin Study – Focus Area 2 Study Limits.


09
04
Great Lake Basin
07
Upper Mississippi
Basin
02
05
Ohio River Basin
11
Courtesy of the USGS
08
06
03

Figure 2. Shaded Relief Map Depicting the Great Lakes and the Mississippi and Ohio River Basins from the USGS National Map.

Not included in the study area are portions along the Great Lakes Basin where water on the other side of the divide flows to a basin other than the Mississippi or Ohio River Basins. Also, both basins have open aquatic pathways to the Atlantic Ocean used for international commercial navigation, the Great Lakes via the Saint Lawrence Seaway and the Mississippi River Basin via the port of New Orleans and the Lock and Dam facilities on the Mississippi and Ohio Rivers upstream of their confluence. Evaluation of those pathways is beyond the scope of the GLMRIS.

The other aspect of the study area involves target species. While Bighead and Silver carp are two of the most significant ANS of concern, the GLMRIS has a broad scope that requires evaluation of the risks posed by all non-indigenous aquatic species within the Great Lakes and Mississippi River Basin, in both directions. This requires careful consideration of the broad array of ANS, including plants, algae, mollusk, bacteria and viruses, invertebrates and fish.

The USFWS helped define the scope of the study from a species perspective by developing and providing a list of non-indigenous aquatic species in the Great Lakes not yet observed in the Mississippi River or its tributaries, and a list of non-indigenous aquatic species in the Mississippi River or its tributaries not yet observed in the Great Lakes. These two lists are presented in Tables 1 and 2.

The risks posed by non-indigenous aquatic species known to be present in the Great Lakes were weighed relative to the likelihood and potential magnitude of impacts to threatened and endangered species and native species populations and habitat in the Mississippi and Ohio River Basin waterways. Likewise, the risks posed by non-indigenous aquatic species known to be present in the Mississippi and Ohio River Basin waterways were evaluated relative to the potential impacts to threatened and endangered species and native species populations and habitat in the Great Lakes.

Table 1. ANS in Mississippi River system, but not in Great Lakes.

	Scientific name	Common name
1	*Alternanthera philoxeroides*	alligator weed
2	*Ameiurus catus*	white catfish
3	*Botumus umbellatus*	flowering rush
4	*Channa argus*	northern snakehead
5	*Ctenopharyngodon idella*	grass carp
6	*Cyprinella lutrensis*	red shiner
7	*Eichhornia crassipes*	water hyacinth
8	*Hydrilla verticillata*	Hydrilla
9	*Hypophthalmichthys molitrix*	silver carp
10	*Hypophthalmichthys nobilis*	bighead carp
11	*Ludwigia peploides*	floating primrose willow
12	*Ludwigia uruguayensis*	Uruguayan primrosewillow
13	*Marsilea mutica*	Australian water clover
14	*Murdannia keisak*	Asian spiderwort
15	*Mylopharyngodon piceus*	black carp
16	*Myocastor coypus*	nutria
17	*Polygonum cuspidatum*	Japanese knotweed
18	*Quadrula apiculata*	southern mapleleaf mussel
19	*Salvinia spp.*	Salvinia
20	*Tamarix.spp.*	western salt cedar
21	*Triadica sebifera*	Chinese tallow tree

Table 2. ANS in Great Lakes but not in Mississippi River System.

	Scientific name	Common name		Scientific name	Common name		Scientific name	Common name
1	*Acanthostomum* sp.	digenean fluke	41	*Epilobium parviflorum*	small flowered hairy willow	81	*Potamothrix vejdovskyi*	oligochaete
2	*Acentropus niveus*	aquatic moth	42	*Eubosmina coregoni*	waterflea	82	*Proterorhinus marmoratus*	tubenose goby
3	*Acineta nitocrae*	suctorian	43	*Gammarus tigrinus*	amphipod	83	*Psammonobiotus communis*	testate amoeba
4	*Actinocyclus normanii form subsalsa*	diatom	44	*Gianius (Phallodrilus) aquaedulcis*	oligochaete	84	*Psammonobiotus linearis*	testate amoeba
5	*Aeromonas salmonicida*	furunculosis	45	*Gillia altilis*	snail	85	*Psammonobiotus dziwnowi*	testate amoeba
6	*Alopecurus geniculatus*	water foxtail	46	*Glugea hertwigi*	protozoan	86	*Puccinellia distans*	weeping alkali grass
7	*Apeltes quadracus*	fourspine stickleback	47	*Glyceria maxima*	reed sweet-grass	87	*Ranavirus* sp.	largemouth bass virus
8	*Argulus japonicas*	parasitic copepod	48	*Gymnocephalus cernuus*	Eurasian ruffe	88	*Renibacterium salmoninarum*	bacterial kidney disease
9	*Bangia atropurpurea*	red alga	49	*Hemimysis anomala*	bloody-red mysid	89	*Rhamnus frangula*	glossy buckthorn
10	*Biddulphia laevis*	diatom	50	*Heteropsyllus nr. nunni*	harpacticoid copepod	90	*Ripistes parasita*	oligochaete
11	*Bosmina maritime*	waterflea	51	*Hydrocharis morsus-ranae*	European frogbit	91	*Rumex obtusifolius*	bitter dock
12	*Branchiura sowerbyi*	oligochaete	52	*Hymenomonas roseola*	cocco-lithophorid alga	92	*Rumex longifolius*	yard dock
13	*Cabomba caroliniana*	fanwort	53	*Ichthyocotylurus pileatus*	digenean fluke	93	*Sagittaria montevidensis*	giant arrowhead
14	*Carex flacca*	sedge plant	54	*Impatiens glandulifera*	Indian balsam	94	*Salmincola lotae*	copepod
15	*Carex acutiformis*	swamp sedge	55	*Juncas inflexus*	rush	95	*Scardinius erythrophthalmus*	rudd
16	*Cercopagis pengoi*	fish-hook waterflea	56	*Juncus gerardii*	black-grass rush	96	*Schizopera borutzkyi*	harpacticoid copepod
17	*Chaetoceros hohnii*	diatom	57	*Juncus compressus*	flattened rush	97	*Scolex pleuronectis*	cestode
18	*Chenopodium glaucum*	oak leaved goose foot	58	*Lasmigona subviridis*	mussel	98	*Skeletonema potamos*	diatom
19	*Chroodactylon ramosum*	red alga	59	*Lupinus polyphyllus*	lupine	99	*Skeletonema subsalsum*	diatom
20	*Cipangopaludina chinensis malleata*	Oriental mystery snail	60	*Lycopus asper*	western water horehound	100	*Skistodiaptomus pallidus*	calanoid copepod
21	*Cipangopaludina japonica*	Oriental mystery snail	61	*Lycopus europaeus*	European water horehound	101	*Skizopera borutzkyi*	harpacticoid copepod
22	*Cirsium palustre*	marsh thistle	62	*Lysimachia vulgaris*	yellow loosestrife	102	*Solidago sempervirens*	seaside goldenrod
23	*Corophium mucronatum*	amphipod	63	*Megacyclops viridis*	cyclopoid copepod	103	*Sonchus arvensis variety glabrescens*	smooth field sow thistle
24	*Cyclops strenuous*	copepod	64	*Mentha gentilis*	creeping whorled mint	104	*Sparganium glomeratum*	bur reed
25	*Cyclotella pseudostelligera*	diatom	65	*Najas marina*	spiny naiad	105	*Sphacelaria fluviatilis*	brown alga
26	*Cyclotella atomus*	diatom	66	*Neascus brevicaudatus*	digenean fluke	106	*Sphacelaria lacustris*	brown alga
27	*Cyclotella cryptic*	diatom	67	*Neoergasilus japonicus*	copepod	107	*Sphaerium corneum*	fingernail clam
28	*Cyclotella woltereki*	diatom	68	*Nitellopsis obtusa*	green alga	108	*Sphaeromyxa sevastopoli*	mixosporidian
29	*Cylindrospermopsis raciborskii*	cyanobacterium	69	*Nitokra hibernica*	harpacticoid copepod	109	*Stellaria aquatica*	giant chickweed
30	*Dactylogyrus amphibothrium*	monogenetic fluke	70	*Nitokra incerta*	harpacticoid copepod	110	*Stephanodiscus binderanus*	diatom
31	*Dactylogyrus hemiamphibothrium*	monogenetic fluke	71	*Oncorhynchus gorbuscha*	pink salmon	111	*Stephanodiscus subtilis*	diatom
32	*Daphnia galeata galeata*	waterflea	72	*Petromyzon marinus*	sea lamprey	112	*Tanysphyrus lemnae*	aquatic weevil
33	*Diatoma ehrenbergii*	diatom	73	*Piscirickettsia salmonis*	muskie pox	113	*Thalassiosira weissflogii*	diatom
34	*Dugesia polychroa*	flatworm	74	*Pisidium amnicum*	pea clam	114	*Thalassiosira guillardii*	diatom
35	*Echinogammarus ischnus*	amphipod	75	*Pisidium henslowanum*	henslow's pea clam	115	*Thalassiosira pseudonana*	diatom
36	*Elimia virginica*	snail	76	*Pisidium supinum*	humpback pea clam	116	*Thalassiosira lacustris*	diatom
37	*Enteromorpha intestinalis*	green alga	77	*Pistia stratiotes*	water-lettuce	117	*Thalassiosira baltica*	diatom
38	*Enteromorpha prolifera*	green alga	78	*Polygonum persicaria*	lady's thumb	118	*Trapa natans*	water chestnut
39	*Enteromorpha flexuosa*	green alga	79	*Potamothrix bedoti*	oligochaete	119	*Trypanosoma acerinae*	flagellate
40	*Epilobium hirsutum*	great hairy willow	80	*Potamothrix moldaviensis*	oligochaete	120	*Valvata piscinalis*	European valve snail

Red Font indicates species that may be present in both basins. See page 31.

3 Methods

This project was designed to provide a rapid preliminary assessment of the hydrological conditions along the entire length of the Divide in order to identify all significant aquatic pathways that currently exist or may form across the Divide, and to determine the risks of ANS transfer through each potential aquatic pathway identified. The premise of the study plan (included as Appendix A) design for this risk characterization was that experts within the state and Federal resource agencies responsible for water resources and aquatic species management are in the best position to quickly provide information and expertise on both the multiple possible pathways across the broad geographic expanse and the diverse array of ANS that are the subject of the study. The study plan addressed there would likely be a wide disparity in the quality and completeness of the available elevation data and hydrologic modeling from one location to another.

The scientists and engineers in the USFWS, USGS, USACE and the state DNRs responsible for water resource management that contributed to the study were asked to help identify potential surface water connection locations, and to assign hydrologic risk ratings for each location identified based on their best professional judgment of the available data and their experience in the area. The study plan accounted for uncertainties regarding the actual universe of species present in the two systems, and the wide range in quality and completeness of information regarding the behavioral characteristics of those species, by relying on experts' localized knowledge and professional judgment of the relevant available information.

The first step in problem identification was to develop a working map of the Divide. The 12-digit hydrologic unit code (HUC) is the best available technology for delineating watershed boundaries and was used in this study to characterize the southern boundary of the Great Lakes Basin Divide. The NRCS and USGS recently led member agencies of the Federal Geographic Data Committee (FGDC) and Subcommittee on Spatial Water Data in complete the 12-digit HUC. The watershed boundary defines the area of a hydrologic unit as delineated in accordance with the "FGDC Proposal, Version 1.0 - Federal Standards for Delineation of Hydrologic Unit Boundaries 3/01/02." (http://www.ftw.nrcs.usda.gov/huc_data.html). At a

minimum, watershed boundaries were delineated and georeferenced to the USGS 1:24,000 scale topographic base map and met National Map Accuracy Standards (NMAS). The 12-digit HUCs were also used when evaluating all local areas using Geographical Information Systems (GIS). Information on the 12-digit hydrological unit delineation can be found at: http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/datainfo.html..

3.1 Hydrological Characterization

The hydrological characterization required compilation of an inventory of locations where a hydrological or surface-water connection exists or could occur spanning the Divide, and the assignment of a Hydrological Risk Rating to each location based on the estimated frequency of a connection occurring and the depth and duration of the connection event. A variety of techniques were used to identify locations where a surface water pathway exists or may form. These included enlisting the best professional judgment of a team of state and federal hydraulics and hydrology experts in each of the states to identify connections. In addition, geographic information system (gis) and aerial photographic resources were invaluable.

After sites were identified and their location specified to a latitude and longitude coordinate system, multiple online database viewing systems and gis software were used to evaluate the potential for inter-basin connections to occur. These resources provided hydrological, elevation, and satellite and aerial imagery useful for assessing local hydrological conditions. The websites included USGS sites, providing data for The National Map, including the New National Map Viewer (TNM: http://nationalmap.gov/viewers.html); the National Hydrography Dataset (NHD: http://nhdgeo.usgs.gov/viewer.htm); the National Elevation Dataset (NED: http://seamless.usgs.gov/); and the USDA Geospatial Data Gateway, (http://datagateway.nrcs.usda.gov/). Each of these sites also offers georeferenced orthophotography including the aerial imagery of the National Agriculture Imagery Program (NAIP). Two commercial servers, Google Earth and bing Maps, also provided especially useful information. Using Google Earth with the National Flood Hazard Layer application developed

by the Federal Emergency Management Agency (FEMA) was very helpful in identifying and characterizing locations where a surface water pathway could form, and low altitude aerial imagery provided by Bing maps as "Birdseye View" was particularly useful at some locations in identifying or confirming drainage patterns.

Elevation models were used to approximate the topography of the regional and local areas for each location. The elevation models were based on the NED data available at resolutions of 1 arc-second (about 30 meters) or 1/3 arc-second (about 10 meters). As discussed in later sections, this resolution, while the best available, was often inadequate in areas of especially flat topography to draw definitive conclusions about the likelihood of a surface water pathway to form across the Divide during a significant storm event with an adequate degree of certainty.

The best available technology for streams, as line features, is the NHD high resolution data which was used in this study when evaluating all local areas using GIS. Relations between stream headwaters, estimates of the location of the drainage divide, FEMA flood plain mapping, and the local topography were used to assist field visitation and local knowledge in determining if a surface-water connection could exist across the Divide. The actual sources of data used in the hydrological characterization are presented in Appendices C through G by state and location.

Field trips were accomplished, as feasible within budget and schedule constraints, to inspect site conditions at the potential connection locations, adjacent habitat and connecting streams and obstructions located on those streams. Where site visits were not feasible, attempts were made to contact county surveyors and local water management professionals for site specific information that might be available at the local level. For each location, a site reconnaissance form was completed, which cites the sources of information, characterizes the hydrologic conditions in proximity to each site, lists obstructions on the streams that connect the location to the Mississippi or Ohio River and associated Great Lake. The last step in completing the form was the assignment of a subjective Hydrologic Risk Rating for both directions based on the professional judgment of the H&H Team members. In some locations, this was limited to two USACE personnel, but in most cases, the ratings include the input of

USGS and state DNR personnel. The H&H Team at each potential surface water connection used the standard form to address and help formulate a Hydrologic Risk Rating at each location. The information collected at each location (as available) included the following:

- Site Name,
- Team Members and Respective organizations,
- Type of connection – Perennial or Intermittent,
- Dimensions of the waterway at the divide location during low flow and during high flow,
- Connecting streams to the Mississippi or Ohio River,
- Connecting streams to the Great Lake,
- Description of in-stream obstructions to water flow in the connecting stream,
- Description of the basis for the estimates,
- Hydrologic Risk Rating, and
- Remarks

At a number of locations, there was insufficient data and time to acquire all the data to fill in the form to a high degree of accuracy. In each case, the H&H Team Leader made a concerted effort to acquire the information within the limited time available and to annotate the forms as completely and accurately as possible. Ultimately, two Hydrologic Risk Ratings were assigned for each location, the risk of water moving into the Great Lakes basin and the risk of water moving into the Mississippi River basin. The risk was broken down into six categories based on the magnitude and extent of the surface water connection that exists or may form across the Divide.

The six categories for the Hydrologic Risk Ratings are based on different recurrence intervals, a term hydrologists use to relate any given storm to a statistical analysis of historical records of rainfall for the area. The recurrence interval is based on the statistical probability that a given storm event will be equaled or exceeded in any given year. For instance, a 1% annual frequency storm is a rainfall event that has a 1% probability (1 chance in 100) of being equaled or exceeded in any given year. This level of storm event was commonly referred to as a 100-year storm event, but this term has led people to incorrectly conclude that a 100-year storm event is one that only occurs once in any given 100 year period.

The H&H team used best professional judgment of the available information at each location evaluated to answer the following two questions with one of the six choices in Table 3.

Considering all obstacles in connecting streams, how do you rate the subject location relative to overall ability to convey and/or maintain standing water across the drainage divide into the Great Lakes?

Considering all obstacles in connecting streams, how do you rate the subject location relative to overall ability to convey and/or maintain standing water across the drainage divide into the Mississippi River Basin?

Table 3. Hydrological Risk Rating for Surface Water Connections across the Divide.

Hydrological Risk Rating	Risk Category Description
Ideal	Perennial stream or intermittent stream known/documented to convey significant volumes of water for days to weeks multiple times per year.
Very Favorable	Intermittent stream capable of conveying significant volumes of water or having 1-ft water depth for multiple days once or more annually.
Favorable	Intermittent stream capable of conveying significant water volumes or having 6-in water depth for days from 10% or less annual return frequency storm.
Possible	Intermittent stream capable of conveying significant volumes of water or having 6-in water depth for days from 1-10% annual return frequency storm.
Unlikely	Intermittent stream only capable of conveying significant water or having standing water depth for days from 0.2 - 1.0% annual return frequency storm.
Highly Unlikely	Intermittent stream requiring greater than 0.2% annual return frequency storm to generate any significant volume of water flow across divide.

The Hydrological Risk Ratings were based on the estimated frequency and magnitude of water flow across the Divide at each location. Each team member was asked to assign a rating according to the criteria above, and where there was a range of answers, the selected rating for the site was generally weighted toward the more conservative answer to prevent underestimating risks at this preliminary stage.

3.2 ANS Assessment

The ANS assessment was comprised of three primary components:

1. Compilation of an inventory of ANS in the Great Lakes threatening to invade the Mississippi River basin and compilation of an inventory of ANS in the Mississippi or Ohio Rivers and their tributaries threatening to invade the Great Lakes.
2. Determination of a Significance Rating for each of the ANS in Tables 1 and 2 based on a qualitative assessment of the potential impacts to the invaded ecosystem and economy if the ANS became established.
3. Assignment of a set of ANS Transfer Risk Ratings for each potential connection based on the results of the Hydrologic Risk Ratings for the location and the proximity and threat posed by each ANS.

The first step of the ANS risk characterization was the construction of an ANS species inventory. The inventory was provided by the U. S. Fish and Wildlife Service (USFWS) in two tables, non-indigenous species known to be in the Great Lakes but not observed within the Mississippi River or any of its tributaries, and vice versa . The inventory was developed using databases, supporting literature and professional experience. The USGS species website (http://nas.er.usgs.gov/default.aspx) includes Fact Sheets for 93 of the total of 141 ANS on both lists. These fact sheets are compiled in Appendix H and were made readily available to the ANS Team to facilitate their evaluation of the species threat.

The second step of the ANS risk characterization was assigning an ANS Significance Rating to each species listed in Tables 1 and 2. Each ANS expert on the team was asked to assign an ANS Significance Rating to each species on both lists. Table 4 presents the five criteria used to rate the relative impacts that could be caused to the Great Lakes or the Mississippi River or its tributaries if the species became established. ANS team members participated in discussions on many of the species and used resources such as the USGS ANS Fact Sheets to identify individual ANS judged to pose the greatest risk to the invaded ecosystem and assign one of the five ANS significance ratings to each species using their best professional judgment.

Table 4. Individual ANS Significance Rating Criteria.

ANS Significance Rating	**Risk Category Description**
Acute	Species is likely to cause dramatic, rapid and irreversible adverse impacts to native, threatened or endangered species populations or existing habitat or regional economics within 50 years from the time of introduction.
Severe	Species is likely to cause adverse impacts to threatened or endangered species populations or their critical habitat, or dramatic adverse impacts to native populations or existing habitat or significant impacts to regional economics within 50 years or greater from the time of introduction.
Significant	Species is likely to cause detectable adverse impacts to threatened or endangered species or significant adverse impacts to native and populations and/or existing habitat and/or regional economics within 50 years or greater from the time of introduction.
Minor	Species is unlikely to cause detectable adverse impacts to threatened or endangered species populations or measurable adverse impacts to native species populations or existing habitat or regional economics within 50 years from the time of introduction
Insignificant	Species is unlikely to cause detectable impacts to threatened or endangered or native species populations or existing habitat or regional economics within 50 years from the time of introduction.

The third step in the ANS risk characterization was the evaluation and assignment of an ANS Transfer Risk Rating to each potential surface water connection identified, and a Webinar Conference was conducted among the entire team on 18 August, 2010 to facilitate this process. Based on the results of the ANS Significance Ratings, the USGS prepared a set of illustrative figures for the species of greatest concern to the Great Lakes and to the Mississippi River and its tributaries according to taxonomic groups. The H&H Team Leader for each location provided a briefing depicting each of the potential surface-water connections and the Hydrologic Risk Rating assigned to the location. Questions were fielded at the end of each briefing, and the briefing materials were posted for additional analysis and review by the ANS Team Members.

The initial Webinar revealed the need to better define and illustrate the connecting streams and in-stream dams at a number of the potential surface water pathways identified. A follow up teleconference was conducted with the ANS Team on 8 September 2010 in which the new information was presented and discussed. ANS Team members subsequently assigned final ANS Transfer Risk Ratings for each location based on the criteria in Table 5 below.

Table 5. ANS Transfer Risk Rating Criteria for Each Potential Surface Water Connection.

ANS Transfer Risk Rating	Risk Category Description
Acute Risk	Location where a viable hydraulic pathway across the basin divide exists or is likely to form, and where there are ANS of concern that could pose severe or acute impacts to the other basin in close proximity that are capable of navigating the hydraulic pathway across the divide. Significant risk warranting prompt implementation of risk reduction measures.
High Risk	Location where a viable hydraulic pathway may form across the basin divide, and there are ANS of concern that could pose severe or acute impacts to the other basin in proximity that are capable of navigating the hydraulic pathway across the divide when it forms. Significant risk warranting prompt action to complete a more detailed risk assessment and/or planning study to formulate viable risk reduction alternatives.
Medium Risk	Location where a viable hydraulic pathway may form, and/or where there are ANS of concern that could pose significant, severe or acute impacts to the other basin in close proximity that might be capable of navigating the hydraulic pathway across the divide. Significant risk warranting completion of a more detailed risk assessment to determine whether risk reduction measures are warranted.
Low Risk	Location where it is highly unlikely that a viable surface water pathway ever forms and/or there are no ANS of concern in proximity to location. Insignificant risk, and no additional study is recommended unless new information becomes available to indicate otherwise or change of condition occurs at the location that could facilitate interbasin transfer ANS through an aquatic pathway.

The criteria were deliberately designed to be subjective due to inherent uncertainties in the completeness and accuracy of the data and information available to develop Hydrologic Risk Ratings and the ANS Significance Ratings. The team of senior scientists was tasked to use their best professional judgment to characterize the relative risks at each potential connection in relation to the potential for transfer of ANS. The four point classification scale for ANS

Transfer Risks is distributed such that only Low Risk is considered insignificant and will result in no further action. As with the Hydrologic Risk Ratings, each ANS Team member was asked to assign a rating according to the criteria above, and where there was a range of answers, the selected rating for the site was generally weighted toward the more conservative answer to prevent underestimating risks during this preliminary phase of the GLMRIS.

4 Results

The results of the preliminary risk characterization are presented in two sections Hydrological Characterization and ANS Assessment. The Hydrological Characterization section presents the inventory of locations where a hydrological or surface-water connection could occur, and the location specific Hydrological Risk Ratings for both directions across the Divide that were assigned based on the probable frequency of a connection occurring and the depth and duration of the hydrologic connection event.

The ANS Assessment presents the inventory of species in the Great Lakes threatening to invade the Mississippi River basin and vice versa. It presents ANS Significance Ratings for each of the species based on the magnitude of potential impacts should the ANS become established in the adjacent basin. Lastly, it provides a set of ANS Transfer Risk Ratings for each potential connection location, one rating for the risks to the Great Lakes and one for the risks to the Mississippi River and its tributaries.

4.1 Hydrological Characterization

When this preliminary risk characterization was initiated in July 2010, it was estimated that there were nine potential locations within Focus Area 2 where a potentially viable surface water pathway across the Divide exists or could form. Through the suggestions of state DNR and USACE personnel combined with an intense review of available records, the list of potential locations needing assessment grew substantially during the two month course of the study.

Ultimately, thirty-six locations were identified where there appeared to be a significant possibility for the existence or development of a surface water pathway across the Divide. The location names with respective state and county are shown in Table 6, and Figure 3 depicts the location along the Divide of each of the 36 potential surface water connection locations. Of the 36 total sites evaluated, five were not rated, two because they were determined to be outside the study domain (Mountain Iron and Scott Lake in Minnesota), and the other three (Hell's Kitchen Lake and the County Road G locations in Wisconsin and the Cloquet location in Minnesota) because there was insufficient evidence to suggest a potential surface water

pathway could actually form across the basin divide. However, it should be noted that the very flat topography over long reaches of the divide led the H&H Team to consider additional locations beyond the 36 identified in Table 6, and to acknowledge that additional locations may be identified in the future as flood insurance studies and available topographical elevation information improves.

Appendices A through E provide detailed maps, photos, other information compiled and evaluated, and the sources of information used to support the hydrologic risk characterization at each location identified in Table 7 and Figure 4. The information in these Appendices is organized by state and location. The Hydrological Risk Ratings assigned to each location are presented in Table 7 based on the criteria in Table 3 and the information in Appendices A through E. Figure 4 depicts the results of each of the Hydrologic Risk Ratings relative to water flow into the Great Lakes basin from the Mississippi River basin. The locations where the risks are significant are denoted by colored symbols and are listed by risk rating from highest (top) to lowest (bottom), and locations where risks are deemed insignificant are indicated by black dots.

An important consideration in developing the Hydrologic Risk Ratings for each location was the presence of in-stream dams that could interrupt a continuous surface-water pathway and prevent flow and species migration in one direction. Figure 5 depicts the locations of dams on the major connecting streams to the Mississippi River, and the Great Lakes. Figure 6 depicts the locations of dams on the major connecting streams to the Ohio River and the Great Lakes.

Table 6. Inventory of Potential Surface Water Pathways across the Divide.

	Site Name	County	State
1	East Mud Lake, NY	Chautauqua	NY
2	Mosquito Lake/Grand River	Trumbull	OH
3	Ohio and Erie Canal at Long Lake (Portage Lakes)	Summit	OH
4	Little Killbuck Creek	Medina	OH
5	Tymochtee – Scioto	Marion	OH
6	Miami and Erie Canal near the City of Minster	Auglaize	OH
7	Grand Lake-St Mary's	Auglaize	OH
8	Clear Creek-Loramie Creek	Marion	OH
9	Pusheta Creek - Willow Creek	Wyandot	OH
10	Muchinippi Creek-Auglaize River	Auglaize	OH
11	Barnes Creek - Kopp Creek	Crawford	OH
12	Eagle Marsh Fort Wayne	Allen	IN
13	Geller Ditch/Roy Delagrange Ditch	Allen	IN
14	Tri County State Reserve/Lake Wawasee	Kosciusko	IN
15	Loomis Lake-Flint Lake (new site)	Porter	IN
16	Parker-Cobb Ditches	Porter	IN
17	Woods Ditch / Harber Ditch	Allen	IN
18	Upstream Portage	Columbia	WI
19	Portage Canal	Columbia	WI
20	Downstream Portage	Columbia	WI
21	Jerome Creek	Kenosha	WI
22	S. Menomonee Falls	Waukesha	WI
23	W. Menomonee Falls	Waukesha	WI
24	Pardeeville	Columbia	WI
25	Rosendale - Brandon	Fond du Lac	WI
26	Hatley-Plover River	Marathon	WI
27	S. Aniwa Wetlands	Marathon-Shawano	WI
28	Brule Headwaters Portage	Douglas	WI
29	Twin Lake	Iron	WI
30	County Road G Locations 1 and 2	Iron	WI
31	Hell's Kitchen Lake	Vilas	WI
32	Scott Lake	St. Louis	MN
33	Swan River Locations 1 and 2	Itasca	MN
34	Libby Branch of Swan River Locations 1 and 2	Aitkin	MN
35	Mountain Iron	St. Louis	MN
36	Cloquet, MN	Carlton	MN

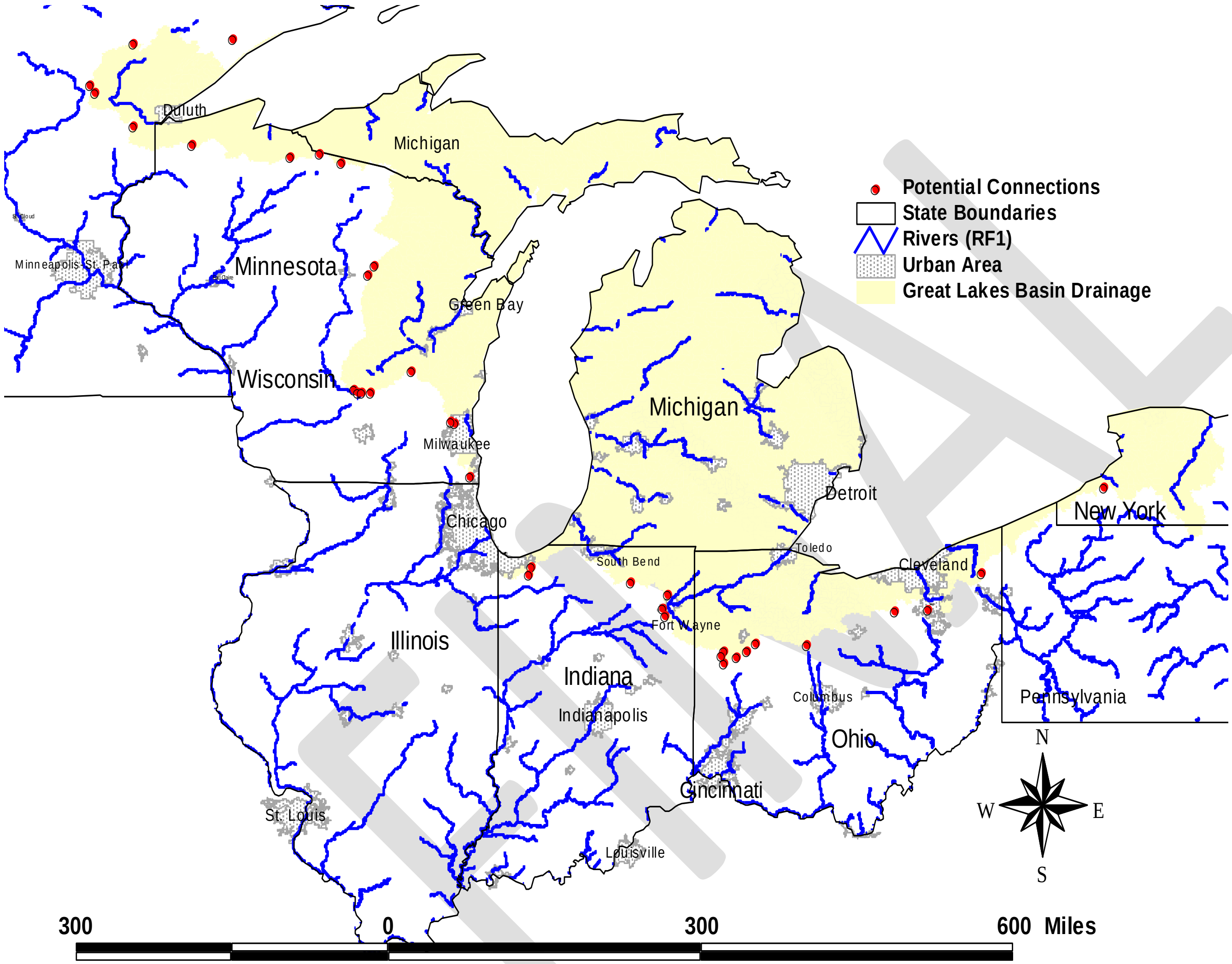

Figure 3. Thirty-six potential Surface Water Pathways between the Great Lakes and Mississippi River Basin along the Divide.

Table 7. Hydrologic Risk Ratings Presented by State from East to West.

	Site Name	State	Hydrologic Risk Ratings	
			Flow into Great Lakes Basin	Flow out of Great Lakes Basin
1	East Mud Lake, NY	NY	Possible	Possible
2	Mosquito Lake/Grand River	OH	Highly Unlikely	Highly Unlikely
3	Ohio & Erie Canal - Long Lake (Portage Lakes)	OH	Ideal	Unlikely
4	Little Killbuck Creek	OH	Possible	Possible
5	Tymochtee - Scioto	OH	Unlikely	Unlikely
6	Miami and Erie Canal near Minster	OH	Highly Unlikely	Highly Unlikely
7	Grand Lake-St Mary's	OH	Favorable	Unlikely
8	Clear Creek-Loramie Creek	OH	Highly Unlikely	Highly Unlikely
9	Pusheta Creek - Willow Creek	OH	Highly Unlikely	Highly Unlikely
10	Muchinippi Creek-Auglaize River	OH	Unlikely	Unlikely
11	Barnes Creek - Kopp Creek	OH	Highly Unlikely	Highly Unlikely
12	Eagle Marsh Fort Wayne	IN	Favorable	Very Favorable
13	Geller Ditch/Roy Delagrange Ditch	IN	Highly Unlikely	Highly Unlikely
14	Tri County State Reserve/Lake Wawasee	IN	Highly Unlikely	Highly Unlikely
15	Loomis Lake-Flint Lake (new site)	IN	Highly Unlikely	Favorable
16	Parker-Cobb Ditches	IN	Possible	Possible
17	Woods Ditch / Harber Ditch	IN	Unlikely	Unlikely
18	Upstream Portage	WI	Possible	Highly Unlikely
19	Portage Canal	WI	Unlikely	Unlikely
20	Downstream Portage	WI	Possible	Highly Unlikely
21	Jerome Creek	WI	Unlikely	Possible
22	S. Menomonee Falls	WI	Unlikely	Unlikely
23	W. Menomonee Falls	WI	Possible	Unlikely
24	Pardeeville	WI	Unlikely	Unlikely
25	Rosendale - Brandon	WI	Unlikely	Possible
26	Hatley-Plover River	WI	Possible	Possible
27	S. Aniwa Wetlands	WI	Possible	Possible
28	Brule Headwaters Portage	WI	Unlikely	Unlikely
29	Twin Lake	WI	Highly Unlikely	Highly Unlikely
30	County Road G Locations 1 and 2	WI	NR	NR
31	Hell's Kitchen Lake	WI	NR	NR
32	Scott Lake	MN	NR*	NR*
33	Swan River Locations 1 and 2	MN	Unlikely	Unlikely
34	Libby Branch of Swan River	MN	Ideal	Ideal
35	Mountain Iron	MN	NR*	NR*
36	Cloquet, MN	MN	NR	NR

NR - Not rated due to insufficent evidence that a surface water pathway may form across basin divide.
NR* - Not Rated. Location is along Great Lakes-Hudson Bay basin divide.

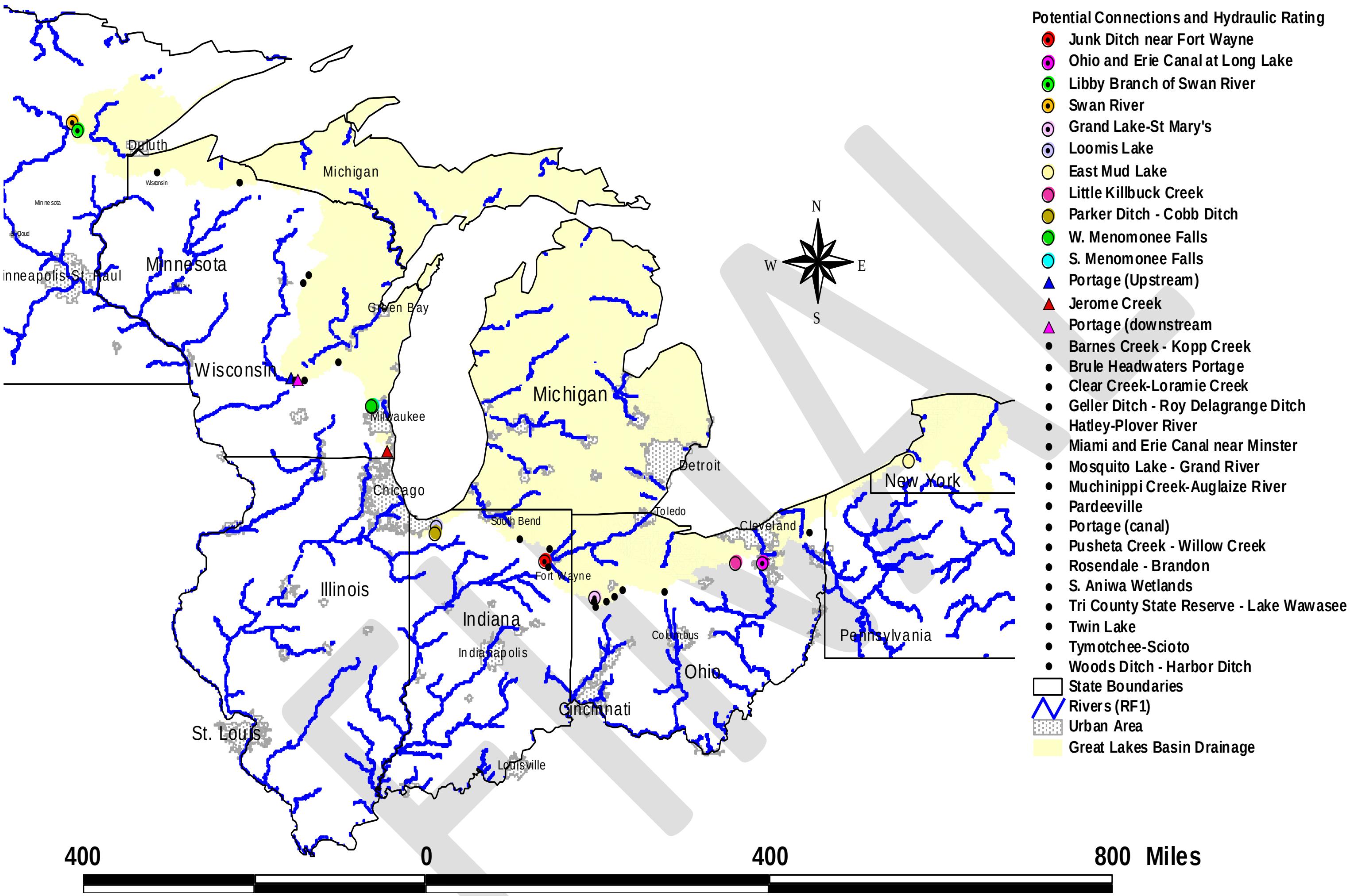

Figure 4. Hydrologic Risk Ratings at 31 Potential Surface Water Pathways across the Divide into the Great Lakes.

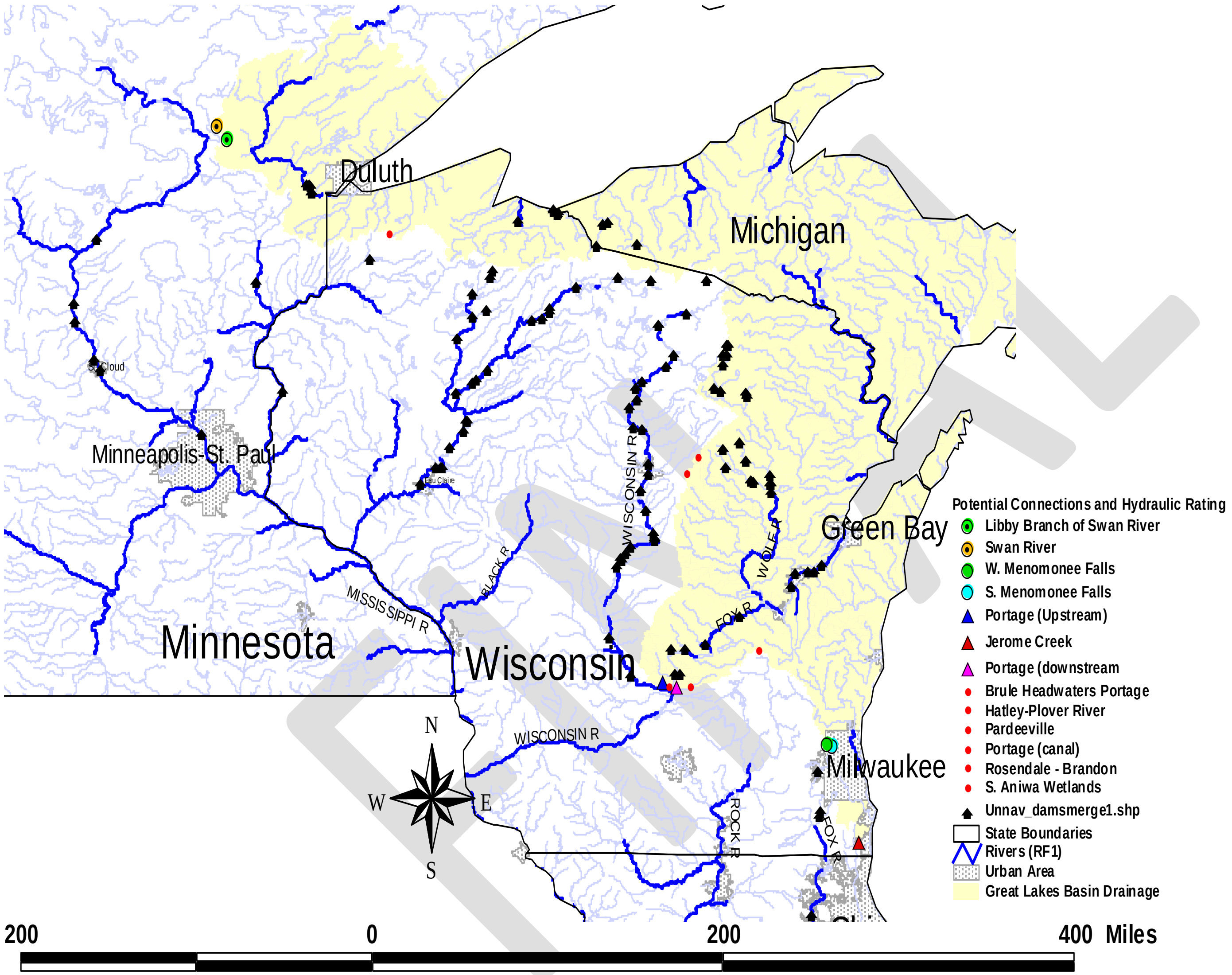

Figure 5. Dams on Major Connecting Streams to the Mississippi River and to the Great Lakes.

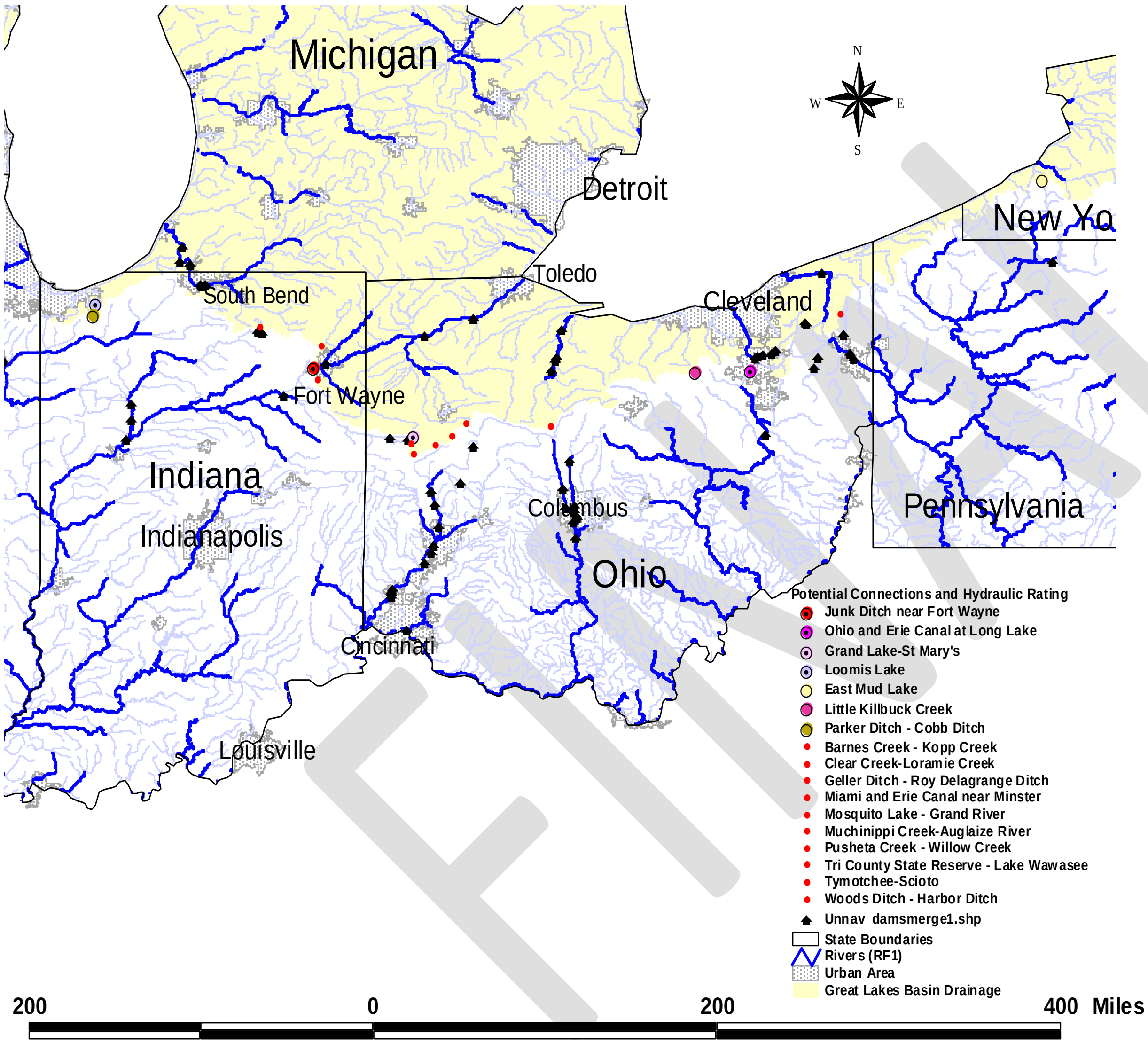

Figure 6. Dams on Major Connecting Streams to the Ohio River in the Mississippi River Basin and to the Great Lakes.

4.1.1 Hydrological Assessment - Flow into the Great Lakes from the Mississippi River Basin

Considering flow into the Great Lakes basin from the Mississippi River basin, two locations were assigned Ideal ratings due to the apparent presence of a standing water column spanning the Divide or perennial flow across the Divide. No location was rated Very Favorable. Two locations were rated Favorable. Eight locations were rated Possible, indicating an intermittent stream capable of conveying significant volumes of water or having 6" water depth for days resulting from a 1-10% (100-year to 10-year) annual return frequency storm event. Ten locations were rated Unlikely meaning that an intermittent stream is only capable of conveying significant water or during a 0.2 - 1.0% annual return frequency storm. Nine locations were rated Highly Unlikely suggesting that an intermittent stream would require a larger storm than a 0.2% annual return frequency storm to generate any significant volume of water flow across the Divide.

4.1.2 Hydrological Assessment - Flow into the Mississippi River Basin from the Great Lakes Basin

Considering flow into the Mississippi River basin from the Great Lakes basin, no location was rated Ideal. One location was rated Very Favorable indicating that an intermittent stream is capable of conveying significant volumes of water or having 1-ft water depth for multiple days once or more annually. One location was rated Favorable indicating that an intermittent stream capable of conveying significant water volumes or having 6" water depth for days resulting from a 10% or less annual return frequency storm. Seven locations were rated Possible for an intermittent stream capable of conveying significant volumes of water or having 6" water depth for days resulting from a 1-10% annual return frequency storm. Eleven locations were rated Unlikely meaning that an intermittent stream is only capable of conveying significant water or having standing water depth for days resulting from a 0.2 - 1.0% annual return frequency storm. Ten locations were rated Highly Unlikely suggesting that an intermittent stream would require less than a 0.2% annual return frequency storm to generate any significant volume of water flow across the Divide.

4.1.3 Most Significant Potential Surface Water Pathway Locations

The Libby Branch of the Swan River received an Ideal rating in both directions due to a network of ditches that intersect apparent perennial tributaries to the Libby Branch of the Swan River with perennial tributaries to the Floodwood River. The Floodwood River is a tributary of the Saint Louis River that enters the southwest corner of Lake Superior between Duluth, MN and Superior, WI. The Swan River is a tributary to the Mississippi River. Hydro electric dams on the Saint Louis River interrupt the standing water column and prevent the transfer of water upstream from Lake Superior to this location. Likewise, hydroelectric dams on the Upper Mississippi River interrupt the standing water column and prevent the transfer of water upstream from the Mississippi River to this location.

The Ohio-Erie Canal location at Long Lake in Ohio received an Ideal rating for flow into the Great Lakes Basin because there is a gate that is maintained with a 3-inch opening to allow continual discharge from Long Lake into a canal that connects with the Cuyahoga River in the Lake Erie Basin. This location is rated Ideal due to the constant flow of water across the drainage divide, but there are many obstructions on the connecting tributaries to the Ohio River that interrupt a continuous surface water column. This location is rated as Unlikely to allow flow out of the Great Lakes Basin.

The location that appeared to pose the most significant potential for the transfer of large volumes of water across the basin divide is the connection that forms between Junk Ditch and the Graham McCulloch Ditch across Eagle Marsh in Fort Wayne, IN. A 2009 Flood Insurance Study indicated that significant backflow from the Saint Mary's and Joseph Rivers at the confluence with the Maumee River occurs through Junk Ditch. Indiana DNR representatives indicated noticeable flow through the Eagle Marsh occurs from as little as the maximum rainfall event expected to occur in any given year. The USGS representatives that studied this location indicated that a 10% frequency storm was likely to provide a water column depth across the drainage divide sufficient for large fish to traverse. This location is a remnant of glacial Lake Maumee, a precursor to Lake Erie and has been a natural location where interbasin flow occurs since the retreat of the glaciers. As such, this location was rated Very Favorable for flow into the Ohio River Basin and Favorable for development of flow into the Lake Erie Basin.

4.1.4 Migratory Difficulty Assessment

During technical review of a completed draft of this report, the uncertainty regarding dams as impediments to ANS migration on the stream alignment from the potential location on the Divide to the associated Great Lake and Mississippi or Ohio River was identified as an issue requiring further review and analysis of relevant available information on dams on the connecting streams. To perform that assessment, the National Inventory of Dams data set was searched to develop a matrix of dams with pertinent information on location, height, purpose and features on each of the streams that connect a Great Lake to the Ohio or Mississippi River. The matrix was assembled to list all of the dams on the connecting streams for 18 locations along the Divide judged to pose a significant risk for ANS Transfer. Over 150 different dams were identified on these streams.

During the assessment, a number of inconsistencies or errors in the NID data were identified. Therefore, the USEPA database on dams was also accessed. When comparing the data from the two data bases, some information matched, but an equal or greater amount of the data did not match. For instance, the Brandon Road Lock and Dam, which is on the Illinois River between the Jerome Creek, Wisconsin location is listed in the NID as having a dam height of 40 feet and a hydraulic height of zero, while the USEPA data field for dam height is left blank and the field for hydraulic height is shown as 34 feet.

These discrepancies in the available data led to a further spot review of available information on specific dams, such as the Dover Dam on the Tuscarawas River in Ohio, which was previously assumed to be an impenetrable barrier to upstream migration of ANS. It was discovered that during flow conditions, this flood control dam allows water to flow directly through the dam with virtually no difference in water elevation from upstream to downstream. The discrepancies in the available databases combined with the large number of dams, each with inherent details in design, purpose and condition create an undesirable level of uncertainty in the difficulty they pose to the migration of species. However, it does provide

relevant information warranting further consideration relevant to the purposes of this preliminary risk characterization.

Table 8 below provides a summary of the assessment of the migratory difficulty associated with 18 locations along the Divide deemed to pose a significant risk of facilitating ANS Transfer across the basin divide. The data for dam height and number of dams referenced in Table 8 was taken from the NID. The matrix reflects an examination of the migratory difficulty from the Great Lakes upstream to each location spanning the Divide and the migratory difficulty from that location at the Divide downstream to the Mississippi or Ohio River. It also examines the opposite direction for migratory difficulty from the Mississippi or Ohio River upstream to the location on the Divide and downstream from the Divide to the Great Lake.

Each of the four legs of the potential ANS journey, from the associated Great Lake up to the Divide and back down to the Mississippi or Ohio River and back, were assigned a subjective migratory difficulty rating; Obstructed, Significantly obstructed, Partially obstructed, Minimally obstructed or Unobstructed. The results of the migratory difficulty assessment in Table 8 were based on review of the NID and USEPA databases on dams and the professional judgment of the study manager from the compilation and consideration of all the information used to develop this report, including the ANS Transfer Risk ratings in Table 17.

Table 8. Migratory Difficulty Assessment Matrix

Location	Migratory Difficulty from Great Lake to Location	Migratory Difficulty from Location to Mississippi or Ohio River	Migratory Difficulty from Mississippi or Ohio River to Location	Migratory Difficulty from Location to Great Lake
Eagle Marsh Fort Wayne	Partially Obstructed by 4 dams on Maumee River w/maximum dam height of 12 feet	Unobstructed. NID indicates no dams. Recon found deteriorated 6'foot high dam on Little River in Huntington, IN.	Unobstructed. 6-foot high dam in Huntington impedes upstream migration during low flow. Minimal water depth impedes migration during low flow.	Minimally obstructed by 4 dams on Maumee River w/maximum dam height of 12 feet.
Ohio and Erie Canal at Long Lake	Obstructed by gate from Long Lake to Ohio & Erie Canal. Reportedly tailwater elevation remains significantly below gate invert. No other dams.	Partially obstructed by 2 dams on Tuscarawas River and 10 dams on Muskingum River w/maximum dam or hydraulic height of 56 feet. NID incorrectly indicates no dams w/lock on Muskingum. All 10 dams have associated lock structures.	Partially obstructed by 2 dams on Tuscarawas River and 10 dams on Muskingum River w/maximum dam or hydraulic height of 56 feet. NID incorrectly indicates no dams w/lock on Muskingum. All 10 dams have associated lock structures.	Unobstructed. No obstruction to downstream migration below gate exiting Long Lake.
Libby Branch of Swan River	Obstructed. NID indicates 20 hydroelectric dams on St Louis River w/maximum dam height of 51 feet.	Partially obstructed by 8 multi-purpose dams on upper Mississippi River and 4 Lock and Dams on the Mississippi River in MN.	Significantly obstructed by 8 multi-purpose dams on upper Mississippi River and 4 Lock and Dams on the Mississippi River in MN.	Partially obstructed. NID indicates 20 hydroelectric dams on St Louis River w/maximum dam height of 51 feet.
Swan River	Obstructed. NID indicates 20 hydroelectric dams on St Louis River w/maximum dam height of 51 feet.	Partially obstructed by 8 multi-purpose dams on upper Mississippi River and 4 Lock and Dams on the Mississippi River in MN.	Significantly obstructed by 8 multi-purpose dams on upper Mississippi River and 4 Lock and Dams on the Mississippi River in MN.	Partially obstructed. NID indicates 20 hydroelectric dams on St Louis River w/maximum dam height of 51 feet.
Little Killbuck Creek	Partially obstructed. NID indicates 1 dam on the East Branch Black River w/maximum dam height of 12 feet.	Partially obstructed by 8 dams on Muskingum River w/maximum dam height of 20 feet. All 8 dams have associated lock structures.	Partially obstructed by 8 dams on Muskingum River w/maximum dam height of 20 feet. All 8 dams have associated lock structures.	Minimally obstructed. NID indicates 1 dam on the East Branch Black River w/max dam height of 12 feet.
East Mud Lake	Partially obstructed. NID indicates 1 dam on Silver Creek w/maximum dam height of 19 feet.	Minimally obstructed by 8 lock and dams on Allegheny River w/maximum dam height of 58 feet combined with steep gradient and Beaver dams on N. Branch Conewango Ck.	Partially obstructed by 8 lock and dams on Allegheny River w/maximum dam height of 58 feet combined with steep gradient and Beaver dams on N. Branch Conewango Ck.	Minimally obstructed. NID indicates 1 dam on Silver Creek w/maximum dam height of 19 feet.
Brule Headwaters	Partially obstructed. NID indicates no dams, but steep gradient and limited depth.	Minimally obstructed by 2 dams on St. Croix River w/max dam height of 60-feet.	Obstructed by 2 dams on St. Croix River w/max dam height of 60-feet.	Unobstructed. NID indicates no dams.
Jerome Creek	Unobstructed. NID indicates no dams.	Minimally obstructed by 2 dams on the Des Plaines River and 7 locks and Dams on the Illinois River w/maximum dam height of 40 feet.	Minimally obstructed by 2 dams on the Des Plaines River and 7 locks and Dams on the Illinois River w/maximum dam height of 40 feet.	Unobstructed. NID indicates no dams.
W. Menomonee Falls	Unobstructed. NID indicates no dams.	Minimally obstructed by 4 dams on the Fox River In WI, and 9 dams on the Fox River in Illinois w/maximum dam height of 40 feet.	Partially obstructed by 4 dams on the Fox River In WI, and 9 dams on the Fox River in Illinois w/maximum dam height of 40 feet.	Unobstructed. NID indicates no dams.
S. Aniwa Wetlands	Significantly obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 4 dams w/o locks on the Embarrass and Middle Branch Embarrass Rivers w/max dam height of 22 feet.	Partially obstructed by 10 hydroelectric dams and 2 recreational dams on Plover and Wisconsin Rivers w/maximum dam height of 61 feet.	Obstructed by 10 hydroelectric dams and 2 recreational dams on Plover and Wisconsin Rivers w/maximum dam height of 61 feet.	Partially obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 4 dams w/o locks on the Embarrass and Middle Branch Embarrass Rivers w/max dam height of 22 feet.
Hatley-Plover River	Significantly obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 4 dams w/o locks on the Embarrass and Middle Branch Embarrass Rivers w/max dam height of 22 feet.	Partially obstructed by 10 hydroelectric dams and 2 recreational dams on Plover and Wisconsin Rivers w/maximum dam height of 61 feet.	Obstructed by 10 hydroelectric dams and 2 recreational dams on Plover and Wisconsin Rivers w/maximum dam height of 61 feet.	Partially obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 4 dams w/o locks on the Embarrass and Middle Branch Embarrass Rivers w/max dam height of 22 feet.
Portage (Upstream) and (Downstream)	Significantly obstructed by 19 remnant locks and dams on Upper and Lower Fox River.	Minimally obstructed by Prairie du Sac Dam on Wisconsin River w/maximum dam height of 38 feet.	Significantly obstructed by Prairie du Sac Dam on Wisconsin River w/maximum dam height of 38 feet.	Partially obstructed by 19 remnant locks and dams on Upper and Lower Fox River.
Grand Lake-St Mary's	Significantly obstructed by 2 dams on the Auglaize River w/maximum height of 25 feet and gate structure from Grand Lake to Ohio & Erie Canal.	Minimally obstructed by Roush Dam on the Wabash River in IN w/maximum dam height of 84 feet.	Obstructed by Roush Dam on the Wabash River in IN w/maximum dam height of 84 feet.	Minimally obstructed by 2 dams on the Auglaize River w/maximum height of 25 feet and gate structure from Grand Lake to Ohio & Erie Canal.
Mosquito Lake - Grand River	Significantly obstructed by 3 dams w/max dam height of 45 feet.	Minimally obstructed by 3 dams prior to confluence with Ohio River w/max dam height of 43 feet.	Obstructed by 3 dams prior to confluence with Ohio River w/max dam height of 43 feet.	Minimally obstructed by 3 dams w/max dam height of 45 feet.
Rosendale - Brandon	Partially obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 1 dam w/o locks on Fond du Lac River w/max dam height of 9 feet.	Minimally obstructed by 18 dams on Rock River in Wisconsin and Illinois w/maximum dam height of 22 feet.	Partially obstructed by 18 dams on Rock River in Wisconsin and Illinois w/maximum dam height of 22 feet.	Minimally obstructed by 12 dams w/formerly operated locks on the Lower Fox River and 1 dam w/o locks on Fond du Lac River w/max dam height of 9 feet.
Loomis Lake	Partially obstructed. NID show no dams, but completion of water column into Lake Loomis appears unlikely.	Minimally obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/maximum dam height of 30 feet.	Partially obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/maximum dam height of 30 feet.	Unobstructed. NID show no dams, but completion of water column out of Lake Loomis is likely very rare.
Parker Ditch - Cobb Ditch	Unobstructed. NID show no dams, and presence of water column across Divide via agricultural ditches appears frequent.	Minimally obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/maximum dam height of 30 feet.	Partially obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/maximum dam height of 30 feet.	Unobstructed. NID show no dams, and presence of water column across Divide via agricultural ditches appears frequent.

4.2 ANS Assessment

Step one of the ANS assessment was the compilation of two lists of species, which was generated by the USFWS using available databases, supporting literature and professional experience one each for the Great Lakes basin and the Mississippi River basin. Table 1 presents an inventory of the 21 non-indigenous aquatic species identified within the Mississippi River basin that aren't known to be present in the Great Lakes. Table 2 presents an inventory of the 120 non-indigenous aquatic species identified as being present in the Great Lakes, but not in the Mississippi River and tributaries. The disparity between the number of taxa in the basins may be more of a reflection of study effort rather than actual circumstance due to the large amount of resources that have been expended in the Great Lakes Basin relative to the Mississippi River basin inventorying and cataloguing invasive species.

It should be noted that the species list was compiled within a very rigid schedule, and it appears that 13 of the 120 species listed as not occurring in the Mississippi River basin have, in fact, been reported in the scientific literature as occurring there (Williams 1964, Williams 1972, and Jarrett and King 1998). These species in Table 2 are highlighted by red font to indicate they may already be present in both basins, or in the case of the plant pista stratiotes, may have been attributed to the wrong basin.

Step 2 of the ANS assessment was determining the ANS of most significant concern. Tables 9 and 10 list the species of greatest concern in the Mississippi River and the Great Lakes Basins, respectively. The ANS Significance ratings are based on averaging the ratings with equal weightings given to each reviewer. Tables 11 through 16 list the ANS assigned an Acute, Severe or Significant ANS Significance Rating sorted by taxonomic group. This discrepancy indicates the need to reevaluate and refine the inventory of ANS of concern to the GLMRIS and the distribution information regarding these species.

The USGS provided the ANS distribution maps included at the end of Appendix H, and the raw datasets for the locations of ANS that have been collected that were used to prepare Figures 7 through 10, which illustrate the spatial distribution of the ANS considered to pose the

most significant potential negative impacts if they became established in the adjacent basin. Figure 7 illustrates the spatial distribution of Silver and Bighead carp relative to the potential

Table 9. Species of Greatest Concern in the Great Lakes Basin.

Scientific Name	Common Name	Species Category	Combined Risk Value
Gymnocephalus cernuus	Eurasian ruffe	Fish	**Acute**
Cipangopaludina chinensis malleata	Oriental mystery snail	Mollusk	**Severe**
Cipangopaludina japonica	Oriental mystery snail	Mollusk	**Severe**
Cirsium palustre	marsh thistle	Plant	**Severe**
Epilobium hirsutum	great hairy willow	Plant	**Severe**
Glyceria maxima	reed sweet-grass	Plant	**Severe**
Hydrocharis morsus-ranae	European frogbit	Plant	**Severe**
Nitellopsis obtusa	green alga (Starry stonewort)	Algae	**Severe**
Petromyzon marinus	sea lamprey	Fish	**Severe**
Rhamnus frangula	glossy buckthorn	Plant	**Severe**
Trapa natans	water chestnut	Plant	**Severe**
Polygonum persicaria	lady's thumb	Plant	**Severe**
Cylindrospermopsis raciborskii	cyanobacterium	Bacteria	**Severe**
Cabomba caroliniana	fanwort	Plant	**Severe**
Hemimysis anomala	bloody-red mysid	Crustacean	**Severe**
Cercopagis pengoi	fish-hook waterflea	Crustacean	**Severe**
Actinocyclus normanii form subsalsa	diatom	Algae	**Significant**
Aeromonas salmonicida	furunculosis	Bacteria	**Significant**
Apeltes quadracus	fourspine stickleback	Fish	**Significant**
Bangia atropurpurea	red alga 2	Algae	**Significant**
Bosmina maritima	waterflea	Crustacean	**Significant**
Echinogammarus ischnus	amphipod	Crustacean	**Significant**
Gammarus tigrinus	amphipod	Crustacean	**Significant**
Ichthyocotylurus pileatus	digenean fluke	Worm-Parasite	**Significant**
Lupinus polyphyllus	lupine	Plant	**Significant**
Lysimachia vulgaris	yellow loosestrife	Plant	**Significant**
Mentha gentilis	creeping whorled mint	Plant	**Significant**
Najas marina	spiny naiad	Plant	**Significant**
Neoergasilus japonicus	copepod	Crustacean-Parasite	**Significant**
Piscirickettsia salmonis	muskie pox	Bacteria	**Significant**
Pistia stratiotes	water-lettuce	Plant	**Significant**
Proterorhinus marmoratus	tubenose goby	Fish	**Significant**
Ranavirus sp.	largemouth bass virus	Virus	**Significant**
Renibacterium salmoninarum	bacterial kidney disease	Bacteria	**Significant**
Rumex longifolius	yard dock	Plant	**Significant**
Rumex obtusifolius	bitter dock	Plant	**Significant**
Schizopera borutzkyi	harpacticoid copepod	Crustacean	**Significant**
Sonchus arvensis variety glabrescens	smooth field sow thistle	Plant	**Significant**

Table 10. Species of Greatest Concern in the Mississippi River Basin.

Scientific Name	Common Name	Species Category	Combined Risk Value
Hypophthalmichthys molitrix	silver carp	Fish	**Acute**
Hypophthalmichthys nobilis	bighead carp	Fish	**Acute**
Channa argus	northern snakehead	Fish	**Acute**
Hydrilla verticillata	Hydrilla	Plant	**Acute**
Mylopharyngodon piceus	black carp	Fish	**Acute**
Alternanthera philoxeroides	alligator weed	Plant	**Severe**
Myocastor coypus	nutria	Mammal	**Severe**
Polygonum cuspidatum	Japanese knotweed	Plant	**Severe**
Salvinia spp.	Salvinia	Plant	**Severe**
Eichhornia crassipes	water hyacinth	Plant	**Severe**
Ctenopharyngodon idella	grass carp	Fish	**Severe**
Cyprinella lutrensis	red shiner	Fish	**Severe**
Ameiurus catus	white catfish	Fish	**Significant**
Botumus umbellatus	flowering rush	Plant	**Significant**
Ludwigia peploides	floating primrose willow	Plant	**Significant**
Ludwigia uruguayensis	Uruguayan primrose willow	Plant	**Significant**
Marsilea mutica	Australian water clover	Plant	**Significant**
Murdannia keisak	Asian spiderwort	Plant	**Significant**
*Tamarix.*spp.	western salt cedar	Plant	**Significant**

Table 11. ANS Fish of Concern in Mississippi River and Tributaries

	Acute	Severe	Significant
silver carp	4	2	
bighead carp	4	2	
black carp	2	2	1
northern snakehead	2	2	2
grass carp	1	1	4
red shiner	1	0	5
white catfish	0	0	1

Table 12. ANS Fish of Concern in Great Lakes

	Acute	Severe	Significant
sea lamprey	2	1	1
Eurasian ruffe	1	2	1
fourspine stickleback			1
tubenose goby			1

Table 13. ANS Plants of Concern in Mississippi River and Tributaries

	Acute	Severe	Significant
Hydrilla	2	2	1
water hyacinth	0	2	2
Salvinia	1	1	0
Japanese knotweed	1	0	1
Australian water clover	0	0	1
Uruguayan primrose willow	0	0	2

Table 14. ANS Plants of Concern in Great Lakes

	Acute	Severe	Significant
European frogbit	2	0	1
water chestnut	0	3	1
reed sweet-grass	1	0	1
fanwort	0	1	1
marsh thistle	0	2	0

Table 15. ANS Invertebrates of Concern in Great Lakes

	Acute	Severe	Significant
Hemimysis anomala		1	3
Cercopagis pengoi	0	1	4
Gammarus tigrinus	0	0	2
Echinogammarus ischnus	0	0	2
Neoergasilus japonicus	0	0	2
Cipangopaludina chinensis malleata	0	1	0
Cipangopaludina japonica	0	1	0

Table 16. Other ANS of Concern in Great Lakes

		Acute	Severe	Siginificant
Bacteria	cyanobacterium	0	1	2
Bacteria	muskie pox	0	1	1
Virus	largemouth bass virus	0	1	1
Bacteria	bacterial kidney disease	0	1	1
Algae	green alga (Starry stonewort)	0	1	0

surface water connection locations. This Asian carp information and the figures in Appendix H of the most significant species of concern by biological grouping were used to help inform individual ANS Transfer Risk Ratings at each potential pathway location.

The Asian carp are capable of traveling considerable distances through waterways although some in-stream obstructions may impede these movements at least temporarily. Figure 7 depicts the distribution of three Asian carp species; *Hypophthalmichthys molitrix* (silver carp), *Hypophthalmichthys nobilis* (bighead carp), and *Mylopharyngodon piceus* (black carp) in the Mississippi River and Ohio River drainage basins. Two of these species, the silver and bighead carps) are plantivorous feeding on phytoplankton and zooplankton (Hill and Pegg, 2008). The black carp is a benthic feeder feeding on mussels and insect larvae. A subset of the National Inventory of Dams http://geo.usace.army.mil/pgis/f?p=397:1:776693018070231) dataset is also depicted in these figures. This subset is restricted to structures that don't contain navigation locks and that are on the waterway leading from the Mississippi River or Ohio River to the potential connection sites and from the Great Lakes to the potential connection.

An important observation is that no Asian carp have been documented upstream of the most downstream structure. This may be a function of inadequate distribution records but suggests that dams without locks or fish passages likely impede upstream Asian carp migratory movements, at least temporarily. If this is true then it may be reasonable to expect that the higher the number structures that exist between the Mississippi River or Ohio River and the potential connection, the lower the relative risks at each potential connection of interbasin transfer.

Figure 8 illustrates the spatial distribution of the five species deemed to pose the most significant threat to the Great Lakes (silver carp, bighead carp northern snakehead Hydrilla and the black carp) and shows that the threat is greatest to Lake Michigan via northern IL and IN and southern MN. Outside the Chicago area the greatest threat is to Lake Erie from northern IN and OH. Hill and Pegg, (2008) using bioenergetics models of Asian Carp metabolism and Great Lakes resource availability, concluded that the silver and bighead carp, which are pelagic plankton feeders would be restricted to nutrient rich areas of the Great Lakes including embayments and the mouths of tributaries.

Threats to the Mississippi River drainage area are primarily from taxa clustered in northern MN and WI. These threats are primarily from the Eurasian ruffe, snails and weeds as

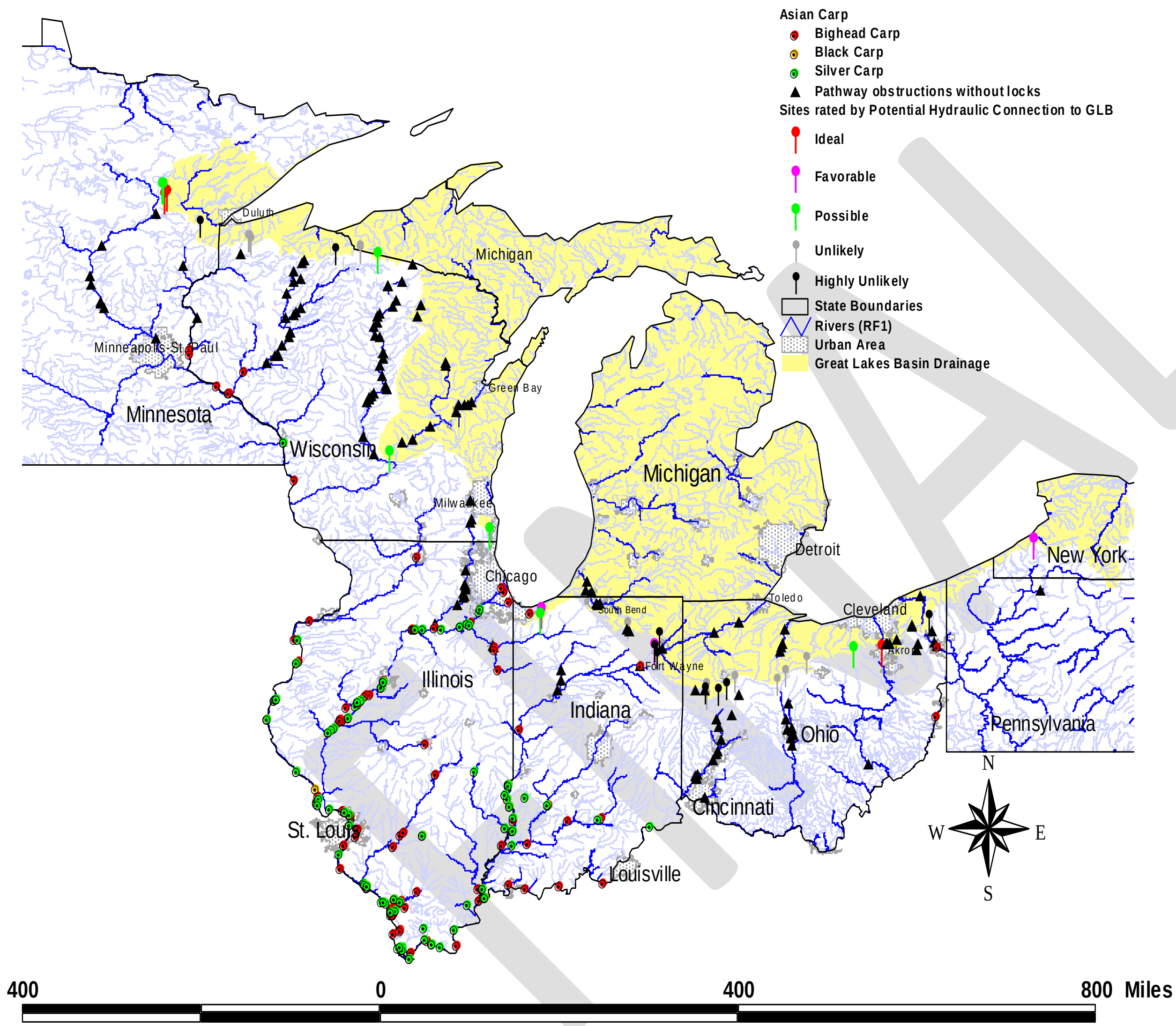

Figure 7. Hydrologic Risk Ratings Relative to the Spatial Distribution of Asian carp.

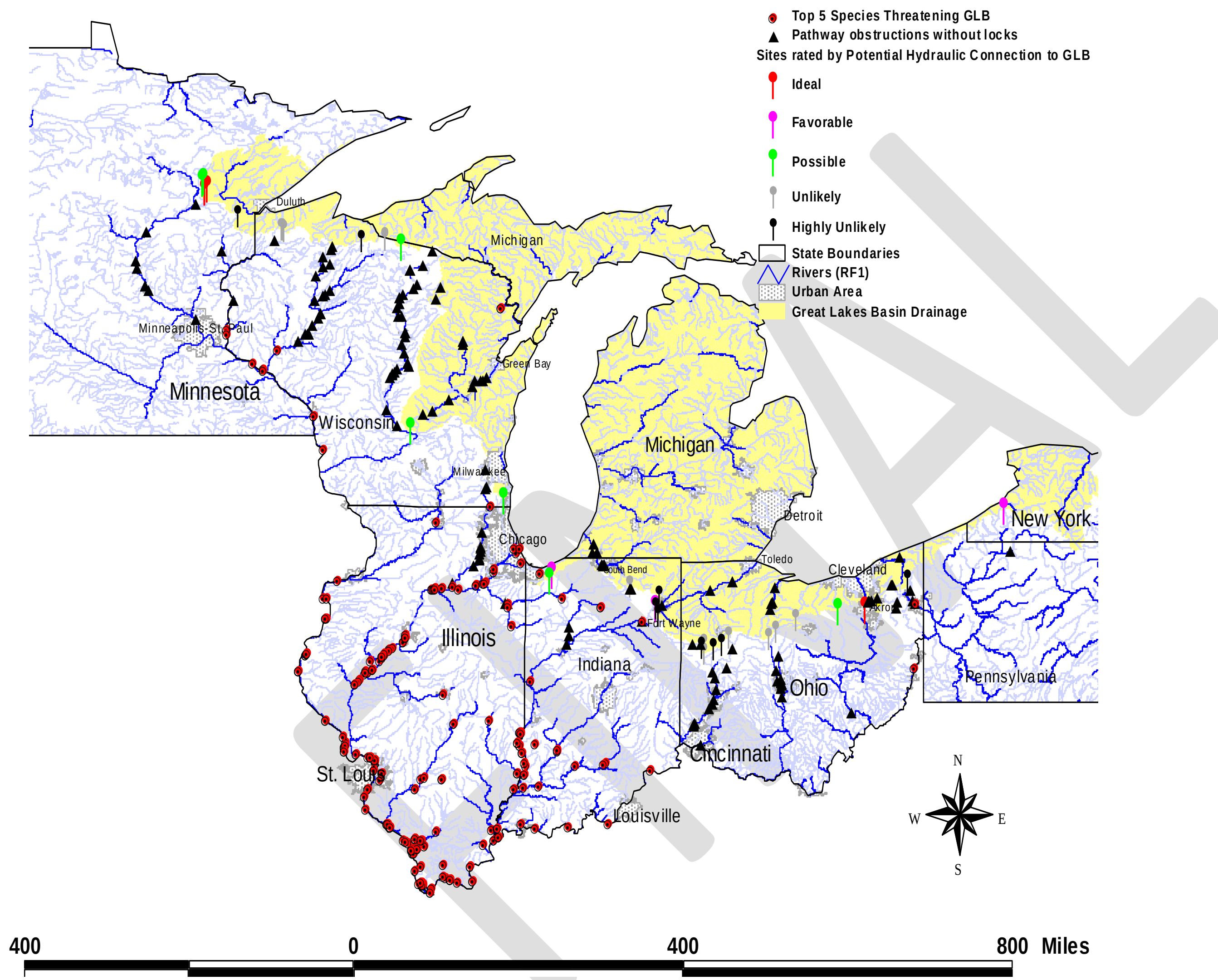

Figure 8. Hydrologic Risk Ratings at Each Potential Surface Water Pathway in Relation to Spatial Distribution of Top Five ANS Threatening the Great Lakes.

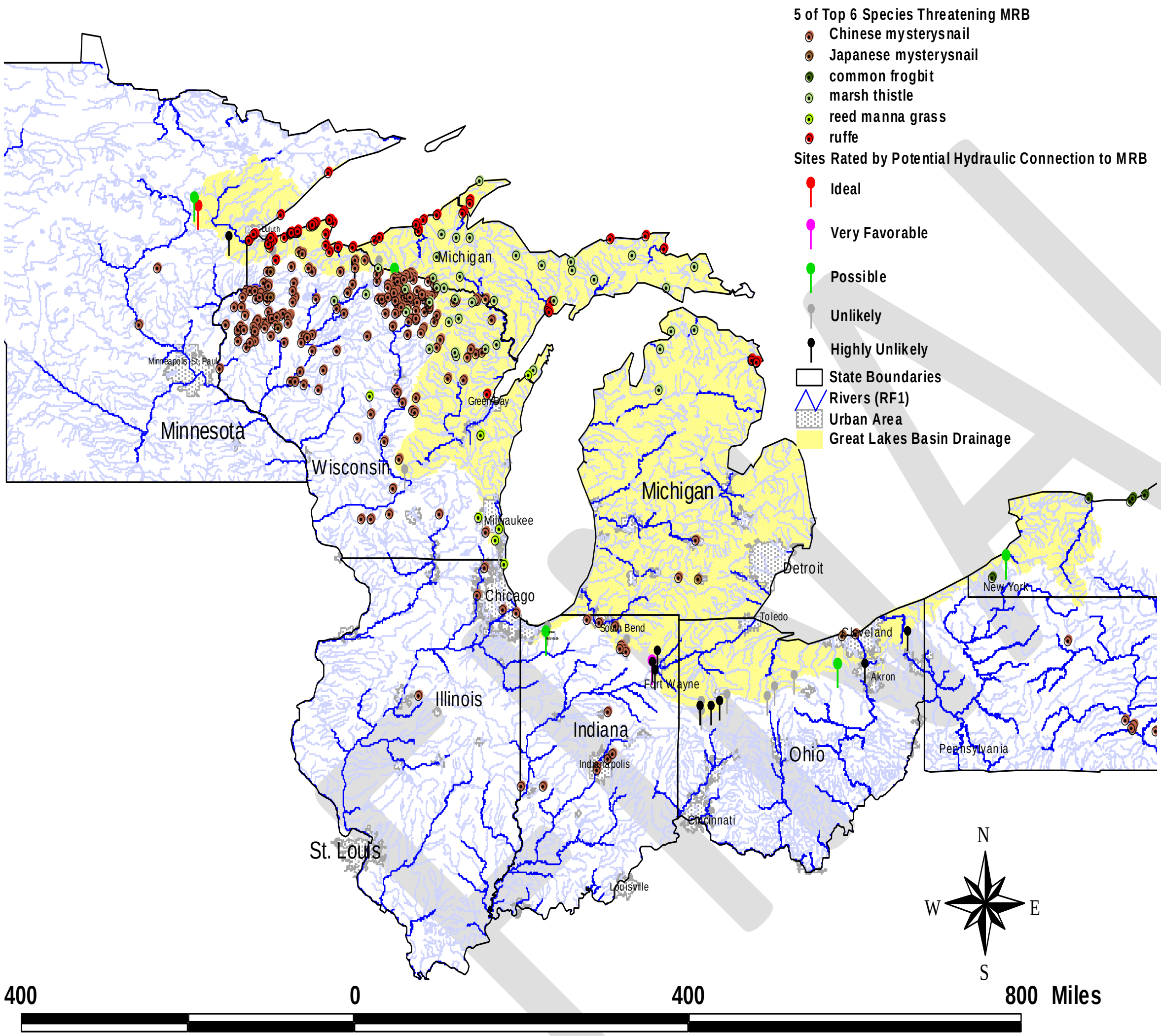

Figure 9. Spatial Distribution of ANS of Greatest Concern Threatening the Mississippi River and Tributaries.

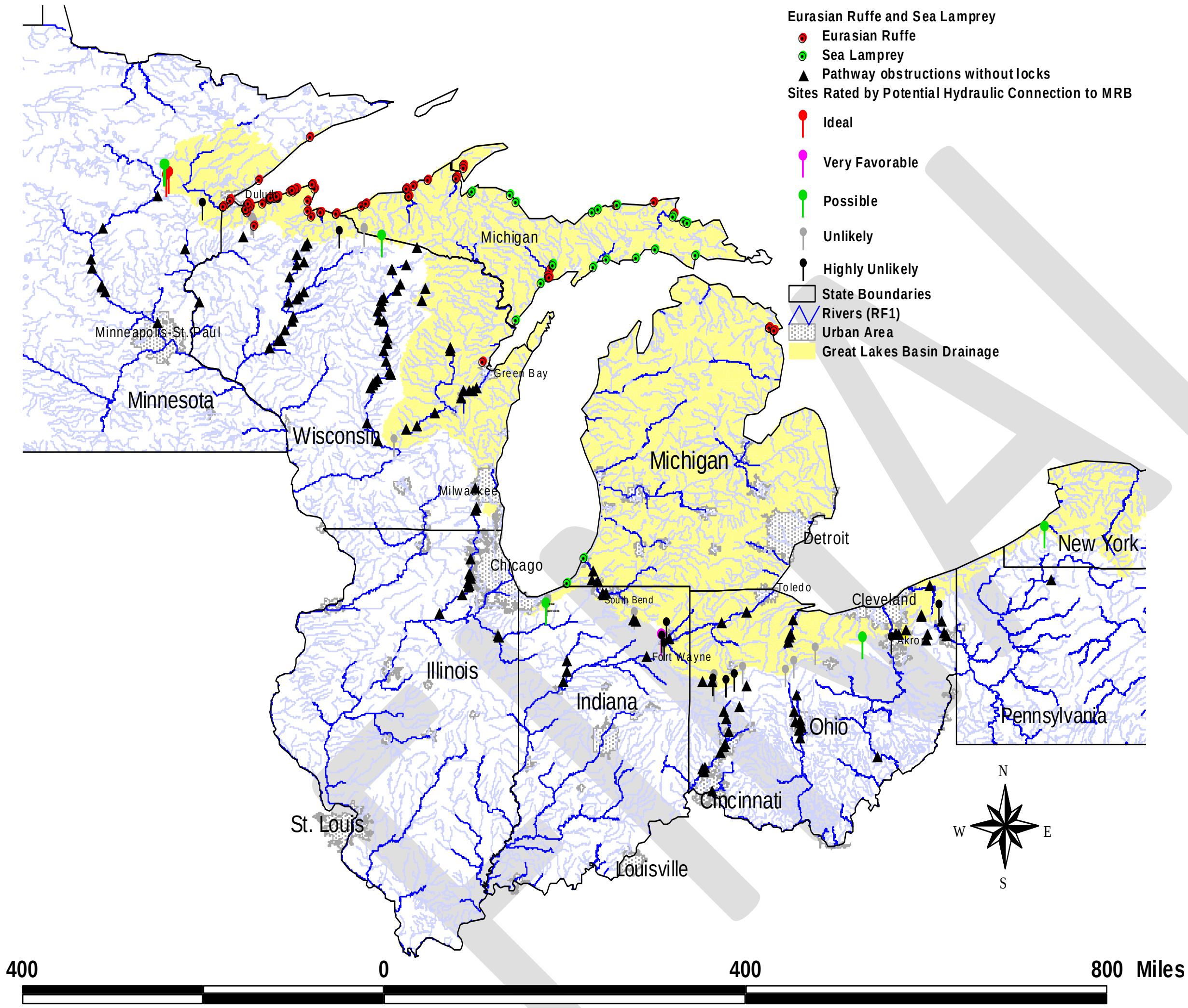

Figure 10. Invasive Fish Species in Great Lakes Threatening Mississippi River and Tributaries.

shown in Figures 9 and 10. Although the threat to the Mississippi and Ohio River drainages is less dramatic, the long-term implications associated with many of the potential ANS invaders is not well understood. ANS access to the large waterway networks of the two river systems and the lakes and reservoirs associated with them could result in major impacts to both ecology and economy.

It is evident from the tables and figures above that the greatest risk is invasion of the Great Lakes basin by the Asian Carp species, the northern snakehead, and the noxious weed *Hydrilla verticillata.* Twelve taxa were deemed to pose acute or severe risk to the Great Lakes basin whereas 16 taxa do the same for the Mississippi River and/or Ohio River basins. Five Acute Risk taxa threaten the Great Lakes although the list above identifies far more potential invaders into the Mississippi River and/or Ohio River basins. The dominant threat to the Mississippi River or Ohio River basins is posed by the Eurasian ruffe, followed by snails, weeds and the sea lamprey.

The third step in the ANS risk characterization was the evaluation and assignment of an ANS Risk Rating to each potential surface water connection based on the best professional judgment of the team experts. The USGS invasive species database was used to generate maps to depict the locations where the most significant ANS have been collected as well as displaying potential connections, small dams that lack lock structures, and the basins' drainage divide to assist in this analysis. A tally of responses of the six ANS Team experts produced the assignment of the ANS Transfer Risk Ratings for each location in both directions presented in Table 17, and Table 17 prioritizes the aquatic pathways in order of ANS Transfer Risk from greatest to smallest. Eighteen of the 31 potential connections given a hydrological rating were deemed to pose a significant risk in one or both directions.

It is important to note that the ANS Transfer Risk Ratings are subjective estimates based on experts' professional judgment of the best available data that could be compiled within a constrained timeframe. The flat topography along much of the Divide and the large array of species in various taxonomic groups pose complicated engineering and science problems to the performance of a quantitative risk characterization. Likewise, obstructions along the waterway,

volumes, depths, velocities, water chemistries, and many different ecosystem interactions are other important variables with inherent uncertainty that complicate the risk characterization.

Table 17. Location Specific ANS Transfer Risk Ratings.

Rank	Name	County	State	ANS Transfer Risk into GLB	ANS Transfer Risk into MRB
1	Eagle Marsh Fort Wayne	Allen	IN	Acute	High
2	Ohio and Erie Canal at Long Lake	Summit	OH	Acute	Medium
3	Libby Branch of Swan River	Aitkin	MN	High	High
4	Swan River	Itasca	MN	High	Medium
5	Little Killbuck Creek	Medina	OH	Medium	Medium
5	East Mud Lake	Chautauqua	NY	Medium	Medium
5	Brule Headwaters Portage	Douglas	WI	Medium	Medium
5	Jerome Creek	Kenosha	WI	Medium	Medium
5	W. Menomonee Falls	Waukesha	WI	Medium	Medium
5	S. Aniwa Wetlands	Marathon-Shawano	WI	Medium	Medium
5	Parker Ditch - Cobb Ditch	Porter	IN	Medium	Medium
6	Portage (Upstream)	Columbia	WI	Medium	Low
6	Portage (Downstream)	Columbia	WI	Medium	Low
7	Grand Lake-St Mary's	Mercer	OH	Low	Medium
7	Mosquito Lake - Grand River	Trumbull	OH	Low	Medium
7	Rosendale - Brandon	Fond du Lac	WI	Low	Medium
7	Hatley-Plover River	Marathon	WI	Low	Medium
7	Loomis Lake	Porter	IN	Low	Medium
8	Tymochtee - Scioto	Marion	OH	Low	Low
8	Geller Ditch - Roy Delagrange Ditch	Allen	IN	Low	Low
8	S. Menomonee Falls	Waukesha	WI	Low	Low
8	Pardeeville	Columbia	WI	Low	Low
8	Tri County State Reserve - Lake Wawasee, IN	Kosciusko	IN	Low	Low
8	Woods Ditch - Harbor Ditch	Allen	IN	Low	Low
8	Barnes Creek - Kopp Creek	Auglaize	OH	Low	Low
8	Clear Creek-Loramie Creek	Shelby	OH	Low	Low
8	Miami and Erie Canal near the City of Minster	Auglaize	OH	Low	Low
8	Muchinippi Creek-Auglaize River, OH	Auglaize	OH	Low	Low
8	Pusheta Creek - Willow Creek	Auglaize	OH	Low	Low
8	Portage (Canal)	Columbia	WI	Low	Low
8	Twin Lake	Iron	WI	Low	Low

4.2.1 Acute and High Risk Locations

4.2.1.1 Eagle Marsh – Fort Wayne, IN

A detailed Trip Report is included in Appendix E detailing the information gathered and evaluated for this study at the Junk Ditch connection with the Graham McCulloch Ditch at the Eagle Marsh in Fort Wayne, Indiana. The following is a summary of the conclusions in that report. Coordinating stakeholder agencies met on Friday, July 09, 2010 at Eagle Marsh in Fort Wayne, Indiana to discuss the surface water connection that develops there during flooding events.

Floodwaters backflow from the Saint Marys River in the Maumee River Basin through Junk Ditch and the Eagle Marsh into the Graham-McCulloch Ditch in the Wabash River Basin. Representatives from Allen County Soil and Water Conservation District (SWCD), Indiana Department of Natural Resources (InDNR), Little River Wetlands Project (LRWP), Maumee River Basin Commission (MRBC), U. S. Department of Agriculture Natural Resource Conservation Service (NRCS), U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE), and U.S. Environmental Protection Agency (USEPA) Great Lakes National Program Office met and reviewed results of a 2009 Flood Insurance Survey along with various maps, aerial photos, and charts relevant to the backflow of water across the basin divide.

Two of those depictions are presented as Figures 11 and 12, which show the extent of the inundated area spanning the Divide in the vicinity of Fort Wayne during a 1% annual return frequency storm (hypothetical storm estimated to be equivalent to the largest flood event that would occur in a 100-year period). The inundated areas in both figures is shaded light blue, and the location of the drainage divide that generally cuts from top to bottom is the orange line in regional view shown in Figure 11 and the green line in the local view shown in Figure 12. The arrows on Figure 12 depict the normal flow direction. During flooding, the flow direction is west from the Saint Marys River to the Little River.

Figure 11. Map of 100-year floodplain spanning the Divide through Eagle Marsh in Fort Wayne, Indiana.

Figure 12. Closer view of the 100-year floodplain through Eagle Marsh in Fort Wayne, Indiana.

The 1% frequency storm elevation is 755.6 ft mean sea level (MSL) at the basin divide, and Light Detection and Ranging (LiDAR) mapping indicated perennial water elevation in the marsh ponds is approximately 749.0 MSL. USGS indicated general consensus among their

experts that a 10% frequency event would allow for sufficient water depths where Asian carp could swim through this connection. However, the USGS expressed concern with the level of the modeling used to support the 2009 Flood Insurance Study, and noted that a more sophisticated hydrological modeling approach might be necessary to accurately estimate the water elevation, flow rate and total volume of flow into the Marsh from a design storm event.

Figure 13. Left is a Bighead carp found, in 2004 near Huntington IN.   Right is a small dam in Huntington that could impede the upstream migration of Asian carp toward Eagle Marsh.

Figure 13 contains two photographs. On the left is a photograph of a bighead carp that was found in 2004 during repairs to the downstream stilling basin at the Roush Dam on the Wabash River in Huntington, Indiana. The photo on the right shows the only known impediment on the Little River to the upstream migration of Asian carp, a deteriorated fixed crest dam approximately 6-feet high.   Roush Dam is approximately 22 river miles downstream of the Eagle Marsh. The confluence of the Little River with the Wabash River occurs on the west side of Huntington, and the Little River extends east to the Eagle Marsh on the west side of Fort Wayne. The Indiana DNR reported Asian carp spawning in the Wabash River near Lafayette, Indiana approximately 100 river miles below the Eagle Marsh.

All stakeholders present concurred that the risks of Asian carp reaching the Great Lakes through this connection warranted prompt implementation of a permanent measure, but that additional information and some time are needed to develop and implement an appropriate

long-term solution. An interagency Steering Committee was formed among the agencies represented at the July 9, 2010 on-site meeting to shepherd implementation of the recommended interim risk reduction measures and complete a USACE planning study to formulate alternatives and select a proposed plan to mitigate the risks of ANS interbasin transfer through this location in both directions.

4.2.1.2 Long Lake Summit County, OH

Appendix F presents detailed information compiled and used as the basis to determine the Ohio and Erie Canal connection with Long Lake location poses an Acute Risk for ANS Transfer into the Great Lakes Basin and a Medium Risk for ANS Transfer into the Tuscarawas River in the Ohio River. The Long Lake connection to the Erie Canal in Summit County, OH south of Akron, OH poses a significant risk because of the gate connections to both the Great Lakes via the Erie Canal and the Ohio River via the Tuscarawas River. The aquatic habitat available near the connection points accentuates the potential ANS interbasin transfer risks at this location. A gated spillway that overflows to the Tuscarawas River is located at the northeast end of the lake.

The Tuscarawas River flows into the Muskingum River and then into the Ohio River. Near the flood gates are a set of two feeder gates that discharge to the Ohio and Erie Canal which flows to the Little Cuyahoga River, to the Cuyahoga River and then Lake Erie. If ANS ever get into Long Lake they will have access to either the Great Lakes Basin or the Ohio River Basin. In addition to the gate connections at Long Lake, another possible connection exists because of the parallel flow of the Tuscarawas River and the Ohio and Erie Canal. These two waterways are within 300 feet of each other at their closest with only a five foot canal embankment separating them. Figures 14 and 15 illustrate the interconnecting and parallel waterways and the Long Lake control structures, respectively.

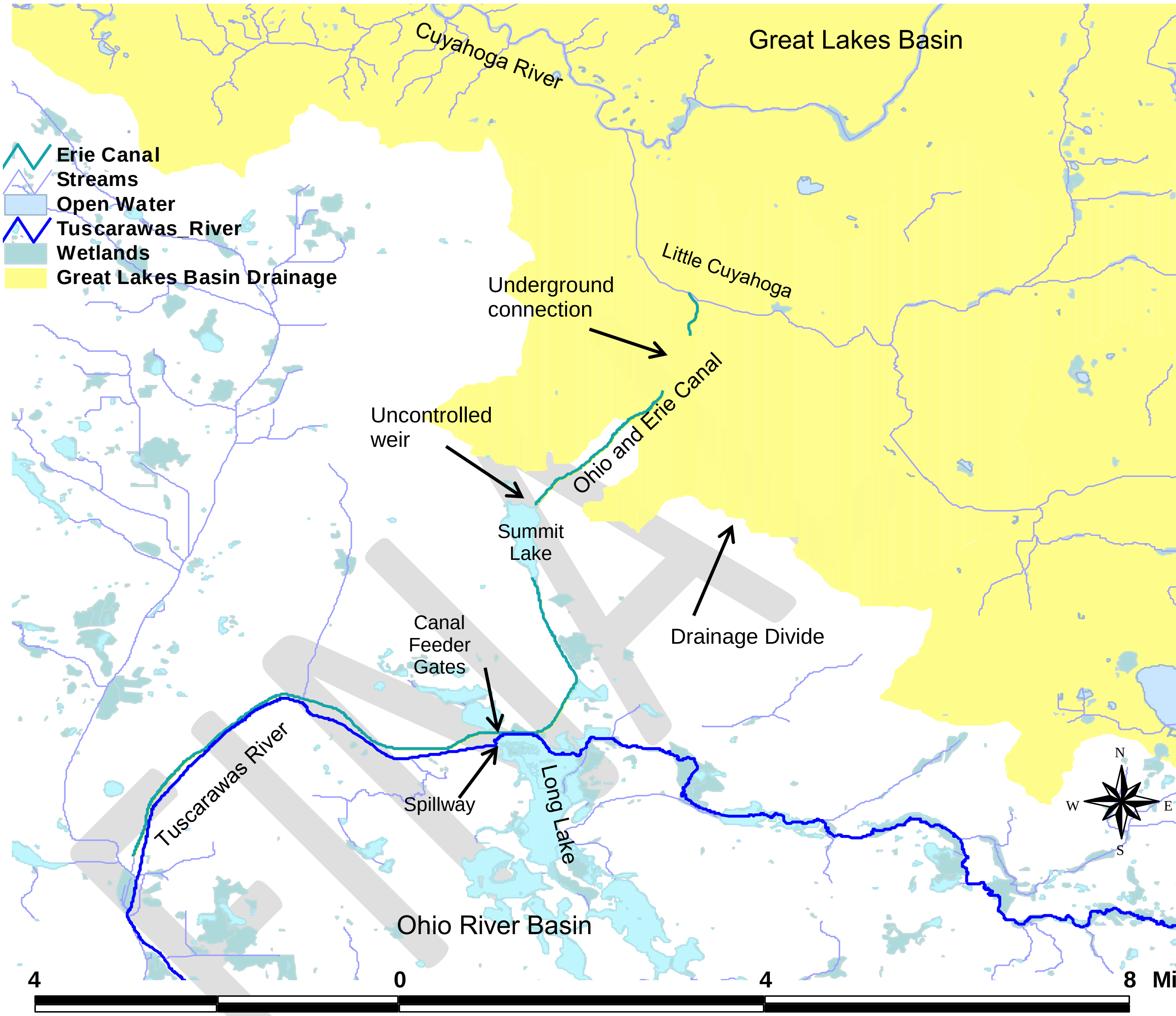

Figure 14. Area map of the river and canal system near Long Lake.

Figure 15 depicts the ease with which water can flow to either the Ohio River drainage basin through the Tuscarawas River or into the Great Lakes by passing through the feeder gates into the Ohio and Erie Canal. The gated spillway between Long Lake and the Tuscarawas River are separated by a five foot drop into the Tuscarawas River but under high water conditions the difference can be as little as one foot (ODNR, 2010), which would not be a significant

impediment to upstream migration of Silver carp. The waterway between the Ohio River and the upper Tuscarawas River at Long Lake is obstructed by ten Lock and Dam facilities on the Muskingum River, with a maximum dam height in the NID listed as 20 feet. However, there was insufficient time to allow an inspection or detailed evaluation of these structures relative to migration of species like the Asian Carp.

Figure 15. Low altitude photograph from NAVTEQ and bing Maps of the Northeast end of Long Lake in Summit County, OH.

There is one major dam structure without locks (Dover Dam near Dover, OH) on the Tuscarawas River. Review of the NID data for this dam indicated that it may be an insurmountable impediment to direct aquatic movement of species from the Ohio River (Figure 16). However, closer evaluation revealed that this flood control dam allows for direct flow through the Dover Dam during low water periods. Entering Long Lake from either direction would be difficult, however, conditions may periodically exist that would make it possible for some ANS fish to enter Long Lake from the Tuscarawas River.

Dover Dam is located approximately 62.6 miles above the mouth of the Tuscarawas River and about 173.6 miles above the mouth of the Muskingum River. The dam has a maximum height of 83 ft above the streambed (Stockstill and Vaughn, 2009). The outlet works, located at the base of the spillway section, consist of 18 gate-controlled conduits arranged in groups of six each at three different levels. Figure 17 provides a photograph of the structure. This structure was originally thought to be an obstruction that completely severed the potential upstream migration of fish; however, a closer look into the configuration and operation of the dam revealed that during low flow, the water column through the dam is open and would readily facilitate fish passage.

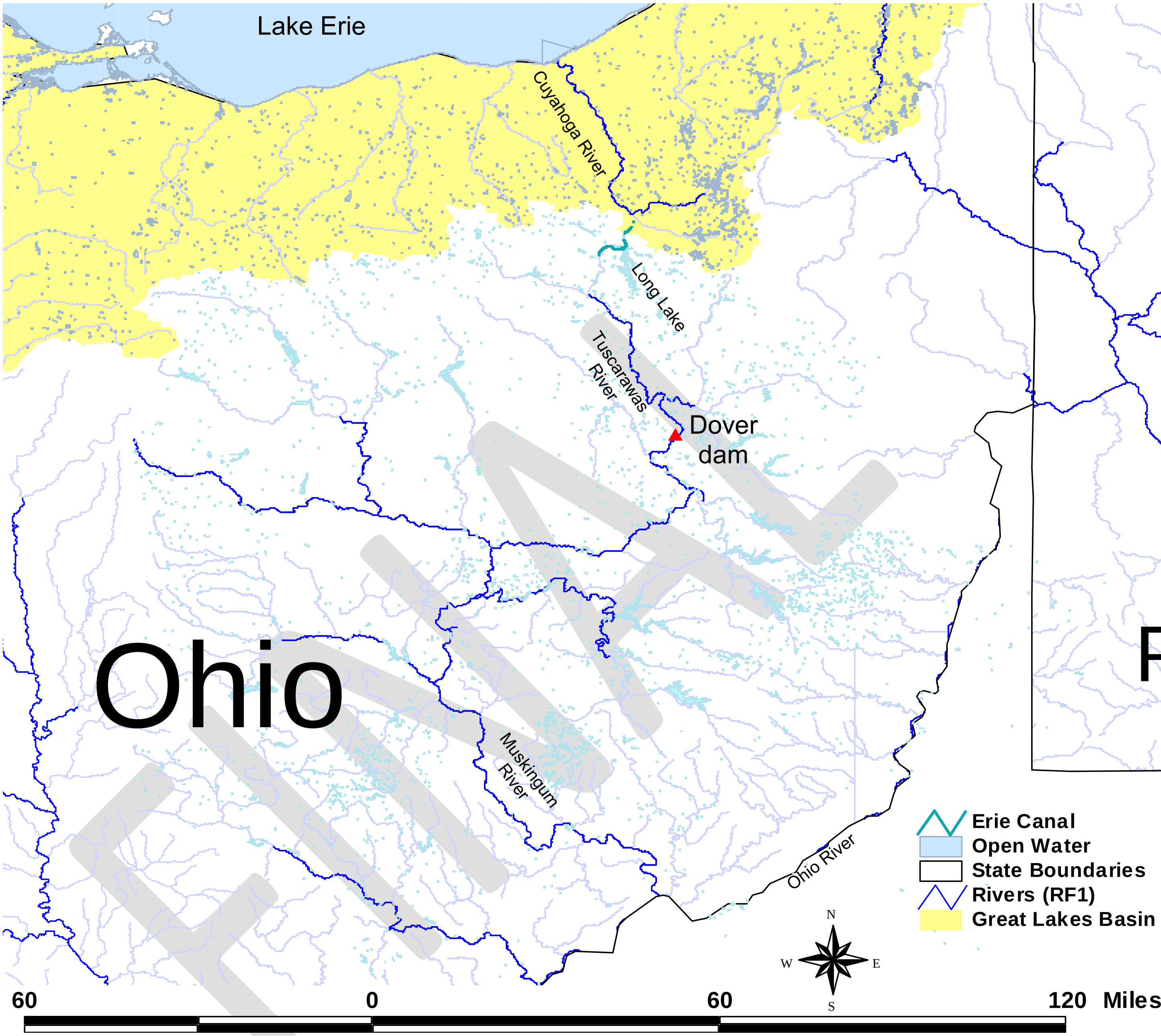

Figure 16. Regional map of connecting streams between the Ohio River and Lake Erie potentially facilitated by the possible connections at Long Lake.

Figure 17. Photograph of Dover Dam on the Tuscarawas River in Dover, OH. Photograph is from the Huntingdon District: http://www.lrh.usace.army.mil/_storage/Photos/2681.jpg.

4.2.1.3 Wetlands of Libby Branch and the Swan River in Itasca and Aitkin Counties, MN

The Libby Branch Swan River was rated High Risk for ANS Transfer both into and out of the Great Lakes Basin. This location was rated the third highest risk primarily due to the apparent perennial hydraulic connection between the basins and the extensive critical wetlands habitat in the area. The nearby Swan River location was the fourth highest rated location, rated High Risk for ANS Transfer into the Great Lakes and Medium Risk for ANS Transfer into the Mississippi River. This large flat area of wetlands and bogs in east central Minnesota is known as the Tamarack Lowlands, and it is one of the top wildlife-watching sites in Minnesota and the nation due to its extensive wetland vegetation and high percentage of public land (MNDNR 2006). The risk ratings are due to the extensive network of canals and habitat available near

the connection points. Appendix C provides aerial photographs, illustrations and assessment results and notes for the locations evaluated in Minnesota.

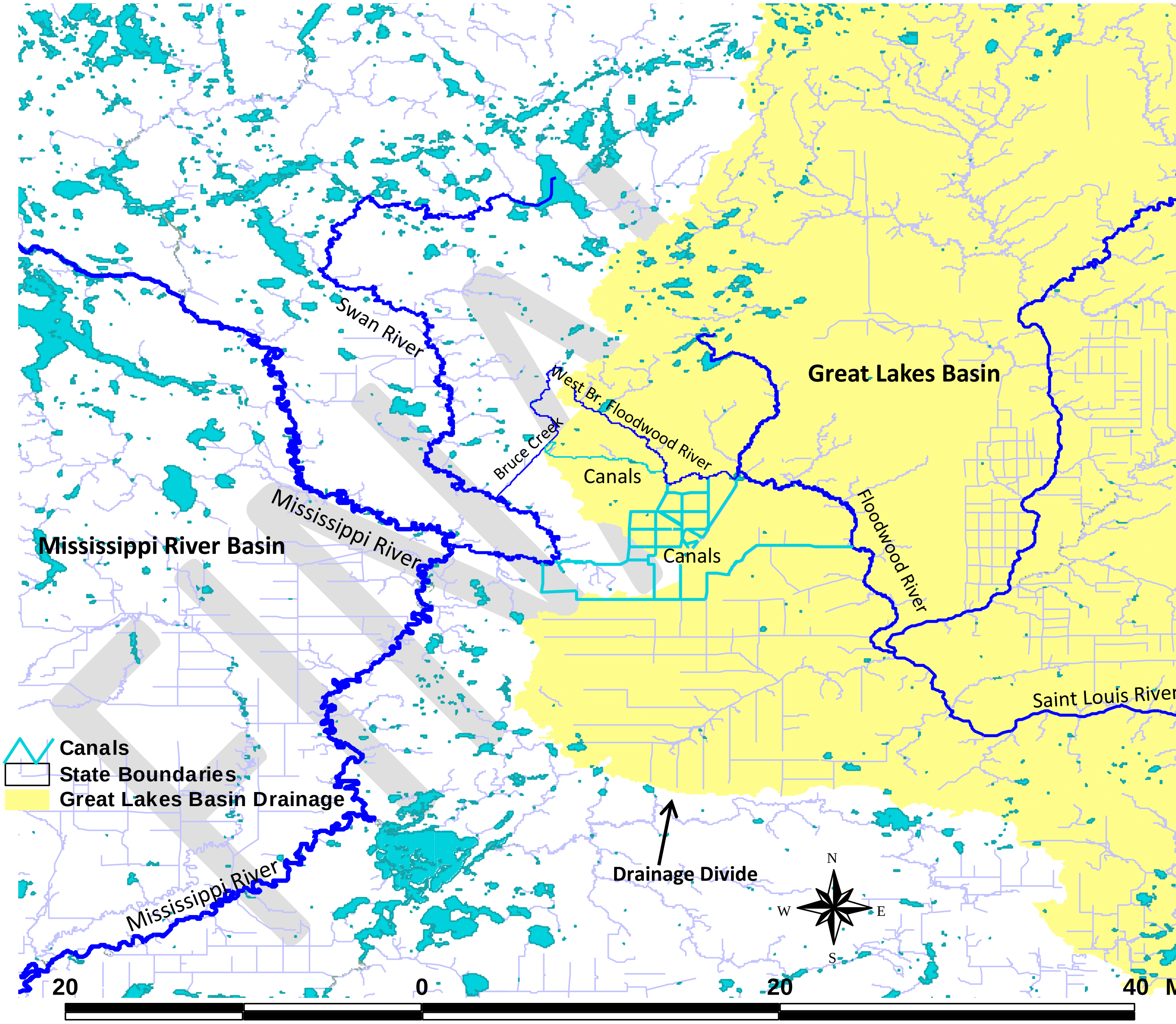

Figure 18. Local area view of the wetlands and canals connecting the Floodwood River / Saint Louis River systems and the Swan River Mississippi River systems.

The Libby Branch location is also about 12 miles north of the Savanna Portage State Park, an approximately 6-mile long marshy corridor across the Divide, which connects the East Savanna River, a tributary to the Saint Louis River, to the West Savanna River, a tributary to the Mississippi River. The East Savanna River lies in a former alignment of the Mississippi River, which existed prior to the current extent of the more rapidly down cutting Saint Louis River. This location was cited as one of the most important links between the ancient alignments of the upper Mississippi and the St. Lawrence Rivers because the surface waters of the two dominant river systems appear to approach each other more closely here than at any other point (Hart 1932).

Figure 18 depicts this general area of concern. An important characteristic of the Libby Branch location, besides the canals, is the location in the two watersheds being connected. Both the Swan River and Floodwood River systems have large drainage areas upstream of the points where connections are expected. Rather than being at the headwaters of these systems it is possible excess flow from either river system may backflow through the drainage canals.

Figure 19. Photographs of waterways in the Aitkin County, MN wetlands taken by hydrologists from the Detroit District, USACE.

Figure 19 is a collection of three photographs taken of waterways in the Aitkin County, MN wetlands complex between the Floodwood River and the Swan River. This network with

large open water areas may provide suitable habitat for ANS, from which, they could stage an interbasin invasion during the periods of the year when this area is thawed.

There are six dams on the Upper Mississippi River, and 20 structures on the Saint Louis River, that interrupt a continuous surface water pathway and pose significant obstacles to upstream migration of ANS to the location of this apparent perennial connection spanning the Divide. Figure 20 presents the locations of these structures relative to the wetlands connections in Aitkin County, MN.

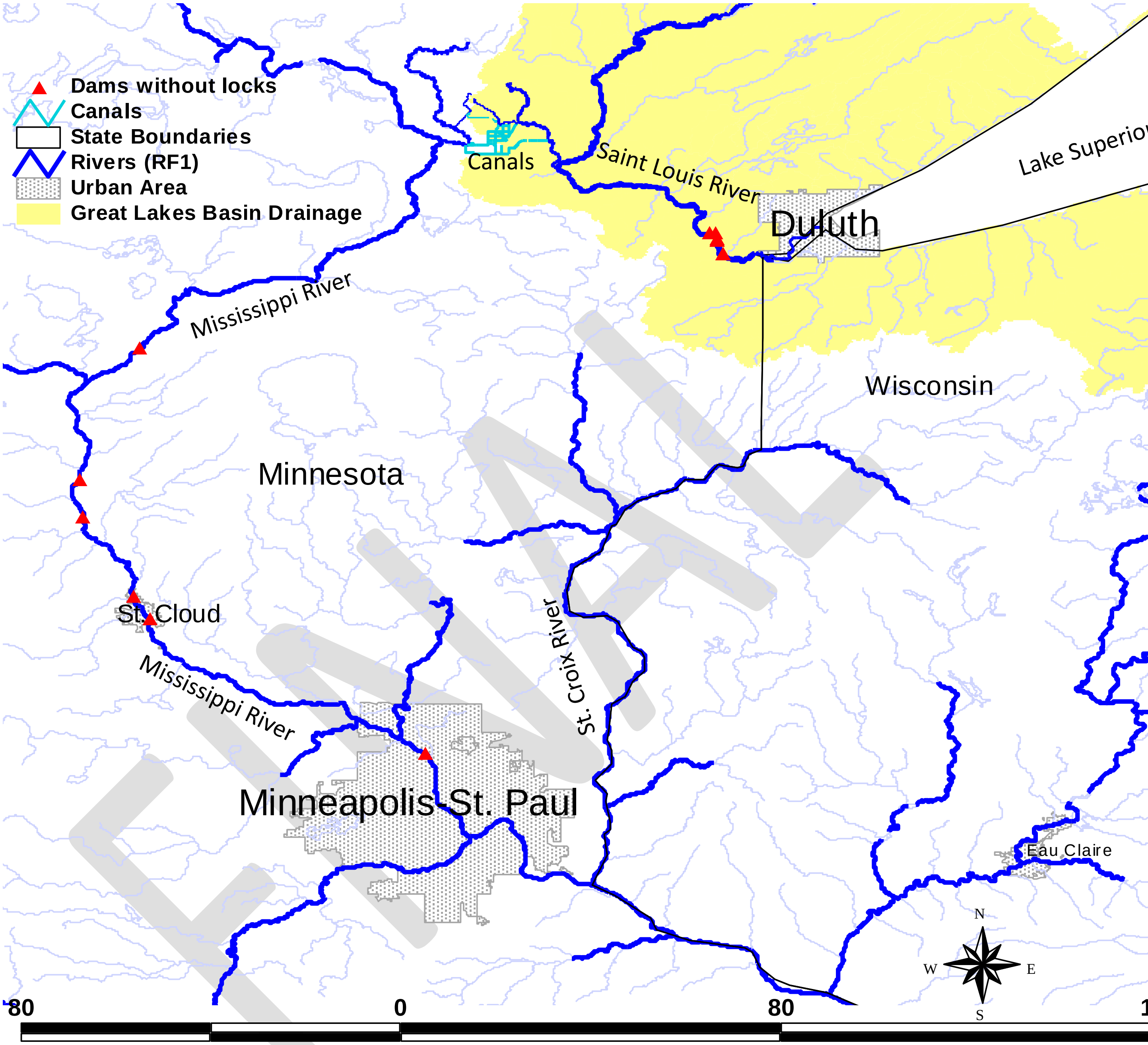

Figure 20. Regional map showing the dams on the Mississippi River and Saint Louis River.

Many of the dams were built for hydropower such as the Cloquet dam on the Saint Louis River at Cloquet, MN shown in Figure 21. Although, the in-stream obstacles may impede or prevent upstream migration, it is also necessary to consider that these obstacles may be obviated inadvertently by ANS transport via other means such as bait buckets, bilge water,

human catch and release, etc. These other vectors may or may not directly transport ANS into the other basin, but these sorts of actions may deliver the ANS to a location close enough to take advantage of the aquatic connection and then facilitate invasion of the other drainage basin when the right hydrologic conditions occur.

Figure 21. Cloquet Dam on the Saint Louis River in Cloquet, MN. Low altitude photograph from NAVTEQ and Bing Maps looking upstream.

4.2.2 Medium Risk Locations

4.2.2.1 Portage, WI

There were three potential connection locations identified in proximity to Portage, Wisconsin, Upstream, Canal and Downstream. The Portage Canal was built by the USACE between 1838 and 1876, and it connects the Wisconsin River in the Mississippi River Basin with the Fox River in the Lake Michigan drainage basin. Canal operations ceased in 1951, and the ownership was transferred to the state of Wisconsin. The Portage Canal is on the National and

State Registers of Historical Places, and the Wisconsin DNR has managed the property since 1981.

Both the Upstream and Downstream locations were deemed to pose Medium Risk for ANS Transfer into the Great Lakes Basin, primarily due to connection of inundated areas of the Fox and Wisconsin Rivers in hydrologic models of the 1% annual return frequency storm (100-year storm).

The Canal location was deemed to pose a Low Risk for ANS interbasin transfer because there is a closed gate preventing surface water flow across the man-made connection at this point. Portions of the canal have been filled in with contaminated materials, and the long-term status of the canal remaining closed is uncertain. If the Canal and/or the gate are reopened, that ANS interbasin transfer rating for this location would change to a rating of Medium or higher.

A significant factor in the interbasin ANS Transfer Risk Ratings assigned to these three locations is the presence of the Prairie du Sac Dam on the Wisconsin River about 23 miles downstream of Portage, WI. The Prairie du Sac Dam was the most downstream lock and dam on the Fox River-Portage Canal-Wisconsin River canal system. Since the system was closed in 1951, the Wisconsin River has cut a deeper channel downstream of the dam that has left the lock unusable, and the dam appears to be a significant impediment to upstream migration of fish. Flood levels came within several inches of the highest ever recorded in Portage during the last week of September 2010, and a representative of the Wisconsin DNR indicated that the flooding may have helped identify another location downstream of Portage where a surface water connection between waters of the Fox River and the Wisconsin River may have occurred.

4.2.2.2 Other WI locations

Appendix D provides separate subsections for each of the 12 locations in Wisconsin evaluated for this report that depict the information used to conduct the assessment and the sources of that information for each location.

4.2.2.2.1 W. Menomonee Falls and Jerome Creek

Two urban/suburban potential surface water connection locations in eastern Wisconsin were rated as posing a Medium Risk for ANS interbasin transfer in both directions, one in Menomonee Falls labeled W. Menomonee Falls and the other labeled Jerome Creek located between Kenosha and Pleasant Prairie. At both locations, storm drain features have the potential to facilitate interbasin flow during a large storm event. There are no significant dams or in stream features between either of these locations and Lake Michigan.

There do not appear to be any significant dams on the Des Plaines River that would impede ANS migration upstream from the Illinois and Mississippi Rivers to the potential connection between Jerome Creek and the urban/suburban drainage system in south Kenosha and Lake Michigan. Relative to the W. Menomonee Falls location, there are approximately 15 dams located on the Fox River (not the same Fox River that flows from Portage to Green Bay) above its confluence with the Illinois River, but most appear to be low head dams where upstream passage may be possible during high water conditions.

4.2.2.2.2 Hatley-Plover, Rosendale-Brandon and S. Aniwa

These are three rural wetland locations in Wisconsin that were rated as Medium Risk for ANS transfer into the Mississippi River Basin; labeled Hatley-Plover, S. Aniwa and Rosendale-Brandon. At each of these locations, there is an overlap of a mapped flood hazard (See Appendix D) area across the drainage divide between the Lake Michigan and Mississippi River Basins, indicating a surface water connection may form at a 1% annual return frequency storm. There is significant natural habitat important to native species and likely amenable to ANS too.

The Rosendale-Brandon location is a wetland located about midway between these two rural communities about seven miles apart in east central Wisconsin. North of the drainage divide, agricultural and roadside ditches connect to the West Branch Fond du Lac River, which flows into the Fond du Lac River through Lake Winnebago and the Lower Fox River to Lake Michigan at Green Bay. There are 11 dams on the Lower Fox River, including 9 federal dams operated by the USACE Detroit District. South of the drainage divide, surface water flows via

the wetland into the West Branch Rock River, through the Horicon Marsh and the Rock River into the Mississippi River just downstream of Rock Island, IL. The National Inventory of Dams lists 21 dams associated with the Rock River in Wisconsin and 29 in Illinois, but it is not readily apparent which, if any, of these would be an impediment to ANS migration.

The potential surface water connection locations labeled S. Aniwa and Hatley-Plover are rural wetland areas situated in the headwaters of the Plover and Embarrass Rivers about eight miles apart. The wetlands south of the Aniwa, WI location appear to drain west into a tributary of the Plover River, as do the wetlands located east of Hatley, WI, which also flow into a tributary of the Plover River.

The Plover River flows south-southwest to its confluence with the Wisconsin River at the town of Plover, WI. To the east of the drainage divide, both the S. Aniwa and Hatley-Plover wetlands appear to connect to headwater tributaries to the Embarrass and South Branch Embarrass River, respectively. The Embarrass River flows into the Lower Fox River, where there are 11 dams, including 9 federal dams operated by the USACE Detroit District, before water enters Lake Michigan via Green Bay. There are several dams on the Wisconsin River that would inhibit migration of ANS from the Mississippi River, including the Prairie du Sac Dam on the Wisconsin River, which has more than 40 feet of head and would prevent the upstream migration of species from the Mississippi River.

4.2.2.3 Other Indiana Locations

Appendix E provides separate subsections for each of the 5 locations in Indiana evaluated for this report, which depict the information used to conduct the assessment and the sources of that information for each location.

The Parker Ditch-Cobb Ditch location in northwest Indiana was rated as Medium Risk for ANS Transfer in both directions due to an agricultural ditch that connects to streams on both sides of the basin divide. This is a very flat area with rich soils that has been cleared and extensively ditched and tiled to support large scale agricultural use, which affords great opportunity for surface water flow to develop across the basin divide.

The Loomis Lake location, also in northwest Indiana, was rated as posing a Medium Risk for ANS transfer into the Mississippi River Basin due to a conduit that connects Loomis Lake on the Lake Michigan side of the basin divide with Flint Lake on the other side of the divide. There is a 13-foot drop in elevation over the 900-foot length of the conduit from the spillway of Loomis Lake to the outlet to Flint Lake, so water flows from the Great Lakes basin into the Mississippi River Basin by design at this location.

4.2.2.4 Other Ohio Locations

Appendix F provides separate subsections for each of the 10 locations in Ohio evaluated for this report that depict the information used to conduct the assessment and the sources of that information for each location.

4.2.2.4.1 Little Killbuck Creek

The Little Killbuck Creek location is in the glaciated Allegheny Plateau region in northeast Ohio, and it appears that Little Killbuck Creek was formed from the overflow of a glacial lake that formed south of the Killbuck sublobe of the Erie Lobe of the Laurentide Ice Sheet. It was rated as Medium Risk in both directions for interbasin transfer of ANS primarily because FEMA Flood Hazard mapping indicates inundation occurs across the divide from a 1% annual return frequency storm. One ANS expert noted that the shallow tortuous streams and agricultural ditches on either side of the divide might not be amenable to Asian carp migration, but that this location might provide ideal habitat and facilitate interbasin transfer of a fish such as the Snakehead.

4.2.2.4.2 Mosquito Lake Grand River

The Mosquito Lake – Grand River location is in a wetland area at the northwest end of Mosquito Lake, also in the glaciated Allegheny Plateau region in northeast Ohio. Although local experts indicate there has never been a completed surface water connection form at this location, it was rated as posing Medium Risk for transfer of ANS into the Ohio River Basin. The

large dam at the southern end of the lake precludes any possible upstream migration of ANS into the Great Lakes Basin via a surface water pathway from the Ohio River Basin.

4.2.2.5 New York Location - East Mud Lake

The East Mud Lake location is in far western New York, and lies in a relatively narrow glacial valley in the glaciated Allegheny Plateau Region, which is clearly illustrated in the figures and photographs in Appendix G. Aerial photographs indicate water flow south across the basin divide from East Mud Lake into the headwaters of the North Branch Conewango Creek. A local person interviewed during a site visit by a representative of the New York State Department of Environmental Conservation indicated that the actual drainage divide is located farther to the north than is indicated by the 12-digit HUC boundary at this location. This is the highest elevation of any of the locations evaluated, and it would be very difficult for ANS to access the location from Lake Erie or the Ohio River solely via the surface water pathway. However, if ANS reached the plateau by other means, then they could likely traverse the divide and enter the other basin.

5 Conclusions

The objective of this study was to complete a Preliminary Inter-basin Connections Risk Characterization report by the end of September 2010 that:

- Provides a comprehensive inventory of all surface water connections between the Great Lakes and Mississippi River Basins;
- Characterizes the relative risks at each potential connection in relation to the transfer of Aquatic Nuisance Species; and
- Provide a basis for prioritizing the connections according to relative risk and scoping a path forward at each potential connection.

The focus of the study area, the drainage divide between the Great Lakes and the Mississippi River and its tributaries, was defined as the 12-digit HUC boundary between the Great Lakes and the Mississippi and Ohio River Basins, which extends from western New York west through Ohio and Indiana and to the north and west in Wisconsin, and Minnesota. The project team identified and evaluated 36 potential surface water pathways in the study area to determine if a continuous water connection exists or may form from up to a 0.2% annual return frequency storm.

It is unlikely that there are surface water pathways where there are large volumes or flow rates of water across the Divide within Focus Area 2 of the GLMRIS other than those listed in Table 16. However, it is possible that there are other locations where small volumes of water flow may occur across the Divide from large infrequent storm events. The very flat topography characterized by subtle nuances in slope that exist in proximity to large portions of the land along the Divide is confounding to hydrologists attempting to model and predict storm runoff. While the 12-digit HUC boundary used for this study is the best available technology, it is important to understand that it is an estimated line based on computer modeling.

Two general types of connections were found; man-made ditches or conduits, and natural backflow locations. Each type of connection was evaluated using available records and mapping to identify all locations where a surface water connection that spans the drainage divides or boundaries exists or may form during periods of wet weather. Man-made connections could be further subdivided into those unassociated with agriculture, and those

associated with agriculture. Storm sewers in urban and suburban areas and transportation canals such as the Erie-Canal system in Ohio make up the bulk of the non-agricultural man-made connections. Agricultural connections were found as a result of the irrigation and drainage canals common throughout the study area. Natural backflow locations included upland wetlands and lake connections, and low lying areas along the divide caused by glacial processes. Little Killbuck Creek in Medina County, OH is an example of a low-lying area along the divide that is also drained by man-made agricultural canals.

Due to the limited time available for this preliminary risk characterization, and the level of uncertainty in much of the hydrologic and species information, the subjective criteria and the reliance on expert opinion were designed to be conservative. Concerted effort was expended in trying to prevent declaring that any site posed an insignificant risk, if in fact it may pose significant risk. Several key conclusions can be reached based on this preliminary risk characterization.

- A total of 18 of the 36 locations were rated as Medium, High or Acute risk of ANS transfer either into or out of the Great Lakes.
- A total of 13 locations were rated as Low risk of ANS transfer either into or out of the Great Lakes, and five locations were not rated because it was considered highly unlikely that a hydraulic connection could ever form there.
- The location of greatest concern is the Eagle Marsh site in Fort Wayne, IN due to the magnitude of the intermittent surface water connection that develops across the Divide during a significant storm event and the proximity of adult Asian carp to the location.
- The Long Lake connection to the Ohio and Erie Canal in Summit County, OH south of Akron, OH, and the Libby Branch of the Swan River large wetlands complex in Itasca and Aitkin Counties, MN are also identified as High Risk locations for ANS interbasin transfer.
- With the exception of the Eagle Marsh site in Fort Wayne, the other 17 locations deemed to pose significant risk of ANS transfer require a more comprehensive risk characterization to fill data gaps and reduce the uncertainty regarding the frequency

and extent a viable aquatic pathway may form and/or the proximity of threatening ANS populations and/or critical habitat to the location.

The significance of in stream dams to ANS migration was another area of uncertainty that could not be adequately evaluated in this preliminary risk characterization. There have been significant efforts by the USACE and other Federal and state agencies to remove dams and build fish ladders or other fish passage facilities to mitigate impacts caused by dams or other impediments to passage. At the locations deemed to pose Medium, High or Acute ANS Transfer Risk in either direction, there needs to be a detailed assessment of the effect that each dam on the connecting streams may have on impeding ANS migration.

Among the most compelling conclusions revealed in this preliminary risk characterization is that local and state knowledge is generally at a higher level of resolution than is federal knowledge, and that most of the locations deemed to pose significant risk likely will not warrant large complicated mitigation measures. In addition, federally proposed solutions are subject to Congressional authorization, often a lengthy process, and appropriation of funds, which can be very uncertain. In many cases, local and state entities may have the authority and ability to take quicker and more effective action that the federal government.

Ultimate management of all aquatic invasive species migration between both basins will require the identification of likely invasion pathways and active management of each of those pathways, whether by efforts to hydrologically separate the basins, application of institutional controls, increased public education and/or active eradication programs. Management will also require monitoring of susceptible locations and sensitive areas for ANS both known and unanticipated (Vander Zanden and others, 2010).

Efforts to develop bioeconomic models of invasive species impacts have attempted to quantify the relative merits of different management strategies. One of these efforts (Leung and others, 2002) concluded that prevention is generally more cost effective than remediation or eradication. The GLMRIS is focused on preventing invasion of either the Great Lakes or the Mississippi River – Ohio River basins by ANS through the surface water pathway. The

complimentary contributions of the Federal and state agencies that produced this report provide a road map for accomplishing the goals of the GLMRIS as well as for development and implementation of the requisite holistic strategy necessary to effectively manage and control not only the aquatic pathway, but all pathways that enable ANS migration. Complimentary coordinated efforts at the local, state and federal levels of government and by other stakeholder organizations will be the key to successfully preventing future ANS invasions of our critical water resources in the Great Lakes and Mississippi River Basins, and provide the most effective and efficient means to manage and control the risks posed by ANS.

6 Recommendations

The following general and location specific recommendations are based on the input of a diverse team of experts from the local, state and Federal stakeholder organizations that helped compile and evaluate relevant information for each location considered. The General Recommendations are listed in order of priority, but all seven of the recommendations should be initiated as soon as resources are available. Location specific recommendations are presented in Sections 6.2, 6.3 and 6.4. To refine the prioritization schedule shown in Table 16 for implementation of the location specific recommendations in a resource constrained environment, an evaluation of migratory difficulty along the waterways that connect each aquatic pathway to the Mississippi or Ohio River and to a specific Great Lake was conducted. The results of the migratory difficulty assessment were presented in Section 4.1.4.

Appendices C through G provide illustrations and aerial photographs of the general and location specific information considered in developing the inventory of locations evaluated and used to formulate expert opinions in selecting ratings for ANS Significance, Hydrologic Risk, and ANS Transfer Risk.

6.1 General Recommendations

1. Continuation of the coordinated stakeholder collaboration at the Eagle Marsh location in Fort Wayne to expedite completion of a Detailed Project Report is the highest priority recommendation. The Detailed Project Report should fully address compliance with the National Environmental Policy Act and meet all the requirements for a decision document to support a Federal action to mitigate ANS transfer risks at this location, as summarized in Section 6.2.1 below and detailed in the Field Report contained in Appendix E.

2. Collaboration with the USFWS and the USGS to update Tables 1 and 2 and maintain accurate lists of ANS threatening the Great Lakes and the Mississippi River and its

tributaries, respectively is recommended as a critical element to accomplishing the objectives of the GLMRIS.

3. Initial and follow up meetings with the natural resource agencies and other stakeholders in New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Minnesota and Michigan is recommended to:
    a. Brief them on the conclusions and recommendations of this Preliminary Risk Characterization;
    b. Elicit input and participation in finalizing and implementing the plan of study to complete the risk characterization at the potential surface connection locations deemed to pose Medium, High or Acute ANS transfer risks. Specifically, collaboratively determine how best to fill the data gaps and reduce the uncertainty associated with the hydrologic and ANS transfer risks.
    c. Determine if there are measures that local or state entities can more effectively and efficiently implement than can be done through a federal action to mitigate ANS transfer risks at the locations within each state deemed to pose significant risk.
    d. Collaborate on how best to incorporate management and control of aquatic pathways in proximity of the basin divide into their respective State Management Plans for Aquatic Nuisance or Invasive Species. Specifically, identify institutional controls that exist or are deemed appropriate that should be used and developed to manage urban and rural development to establish and maintain hydrologic separation of the basins into the future where feasible.

4. A detailed evaluation of the dams on the streams that connect all 18 locations deemed to pose significant risk for ANS transfer is recommended to adequately quantify the migratory difficulty these structures pose to ANS use of the aquatic pathway in both directions.

5. The Asian Carp Regional Coordinating Committee (ACRCC) should be briefed on the results of the preliminary risk characterization. ACRCC members should recommend how best to formulate and implement a strategy that draws upon the resources and capabilities of the various local, state and Federal government organizations and other prominent stakeholder organizations to prevent, manage and/or control migration of all ANS in both basins by all pathways.

6. The USACE and the state water resource management agencies should promptly develop and implement internal procedures to assure a deliberate risk assessment process occurs prior to making or implementing any decision to remove a dam or install a fish passage at an existing dam.

7. This preliminary risk characterization should be used as a basis to update and revise the scope, schedule and budget of the GLMRIS Project Management Plan for Focus Area 2.

8. With the exception of the Eagle Marsh location in Fort Wayne, Indiana, a more detailed risk assessment, conducted in collaboration with local, state and Federal stakeholders, is recommended at each of the other 17 locations deemed to pose a Medium, High or Acute ANS transfer risk. Reformation of the team used to complete this preliminary ANS risk characterization is recommended to develop and implement a plan of study to implement the recommendations in this report and complete the ANS risk characterization for Focus Area 2 of GLMRIS. The relative priority for implementation of the location specific recommendations detailed below is provided in Section 6.5, and should be used as a guide to development of the plan of study.

6.2 Highest Risk Locations

6.2.1 Eagle Marsh Fort Wayne, IN

The circumstances at the Eagle Marsh in Fort Wayne, Indiana led an interagency team to recommended rapid implementation of both interim and long-term risk reduction measures to prevent Asian carp from swimming across the surface water connection that forms there between the Junk and Graham-McCulloch Ditches in Fort Wayne, Indiana.

To facilitate fastest implementation of the possible interim risk reduction measure, the Indiana DNR took the lead role in designing and implementing the recommended action, which was construction of a mesh fence across the Eagle Marsh. The interim risk reduction measure implemented, a fortified chain link fence with rock abutments, is a modification to the type of barrier recently completed by the USACE to prevent ANS transfer between the Des Plaines River and the Chicago Sanitary Ship Canal and the I&M Canal. The Indiana DNR designed the interim measure to protect against the upstream migration of Adult Asian carp and for it to be in place for up to five years. A construction and maintenance contract was awarded, and construction of the mesh fence across the Eagle Marsh was completed prior to October 1, 2010. Figure 22 is a progress photograph taken on September 24, 2010. Rip rap stone remained to be placed at the north abutment of the mesh fence with the levee along the Graham-McCulloch at the right of the photo, and at the south abutment with a railroad embankment, which is not distinguishable in the photo.

The interagency team also recommended rapid implementation of a USACE planning study to support implementation of a long-term remedy, with a goal of having a long-term risk reduction measure in place at this location within two years. The USACE has initiated preparation of an expedited USACE planning study for the Eagle Marsh to identify viable long-term risk reduction measures and recommend an optimal risk reduction measure plan. That study is scheduled to be completed in less than one year. Actual implementation of the recommended measure will require identification of an appropriate Congressional authority and funding. Furthermore, most USACE authorities available for this type of project require identification of a local cost-sharing sponsor that is responsible for real estate acquisition.

USACE would assist the local sponsor through design and construction, and then turn the completed facility over to the sponsor to operate and maintain.

A USACE Project Delivery Team has been formed and a Project Management Plan is being drafted to complete compliance with the National Environmental Policy Act and with the requirements of ER 1105-2-100 to support a Federal action at this location by the USACE. The USACE Project Delivery Team will actively engage the interagency Steering Committee throughout this process, from approval of the Project Management Plan through the formulation and selection of an alternative, to identify a viable local partner for design, construction and operation of the recommended alternative.

Figure 22. Mesh Fence Barrier construction across Eagle Marsh in Fort Wayne, Indiana

6.2.2 Ohio and Erie Canal, Long Lake, OH

The constant flow of surface water across the basin divide from Long Lake into the Ohio and Erie Canal near Akron, Ohio creates a high probability that any ANS that might reach Long Lake from the Ohio River and tributaries by any means, would be able to migrate to Lake Erie. However, the complex interrelated circumstances at this location associated with the remnant features of the former Ohio and Erie Canal connection of the basins requires a more detailed evaluation. As such, a more detailed risk assessment is recommended to better define the risks associated with ANS from the Mississippi and Ohio Rivers and their tributaries reaching Long Lake or the Ohio and Erie Canal. Likewise, the potential for overflow from either the Tuscarawas River or the Ohio and Erie Canal where they run parallel needs to be better quantified to better understand the risks associated with ANS transfer in both directions.

Refinement of the risk assessment should be accompanied with the formulation of alternatives to mitigate the risks associated with maintenance of remnants of the Ohio and Erie Canal. It is possible that relatively inexpensive actions such as changes in operations, minor modifications of structures, or adoption of institutional controls could be implemented at the local or state level that could mitigate the risks at this location to insignificant levels; thereby precluding the need for a Federal action. Therefore, it is recommended that the USACE and the Ohio DNR collaborate to complete the more detailed risk assessment as well as a planning study to formulate viable risk reduction alternatives and select an efficient and effective mitigation plan for this location.

6.2.3 Minnesota Locations

A more detailed risk assessment, conducted in collaboration with the Minnesota DNR, the USFWS and the USGS is recommended at Libby Branch and Swan River locations, and it should include:

- An evaluation of the dams on the Saint Louis and Mississippi Rivers relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.

- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.
- A set of revised ANS Transfer Risk Ratings for each location based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

Also, USACE should work with Minnesota DNR, the USFWS and the USGS to assure there are no other locations where a surface water pathway may develop across the basin divide from a 1% annual return frequency storm and to identify and characterize ANS interbasin transfer risks at other vulnerable locations.

Relatively inexpensive actions such as filling in segments of the agricultural ditches and adoption of institutional controls could be implemented at the local or state level to mitigate the risks in this area to insignificant levels. In any case; the USACE should collaborate with the other stakeholders on formulation, consideration and selection of one or more risk mitigation alternatives at each of these two locations.

6.3 Medium Risk Locations

6.3.1 Wisconsin Locations

A more detailed risk assessment, conducted in collaboration with the Wisconsin DNR, the USFWS and the USGS is recommended at each of the locations deemed to pose a Medium ANS Transfer Risk in Wisconsin, and for each location it should include:

- An evaluation of the dams on the connecting streams to the Great Lakes and the Mississippi River relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.
- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.
- A set of revised ANS Transfer Risk Ratings for each location based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

- The following are additional location specific recommendations for the potential interbasin surface water connections in Wisconsin.

6.3.1.1 Portage – Upstream, Downstream and Canal

For the Canal connection location in Portage as well as for the entire length of the former Portage Canal, the USACE and the WiDNR should establish protocol to consider ANS transfer risks prior to making any decisions to open the gate that separates the basins in Portage or to make any structural or operational modifications to the facilities along the Portage Canal. The following site specific recommendations are also suggested at this location.

- A detailed evaluation of the Prairies Du Sac Dam on the Wisconsin River and the locks and dams on the Fox River relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.
- A more detailed evaluation of the hydrologic conditions that may cause an intebasin surface water pathway to form at the Upstream and Downstream locations to better determine frequency of occurrence, estimated width and depth of flow during a 1% return frequency storm and revised hydrologic risk characterizations.
- A set of revised ANS Transfer Risk Ratings for both the Upstream and Downstream locations based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

6.3.1.2 W. Menomonee Falls and Jerome Creek

The following site specific recommendations are also suggested at these two similar locations.

- Collaboration with local and state stakeholders to discuss preliminary risk characterization results and conduct site visits to observe potential connection locations and review available flood hazard information in these expanding suburban locations.

- Local and state stakeholder identification of risk reduction measures that could be most effectively and efficiently implemented at the local or state level to mitigate the risks to insignificant levels, including but not limited to development and implementation of policies and regulations regarding storm water management for developments in proximity to these two locations along the Divide.

6.3.1.3 Hatley, Rosendale and Aniwar

At these three similar locations, the following recommendations are also suggested.

- Meet with local, state and Federal stakeholders (ie USGS Water Science, WiDNR Division of Water, County Surveyor, and or local National Resource Conservation representatives) to discuss preliminary risk characterization results and conduct site visits to observe potential connection locations and compile and review their available topographic mapping and flood hazard information.
- Revise both the Hydrologic Risk and ANS Risk ratings and characterization for each site based on the new information.
- Identify simple and inexpensive measures that could be implemented at the local or state level to mitigate significant risks.

6.3.1.4 Brule Headwater

It appears highly unlikely that a hydraulic connection spanning the Divide can form at this location. Recommend accumulation of better flood risk management information from local and state sources, and a reassessment and revision of the Hydrologic Risk and ANS Transfer Risk characterization and ratings for this site based on the new information. If it appears the location may pose a significant risk for ANS Transfer, identify simple and inexpensive measures that could be implemented at the local or state level to mitigate all significant risks.

6.3.2 Indiana Locations

A more detailed risk assessment, conducted in collaboration with the Indiana DNR, the USFWS and the USGS is recommended at each of the locations deemed to pose a significant risk in Indiana, and for each location it should include:

- An evaluation of the dams on the connecting streams to the Great Lakes and the Mississippi or Ohio Rivers relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.
- Consultation with the Indiana DNR and County Surveyors in each county along the basin divide in Indiana to assure there are no other viable surface water pathways across the basin divide (including those evaluated in this report that were determined not to pose a significant ANS transfer risk), and identify measures that could be implemented at the local or state level to mitigate significant risks at all rural locations where there is potential for interbasin flow of surface water.
- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.
- Meeting with stakeholders at Loomis Lake to observe conditions and compile and review available information on the design, relationship and operations of Loomis and Flint Lake.
- Revise ANS Transfer Risk Ratings for each location based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

6.3.3 Ohio Locations

A more detailed risk assessment, conducted in collaboration with the Ohio DNR, the USFWS and the USGS is recommended at each of the locations deemed to pose a significant risk in Indiana, and for each location it should include:

- An evaluation of the dams on the connecting streams to the Great Lakes and the Ohio River relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.

- Consultation with the Ohio DNR and County Surveyors in each county along the basin divide in Ohio to assure there are no other viable surface water pathways across the basin divide (including those evaluated in this report that were determined not to pose a significant ANS transfer risk), and identify simple and inexpensive measures that could be implemented at the local or state level to mitigate significant risks at all rural locations where there is potential for interbasin flow of surface water.
- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.
- Meet with stakeholders at Grand Lake St Marys to observe conditions and compile and review available information on the design and operations of Grand Lake, and identify modifications to operations or structures that could be implemented to effectively mitigate the risks to insignificant levels.
- Revise ANS Transfer Risk Ratings for each location based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

6.3.4 East Mud Lake, New York

Conduct a site visit with representatives of the NYSDEC and the USGS Water Science office in New York to observe site conditions and compile and review available topographic mapping, the National Hydrography Dataset and local flood hazard mapping and records. If the results of this visit indicate a viable surface water connection may occur at a 1% annual return frequency storm, then perform the following tasks.

- Conduct an evaluation of the dams on the connecting streams to Lake Erie and the Ohio River relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.
- Evaluate habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to each location.
- Revise ANS Transfer Risk Ratings for each location based upon a more detailed evaluation of ANS transfer risk via the aquatic pathway in both directions.

6.4 Low Risk Locations

At the other 13 locations evaluated for this report with Low risk, no further investigation is recommended unless new information becomes available or there is a significant change in circumstances at the location. However, it is recommended that these locations and the material included in Appendices C through G for each of these locations be maintained for record within the Final GLMRIS report.

6.5 Location Specific Prioritization Recommendations

To better differentiate the prioritization of locations for implementation of the site specific recommendations in Section 6.2 and 6.3 above, a closer examination of obstructions and their impact on species migration was made through an organized review of the NID and other readily available sources regarding dams.

The location specific prioritization results based on this analysis are depicted in Table 18 below. The primary changes to the prioritization order depicted in Table 17 were to lower the priority on the Libby Branch Swan River and Swan River locations in Minnesota due to the formidable obstructions to ANS migration created by the hydroelectric dams in the upper Mississippi and St. Louis Rivers. Also, the priority of three locations in Wisconsin was raised due to the presence of Asian carp in the Illinois River in proximity to the Des Plaines, Fox and Rock Rivers for the Jerome Creek, W. Menomonee and Rosendale-Brandon locations, respectively.

The prioritization shown in Table 18 is based solely on perceived risk. However, it should be noted that other logistical constraints will likely need to be considered for actually implementing the recommendations in an effective and efficient manner. Therefore, the prioritization recommended in Table 18 should be considered as guidance, and not constrain the actual order in which the risk characterization at these 18 locations is completed.

Table 18. Recommended Priority for Completing Risk Characterization

Aquatic Pathway	State	Priority
Eagle Marsh Fort Wayne	IN	1
Ohio and Erie Canal at Long Lake	OH	2
Jerome Creek	WI	3
W. Menomonee Falls	WI	3
Rosendale – Brandon	WI	3
Little Killbuck Creek	OH	4
Portage (Upstream), WI	WI	4
Portage (Downstream), WI	WI	4
Libby Branch of Swan River	MN	5
Swan River	MN	5
Parker Ditch - Cobb Ditch	IN	6
Grand Lake-St Mary's	OH	7
S. Aniwa Wetlands	WI	9
Hatley-Plover River	WI	9
Loomis Lake	IN	9
Mosquito Lake - Grand River	OH	10
East Mud Lake	NY	11
Brule Headwaters Portage	WI	12

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