GLMRIS

Great Lakes and Mississippi River Interbasin Study


Aquatic Nuisance Species


Ecosystems


Navigation


Recreation


Flood Risk Management


Water Use

Focus Area 2 Aquatic Pathway Assessment Report

Brule Headwaters, Wisconsin

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Executive Summary

This assessment characterizes the potential for transfer of aquatic nuisance species (ANS) between the Great Lakes and Mississippi River Basins through an aquatic pathway that forms at the headwaters of the Brule River in northwest Wisconsin. This was done by first evaluating the hydrologic and hydraulic characteristics of the site based on readily available information, which was then followed up with a species-specific assessment of potential ANS capabilities to arrive at the pathway and cross into the adjacent basin. This site is located at the headwaters of the Brule River (Great Lakes Basin) and of the St. Croix River (Mississippi River Basin), within the Brule River State Forest. Habitat at the location includes predominantly coniferous and deciduous forested wetlands within a narrow valley surrounded by uplands. The area is a bog environment with a number of what are likely shallow groundwater connections that are the source of water for tributaries to both the Great Lakes and Mississippi River watersheds.

A long narrow valley spans the basin divide at this location, which is a remnant of a spillway outlet that formed on the southern end of Lake Duluth, a predecessor to current Lake Superior. An intermittent surface water connection forms in the bottom of the valley which connects Porcupine Creek in the Mississippi River Basin with the West Fork Brule River which drains to Lake Superior. This led the pathway assessment team to determine that there is a medium probability for this location to develop hydrologic conditions that could potentially facilitate spread of ANS between the basins. There is some uncertainty regarding the frequency, duration, and magnitude of the surface water connection, but a completed surface water pathway across the basin divide appears most likely to occur when associated with melting snow and significant rainfall events in the spring. The duration of the surface water connection appears to be limited to several days during any given year.

As a result of the medium rating for the probability of an aquatic pathway existing at this location, the viability of this pathway for specific ANS of concern was then evaluated by looking at the biological requirements and capabilities of nine ANS, along with the habitat and aquatic conditions within the pathway. After consideration of these species, the site was determined to have an overall viability rating of “medium” for the probability of developing conditions suitable to facilitate the spread of only viral hemorrhagic septicemia virus (VHSv) from the Great Lakes Basin (where it is currently established) to the Mississippi River Basin during a flood event up to the one percent annual recurrence interval event. Viral hemorrhagic septicemia virus is the only species driving this rating and without this species the overall viability rating would have been low.

Aquatic Nuisance Species of Concern	
Species	**Common Name**
Hypophthalmichthys molitrix	silver carp
Hypophthalmichthys nobilis	bighead carp
Mylopharyngodon piceus	black carp
Menidia beryllina	inland silverside
Channa argus	northern snakehead
Gasterosteus aculeatus	threespine stickleback
Gymnochephalus cernua	ruffe
Proterorhinus semilunaris	tubenose goby
Novirhabdovirus sp	Viral Hemorrhagic Septicemia Virus

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Acronyms

ANS . . . . . Aquatic Nuisance Species
ANSTF. . . . Aquatic Nuisance Species Task Force
CAWS . . . . Chicago Area Waterway System
CEQ. . . . . Council on Environmental Quality
DEM. . . . . Digital Elevation Model
FEMA. . . . . Federal Emergency Management Agency
GIS . . . . . Geographic Information System
GLFC. . . . . Great Lakes Fishery Commission
GLMRIS. . . Great Lakes and Mississippi River Interbasin Study
HUC. . . . . Hyrdologic Unit Codes
NAS . . . . . Nonindigenous Aquatic Species
NEPA. . . . . National Environmental Policy Act
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
WDNR . . . . Wisconsin Department of Natural Resources
WRDA . . . . Water Resources Development Act

Brule Headwaters

May, 2013

1 Introduction

The Great Lakes and Mississippi River Interbasin Study (GLMRIS) was authorized in Section 3061(d) of the Water Resources Development Act of 2007, and therein, it prescribes the following authority to the Secretary of the Army and the U.S. Army Corps of Engineers (USACE) (WRDA, 2007):

> *"(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."*

This GLMRIS Focus Area 2 Aquatic Pathway Assessment report addresses the Brule Headwaters location, near Solon Springs, Wisconsin. The Brule Headwaters location is one of 18 locations identified in the Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization as a potential aquatic pathway spanning the watershed divide between the Great Lakes and Mississippi River Basins outside of the Chicago Area Waterway System (CAWS) (USACE, 2010) . This report is downloadable from the GLMRIS web site (glmris.anl.gov/).

The dashed line in Figure 1 depicts the nearly 1,500-mile (2,414 kilometer) basin divide from the New York-Pennsylvania state line to north eastern Minnesota, and it depicts each of the 18 potential aquatic pathway locations previously identified. Figure 1 shows the Brule Headwaters location as site number 16 in northwest Wisconsin near Lake Superior.

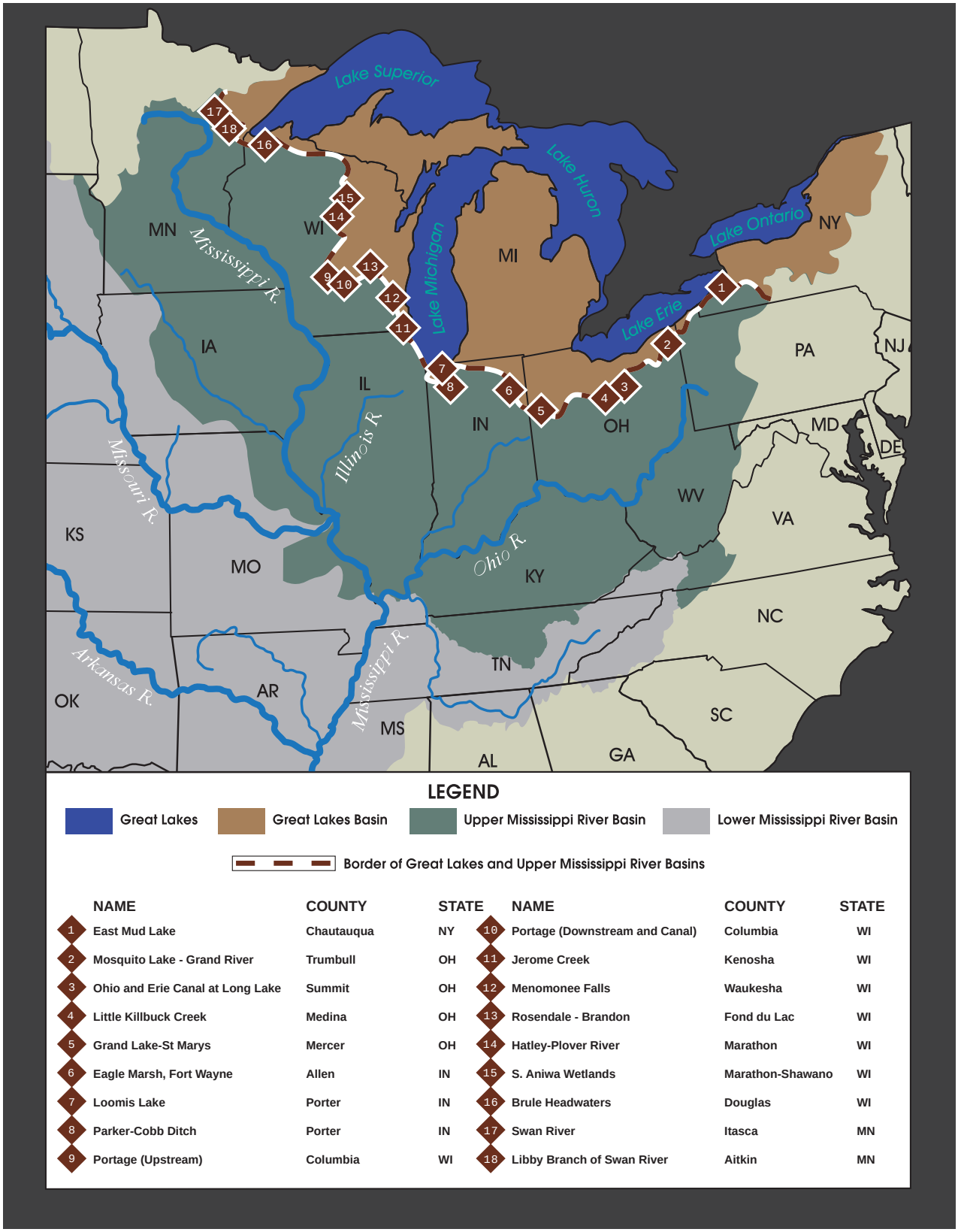
The GLMRIS is a very large and complicated task involving multiple USACE Districts and Divisions. Program Management of the study is conducted by the Great Lakes and Ohio River Division. The study considers several ANS of concern, however, the proximity of Asian carp in the Mississippi River Basin to the basin divide at two locations lend a sense of urgency and national significance to completion of the GLMRIS. These two locations are the CAWS in Chicago, Illinois and Eagle Marsh in Fort Wayne, Indiana. To help accelerate completion of the feasibility study, the Great Lakes and Ohio River Division split management of the GLMRIS into two separate focus areas. Focus Area 1 is managed by the USACE, Chicago District of the USACE and addresses the CAWS that open to Lake Michigan. Focus Area 2 is managed by the USACE, Buffalo District and evaluates all other potential aquatic pathways that exist or are likely to form across the basin divide separating runoff that flows into the Mississippi River and its tributaries from runoff that flows into the Great Lakes and its tributaries.

1.1 Study Purpose

The preliminary report from 2010 and the subsequent analysis contained in this report have been produced for a broad audience ranging from the scientific community to the general public, and are specifically intended to identify any locations where an aquatic pathway exists or may form between the basins, and to evaluate the probability that specific ANS would be able to arrive at that pathway and cross into the new basin. The information in this and the other Focus Area 2 reports are intended to provide a sound scientific basis for helping to prioritize future funding of GLMRIS and/or other actions at these potential aquatic pathway locations.

This report is part of a tiered approach to assess the likelihood of ANS spreading between the Great Lakes and Mississippi River Basins via aquatic pathways, and it was prepared in accordance with the detailed procedures and criteria specified in the GLMRIS Focus Area 2 Study Plan (USACE, 2011a). The primary purpose of this report is to present the evidence and explain the procedures used to qualitatively estimate the likelihood that a viable aquatic pathway exists at the Brule Headwaters location that will enable the interbasin spread of ANS. It is also intended to contribute to the accomplishment of each of the four objectives identified in the plan by including the following:

- A definitive determination of whether the Brule Headwaters location should be included in the inventory of locations where a viable surface



	NAME	COUNTY	STATE
1	East Mud Lake	Chautauqua	NY
2	Mosquito Lake - Grand River	Trumbull	OH
3	Ohio and Erie Canal at Long Lake	Summit	OH
4	Little Killbuck Creek	Medina	OH
5	Grand Lake-St Marys	Mercer	OH
6	Eagle Marsh, Fort Wayne	Allen	IN
7	Loomis Lake	Porter	IN
8	Parker-Cobb Ditch	Porter	IN
9	Portage (Upstream)	Columbia	WI
10	Portage (Downstream and Canal)	Columbia	WI
11	Jerome Creek	Kenosha	WI
12	Menomonee Falls	Waukesha	WI
13	Rosendale - Brandon	Fond du Lac	WI
14	Hatley-Plover River	Marathon	WI
15	S. Aniwa Wetlands	Marathon-Shawano	WI
16	Brule Headwaters	Douglas	WI
17	Swan River	Itasca	MN
18	Libby Branch of Swan River	Aitkin	MN

Figure 1. Potential aquatic pathway locations identified in the GLMRIS Preliminary Risk Characterization Study (USACE, 2010).

water connection between headwater streams on both sides of the drainage divide exists or is likely to form between the Great Lakes and Mississippi River basins;

- A standalone report that characterizes the probability of aquatic pathway formation and the probability that a viable aquatic pathway exists at the Brule Headwaters location and will enable the interbasin spread of ANS;

- Development of clear problem statements that frame the means, constraints, and likelihood of the interbasin spread of ANS via the potential aquatic pathway at the Brule Headwaters location; and

- Development of clear opportunity statements that illustrate how the collective authorities, resources, and capabilities of USACE and other applicable Federal, State, local, and non-governmental stakeholder organizations may best be coordinated and applied to prevent the interbasin spread of ANS through the Brule Headwaters location.

1.2 Summary of Preliminary Risk Characterization for Brule Headwaters

The Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization was designed as the first step of a tiered approach to rapidly conduct a study intended to accomplish two objectives (USACE, 2010). The first and primary objective was to determine if there were any locations within the GLMRIS, aside from the CAWS, where a near term risk for the interbasin spread of ANS exists. Near term, in this case, indicates that implementation of some measure(s) might be warranted to reduce the potential for ANS transfer at that particular location in the short term versus setting that site aside for further analysis. The second objective was to refine the scope of the other aquatic pathways portion of the GLMRIS by developing a list of potential aquatic pathways that could form anywhere along the divide separating the Great Lakes and Mississippi River Basins, and help provide a basis for prioritizing future feasibility study efforts based upon relative risk.

The USACE solicited the input and collaborated with the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), Great Lakes Fishery Commission (GLFC) and the natural resource agencies in the states of Minnesota, Wisconsin, Indiana, Ohio, Pennsylvania, and New York. A total of 36 potential locations were initially identified along the divide where it appeared that interbasin flow could occur. These were locations situated in a mixture of rural, forested, suburban, and urban areas, and included locations where surface water flow patterns have been modified through the building of navigation canals, excavation of ditches, and construction of sewers to facilitate storm water management for agricultural, flood damage reduction, or other water management purposes. Also, many of the potential aquatic pathways identified in 2010 were locations where extensive natural wetlands exist in close proximity to, and in some instances appear to span, the basin divide. The lack of prior hydrologic studies and the level of uncertainty in the hydrology information led to a conservative approach in estimating the individual aquatic pathway risk ratings.

At 18 of these locations the interagency group determined that it would likely require an epic storm and flooding event for an aquatic pathway to ever form across the basin divide. These were not recommended for further investigation because this was considered a low level of risk. However, at the remaining 18 locations the group did recommend that a more detailed assessment be conducted (Figure 1). Only one location, Eagle Marsh in Fort Wayne, Indiana, was determined to pose a near term risk for the potential spread of Asian carp into the Great Lakes Basin, and this led to the installation of a temporary barrier by Indiana Department of Natural Resources (IDNR) until a more complete assessment and remedy could be implemented.

The Brule Headwaters location was initially identified from an analysis of aerial photos that revealed the presence of a long, narrow valley spanning the basin divide and connecting to headwater streams in both basins. The headwaters of both the Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, are very close (approximately less than 0.3 mile apart, or 482 meters), and topography indicated that the valley floor was relatively flat. A site visit in June 2010 found no evidence of a direct surface water flow connection, such as open channels, drift lines on the ground, and water marks on trees. However, an extensive wetland was found spanning the distance between perennial streams in both basins.

Although the preliminary risk characterization did not identify the Brule Headwaters Pathway as a location where there is a near term risk for the interbasin spread of ANS, there was some uncertainty with this rating. This was mainly due to the presence of the large wetland area and lack of readily available hydrological evidence found during the preliminary study effort to discern the relative frequency and potential magnitude of any aquatic pathway at this location. The preliminary effort recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the Wisconsin Department of Natural Resources (WDNR), USFWS, USGS, and other government agencies. The following actions were taken:

- Federal, State, and local stakeholders (e.g. USGS Water Science, WDNR Division of Water, County Surveyor, and local Natural Resource Conservation representatives) were briefed on the preliminary risk characterization results. Detailed site visits to observe potential connection locations were made and the available topographic mapping and flood hazard information were compiled and reviewed.

- The dams on the connecting streams to the Great Lakes and Mississippi River were evaluated relative to the potential for ANS passage through, around, or over each in-stream structure in both directions.

- Habitat and abiotic conditions in proximity to the location were analyzed relative to the needs and preferences of ANS in proximity to each location.

- The hydrologic and ANS ratings and characterization were revised, as appropriate, for each site based on the new information.

- Measures that could be implemented at the local or state level were identified to help mitigate probabilities of ANS transfer.

1.3 Aquatic Pathway Team

Due to the large amount of unknowns and natural variability associated with the hydrology and the biology of such a large geographic area, the Study Plan specified formation of a “team of teams,” combining the best available local, state, and national hydrologists and biologists to assess conditions at each potential aquatic pathway. The results of this assessment reflect the collective experience, expertise, and focused effort of these biologists and hydrologists from the USACE, Detroit and St. Paul Districts, NRCS, USGS, and WDNR. The results also reflect the guidance, input, review comments, and concurrence of the multi-organization Agency Technical Review (ATR) of experts from the NRCS and the USACE. In addition, the Michigan Departments of Natural Resources and Environmental Quality participated on the ATR team and jointly concluded their reviews on April 23, 2012 by stating that “we have reviewed the Brule pathway report and we don’t have any objections to it moving forward.”

2 Study Methodology

The GLMRIS risk analysis process is an adaptation of the generic model and process described in the Generic Nonindigenous Aquatic Organisms Risk Analysis

Review Process (For Estimating Risk Associated with the Introduction of Nonindigenous Aquatic Organisms and How to Manage for that Risk) (ANSTF, 1996). The Aquatic Nuisance Species Task Force (ANSTF) defines the first step in this process as identification of interested parties and solicitation of input.

2.1 Coordination

The USACE identified interested parties and solicited input early in the process for Focus Area 2 and has included individual visits and discussions with the state agencies responsible for water resources, and fish and wildlife management in the eight states bordering the Great Lakes. The process used for the Focus Area 2 assessments has also been discussed in meetings with representatives of the Council on Environmental Quality (CEQ), USGS, USFWS, NOAA, NRCS, and GLFC. Development of this plan also included input from the public and interested non-governmental organizations received during formal National Environmental Policy Act (NEPA) public scoping meetings which were held at 12 locations across the region in both basins between December 2010 and March 2011. The USACE requested the support and participation of the best available experts from the State and Federal agencies responsible for water resources, and fish and wildlife management in the states along the Great Lakes and Mississippi River Basin divide to address the critically important issue of preventing interbasin transfer of ANS. The USGS, NRCS, and each state DNR assigned personnel to assist each USACE pathway assessment team. In addition, a technical review team comprised of 16 senior level experts from the USACE and these external partner agencies, including NOAA and GLFC, was assembled to review and guide the work of these teams. Overall, extensive collaboration among partner agencies, the review team, and other subject matter experts has led to detailed Focus Area 2 pathway assessments.

2.2 Identification of Potential Pathways

At 18 of the potential aquatic pathways identified during the 2010 Preliminary Risk Characterization, it was determined it would likely require an epic storm and flooding event (i.e., greater than a one percent annual recurrence interval storm event) for an aquatic pathway to ever form across the basin divide. These locations were not recommended for further investigation because areas that might require a flooding event in excess (greater magnitude, less frequency) of the one percent annual recurrence interval flood are less likely, and therefore present a low level of risk. This one percent threshold criterion was established through collaboration with the USGS, USFWS, NRCS, GLFC, and the departments of natural resources in the states of MI, MN, WI, IL, IN, OH, PA, and NY. This threshold is also widely used in flood risk management and is typically aligned with most readily available hydrologic information. The one percent annual recurrence interval threshold only indicates at what level event an aquatic connection can begin to form and would indicate a location that should then be subjected to a more labor intensive evaluation of the probability of ANS being able to utilize that pathway. At the remaining 18 locations, it was recommended that a more detailed assessment be conducted (Figure 1). This was subsequently done in 2011-2012 in collaboration with USGS, NRCS, USFWS, state natural resource agencies, and county surveyors (where applicable), and the results for the Brule Headwaters location are presented in this report.

Although the focus of this assessment is on aquatic pathways, it should also be mentioned that there are other non-aquatic pathways that may enable ANS to transit across the aquatic pathway or across the basin divide. Although these other pathways do not influence the overall pathway rating outlined in this report, they are included to point out potential other pathways (e.g., anthropogenic) and their potential influence on the same list of ANS as evaluated in Section 4 of this report. Any further analysis of these non-aquatic pathways outside of this study should develop a separate list of ANS that will likely differ from the list of ANS evaluated as part of this aquatic pathway report.

2.3 Aquatic Nuisance Species of Concern

This report addresses the problem of ANS invading, via surface-water pathways, the Great Lakes Basin from the Mississippi River Basin and vice versa. ANS is defined by the ANSTF 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." The USGS Nonindigenous Aquatic Species (NAS) information resource http://nas.er.usgs.gov/about/faq.aspx defines ANS as "…a species that enters a body of water or aquatic ecosystem outside of its historic or native range" (USGS, 2012). Based on discussions between the USACE, USGS, and 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 for GLMRIS. 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 also considered as ANS of concern for the GLMRIS. Therefore, the term ANS is synonymous with the term non-indigenous aquatic species in this report.

2.3.1 Lists of Non-indigenous Species in Great Lakes and Mississippi River Basins

The list of ANS of concern for a particular location was developed by first consulting the USACE white paper titled, Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study released in September 2011 (USACE, 2011b). This technical paper, prepared by a multi-disciplinary USACE natural resources team, took a broad look at the potential range of species that could be of concern to the GLMRIS. The paper is Appendix C of the GLMRIS Focus Area 2 Study Plan and it is an integral component of the plan. This USACE white paper included a review of 254 aquatic species that are either non-indigenous to either basin or native species that occur in one basin or the other. The list of 254 aquatic species were iteratively screened to identify all potential ANS that could be of concern in either basin and to systematically focus the study toward those species judged to pose the highest potential risk of ecological impacts if they became established in the other basin.

In the first screening iteration, 119 of the 254 aquatic species reviewed were determined to pose a potential threat of infiltrating the other basin and were carried into the second iteration of the analysis. The other 135 species were rejected for further analysis for several reasons. Initially, 104 species were dropped from further consideration because they were determined to already be established in both basins. Another 31 species were removed from further analysis because they were not yet located in either basin, could bypass any aquatic control mechanism by terrestrial movement, or had no potential to cause adverse affects to the invaded ecosystem.

2.3.2 List of ANS of Concern for GLMRIS

To determine species of concern that are pertinent for the GLMRIS from the list of 119 species, the USACE natural resources team compiled, reviewed, and analyzed the best available information. Literature reviews, species proximity to aquatic interbasin connections (in particular the CAWS), ecological tolerances and needs, and vagility of the species were all included in the analysis. The team ranked each species as high, medium, or low risk according to these parameters. The result was the establishment of a list of 39 species, each identified as having both a high level of potential risk for both transferring from one basin to another, and potentially a high risk in that if they do disperse, and the invaded ecosystem could be moderately to severely affected by their colonization (Table 1). A fact sheet was developed for each of these species of concern detailing morphological characteristics useful for identification, including color photographs of the species, information on their ecology, habitat, distribution, and current status in the Mississippi River or Great Lakes Basins (USGS, 2011b).

Table 1: ANS of Concern for GLMRIS				
Taxon	**Scientific Name**	**Common Name**	**Basin**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	GL	swimmer
fish	*Alosa chrysochloris*	skipjack herring	MS	swimmer
fish	*Alosa pseudoharengus*	alewife	GL	swimmer
crustacean	*Apocorophium lacustre*	a scud	MS	ballast water
algae	*Bangia atropupurea*	red macro-algae	GL	ballast / rec. boating
annelid	*Branchuris sowerbyi*	tubificid worm	GL	sediment transport
crustacean	*Bythotrephes longimanus*	spiny waterflea	GL	ballast water/sediment transport
plant	*Carex acutiformis*	swamp sedge	GL	recreational boating & trailers
crustacean	*Cercopagis pengoi*	fish-hook water flea	GL	ballast / rec. boating
fish	*Channa argus*	northern snakehead	MS	swimmer
algae	*Cyclotella cryptica*	cryptic algae	GL	unknown / any water
algae	*Cyclotella pseudostelligera*	cylindrical algae	GL	unknown / any water
crustacean	*Daphnia galeata galeata*	water flea	GL	ballast water
crustacean	*Echinogammarus ischnus*	a European amphipod	GL	ballast water
algae	*Enteromorpha flexuosa*	grass kelp	GL	ballast / rec. boating
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
plant	*Glyceria maxima*	reed sweetgrass	GL	recreational boating & trailers
fish	*Gymnocephalus cernua*	Ruffe	GL	swimmer
crustacean	*Hemimysis anomala*	bloody red shrimp	GL	ballast water
fish	*Hypophthalmichthys molitrix*	silver carp	MS	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer
plant	*Landoltia (Spirodela) punctata*	dotted duckweed	MS	recreational boating & trailers
bryozoan	*Lophopodella carteri*	bryozoans	GL	with aquatic plants
fish	*Menidia beryllina*	inland silverside	MS	swimmer
plant	*Murdannia keisak*	marsh dewflower	MS	recreational boating & trailers
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer
crustacean	*Neoergasilus japonicus*	a parasitic copepod	GL	parasite to fish
plant	*Oxycaryum cubense*	Cuban bulrush	MS	recreational boating & trailers
fish	*Petromyzon marinus*	sea lamprey	GL	swimmer
mollusk	*Pisidium amnicum*	greater European pea clam	GL	ballast water
fish	*Proterorhinus semilunaris*	tubenose goby	GL	swimmer
protozoan	*Psammonobiotus communis*	testate amoeba	GL	ballast water
protozoan	*Psammonobiotus dziwnowi*	testate amoeba	GL	ballast water
protozoan	*Psammonobiotus linearis*	testate amoeba	GL	ballast water
crustacean	*Schizopera borutzkyi*	parasitic copepod	GL	ballast water
mollusk	*Sphaerium corneum*	European fingernail clam	GL	ballast water
algae	*Stephanodiscus binderanus*	diatom	GL	ballast water
plant	*Trapa natans*	water chestnut	GL	recreational boating & trailers
mollusk	*Valvata piscinalis*	European stream valvata	GL	ships

2.3.3 List of ANS of Specific Concern at the Brule Headwaters Divide Location

The Brule Headwaters aquatic pathway team then subdivided the set of species listed in Table 1 into two groups: ANS threatening the Great Lakes, and ANS threatening the Mississippi River and its tributaries. Each of these two lists was then sorted into subgroups in accordance with taxonomy and common dispersal mechanism. Table 2 and Table 3 reflect these groupings of species that were found to pose a significant risk to the Mississippi River and its tributaries, and to the Great Lakes and its tributaries, respectively (USACE, 2011b).

Additionally, the Brule Headwaters aquatic pathway team reviewed the information on the 119 species initially determined to pose a potential threat of infiltrating the other basin to see if any were in close enough proximity to the Brule Headwaters location to be of concern. The team reviewed information on the NOAA Watchlist of species threatening the Great Lakes from international waters, and information on other species cited by the review team as high risk potential invaders not yet in either basin (NOAA, 2011). No additional species from the NOAA Watchlist were added to the species of concern for the Brule divide location. However, the NOAA Watchlist was utilized as a resource, at the recommendation of agency team members, to identify any additional potential future species that could be introduced into either basin and possibly spread from there to the other basin.

Each Focus Area 2 aquatic pathway team was granted flexibility in determining whether to add additional species to their assessment based on their review of available information and the actual location of the specific potential pathway relative to the known location of those ANS being considered. Based on concerns from local agencies about the potential for spread of viral hemorrhagic septicemia virus (VHSv, *Novirhabdovirus* sp), each Focus Area 2 aquatic pathway team evaluated whether VHSv should be included on the ANS of concern list for each of the Focus Area 2 aquatic pathways. Although VHSv has been identified in both basins (i.e., VHSv was confirmed in Ohio River Basin in the Clear Fork Reservoir in Richland and Morrow Counties, Ohio in 2008), it has not yet been determined that VHSv has established within the Mississippi or Ohio River Basins. Minimizing the spread of VHSv remains a priority for the state of Wisconsin (Great Lakes Commission, 2011; USGS, 2011b). It was therefore included as an ANS of concern threatening the Mississippi River Basin for the Brule Headwaters aquatic pathways.

Each of the three subgroups in Tables 2 and Table 3 were evaluated based on the dispersal mechanisms and general mobility of the species within each group. Since the Brule Headwaters potential pathway is positioned on the basin divide, well upstream of any know ANS listed in this assessment, any organism that moves solely through the aquatic pathway must possess either self-propelled mobility or the ability to hitchhike on other organisms to travel upstream. Thus, this eliminates organisms that rely on current for dispersal, such as plants and algae.

Based on the evaluation by subgroups, only fish and fish pathogens were considered to have the ability to reach the Brule River divide on their own from either direction. However, this is not to say at this point that the habitat conditions at the pathway are suitable for these fish and fish pathogens. To facilitate determination of the ANS transfer potential at the site, the team of biologists selected a smaller group of representative species for a more focused assessment. The species selected may be those most likely to arrive at the divide, may pose the greatest threat, and/or exhibit a broader range of biological characteristics that may enable them to reach the pathway and perhaps establish in the vicinity. Of all the species considered, the Brule Headwaters aquatic pathway team identified five ANS as a potentially significant threat to the Great Lakes Basin, and four ANS as a potential significant threat to the Mississippi River Basin (Table 4). Assessment of these species provides an indication that the potential exists for VHSv to transfer across the divide at this location and into the Mississippi River Basin.

Table 2: ANS of Concern Threatening the Mississippi River Basin			
Taxon	**Scientific Name**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	swimmer
fish	*Alosa pseudoharengus*	Alewife	swimmer
fish	*Gasterosteus aculeatus*	threespine stickleback	swimmer
fish	*Gymnocephalus cernua*	ruffe	swimmer
fish	*Petromyzon marinus*	sea lamprey	swimmer
fish	*Proterorhinus semilunaris*	tubenose goby	swimmer
crustacean	*Neoergasilus japonicus*	a parasitic copepod	parasite to fish
crustacean	*Bythotrephes longimanus*	spiny waterflea	ballast water/sediment
crustacean	*Cercopagis pengoi*	fish-hook water flea	ballast / rec. boating
crustacean	*Daphnia galeata galeata*	water flea	ballast water
crustacean	*Echinogammarus ischnus*	a European amphipod	ballast water
crustacean	*Hemimysis anomala*	bloody red shrimp	ballast water
crustacean	*Schizopera borutzkyi*	parasitic copepod	ballast water
mollusk	*Pisidium amnicum*	greater European pea clam	ballast water
mollusk	*Valvata piscinalis*	European stream valvata	ships
mollusk	*Sphaerium corneum*	European fingernail clam	ballast water
protozoan	*Psammonobiotus communis*	testate amoeba	ballast water
protozoan	*Psammonobiotus dziwnowi*	testate amoeba	ballast water
protozoan	*Psammonobiotus linearis*	testate amoeba	ballast water
annelid	*Branchuris sowerbyi*	tubificid worm	sediment transport
plant	*Carex acutiformis*	swamp sedge	recreational boats & trailers
plant	*Glyceria maxima*	reed sweetgrass	recreational boats & trailers
plant	*Trapa natans*	water chestnut	recreational boats & trailers
bryozoan	*Lophopodella carteri*	bryozoans	with aquatic plants
algae	*Bangia atropupurea*	red macro-algae	ballast / rec. boating
algae	*Cyclotella cryptica*	cryptic algae	unknown / any water
algae	*Cyclotella pseudostelligera*	cylindrical algae	unknown / any water
algae	*Enteromorpha flexuosa*	grass kelp	ballast / rec. boating
algae	*Stephanodiscus binderanus*	diatom	ballast water

Table 3: ANS of Concern Threatening the Great Lakes			
Taxon	**Scientific Name**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa chrysochloris*	skipjack herring	swimmer
fish	*Channa argus*	northern snakehead	swimmer
fish	*Hypophthalmichthys molitrix*	silver carp	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	swimmer
fish	*Menidia beryllina*	inland silverside	swimmer
fish	*Mylopharyngodon piceus*	black carp	swimmer
crustacean	*Apocorophium lacustre*	a scud	ballast water
plant	*Landoltia (Spirodela) punctata*	dotted duckweed	recreational boats & trailers
plant	*Murdannia keisak*	marsh dewflower	recreational boats & trailers
plant	*Oxycaryum cubense*	Cuban bulrush	recreational boats & trailers

Table 4: Species of Greatest Concern for Transfer at the Brule River Divide				
Taxon	**Scientific Name**	**Common Name**	**Basin**	**Interbasin Dispersal Mechanism**
fish	*Hypophthalmichthys molitrix*	silver carp	MS	swimmer
fish	*Hypophthalmichthys nobilis*	bighead carp	MS	swimmer
fish	*Mylopharyngodon piceus*	black carp	MS	swimmer
fish	*Menidia beryllina*	inland silverside	MS	swimmer
fish	*Channa argus*	northern snakehead	MS	swimmer
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
fish	*Gymnocephalus cernua*	ruffe	GL	swimmer
fish	*Proterorhinus semilunaris*	tubenose goby	GL	swimmer
Virus	*Novirhabdovirus sp*	VHSv	GL	Pathogen to Fish & Water Column

2.3.4 Key Attributes of Selected Organisms

Excluding the information for VHSv, a significant amount of ANS information was obtained from the USACE White Paper listing the non-native species of concern and dispersal risk for GLMRIS (USACE, 2011b). The VHSv was not identified as a species of concern in this white paper. However, during interagency coordination VHSv was identified as a species of concern for Brule Headwaters. Additional information was obtained from the USGS NAS website (USGS, 2011).

2.4 Pathway Assessment Process

The GLMRIS risk analysis process is an adaptation of the generic model and process described in the Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (For Estimating Risk Associated with the Introduction of Nonindigenous Aquatic Organisms and How to Manage for that Risk) (ANSTF, 1996). ANSTF defines the risk associated with an ANS as:

Equation 1

$R_{Establishment} = P_{Establishment} \times C_{Establishment}$

Where:

$R_{Establishment}$ = Risk of Establishment
$P_{Establishment}$ = Probability of Establishment
$C_{Establishment}$ = Consequence of Establishment

Note the risk is defined as a multiplicative function. That means, if either of these components is zero or low, the overall risk will also be zero or low. In order to work most efficiently given the large number of potential pathways, the GLMRIS Other Aquatic Pathways Team (Focus Area 2) concentrated its effort on characterizing the probability of establishment, while the GLMRIS Focus Area 1 Team for the CAWS is focusing on both components. An estimate of the consequences of any ANS establishment from the Focus Area 2 aquatic pathways will be deferred until possible future study by USACE or others.

ANSTF divides the probability of establishment component shown in Equation 1 into four basic elements which describe the basic events that must occur for an ANS to establish in the new environment:

Equation 2

$P_{Establishment} = [P_1 \times P_2 \times P_3 \times P_4]$

Where:

P_1 = P *ANS associated with pathway*
P_2 = P *ANS survives transit*
P_3 = P *ANS colonizes in new environment*
P_4 = P *ANS spreads beyond colonized area*

Each of the four elements of Equation 2 is qualitatively rated a High (H), Medium (M), or Low (L) based on the available evidence. They are also qualitatively assigned a level of certainty [Very Certain (VC), Reasonably Certain (RC), Moderately Certain (MC), Reasonably Uncertain (RU), Very Uncertain (VU)]. The overall probability rating is the rating of the element with the

lowest probability. Thus, in a quartet of HLHH the overall probability rating is "L". The multiplicative nature of the function assures this is actually a somewhat conservative estimate. With actual numbers the overall probability would always be smaller than the smallest of the four factors. These elements have been modified for use in GLMRIS (Equation 3) to describe the basic sequence of events that must occur for an ANS to successfully cross the basin divide through an aquatic pathway and establish in the new basin:

Equation 3 [FA1 Model]

$P_{Establishment} = [P_0 \times P_1 \times P_2 \times P_3 \times P_4]$

Where:

P_0 = P *Pathway exists*
P_1 = P *ANS has access to pathway*
P_2 = P *ANS transits pathway*
P_3 = P *ANS colonizes in new waterway*
P_4 = P *ANS spreads in new waterway*

This model works well in areas where a viable pathway is already known to exist, such as the CAWS. However, for many of the 18 locations identified in GLMRIS Focus Area 2, it was uncertain at the outset whether or not an aquatic pathway does in fact ever form. The team recognized that formation of a pathway at these locations would likely be infrequent, and with a limited duration and magnitude (width, depth, and rate of surface water flow across the basin divide). Consequently, the model in Equation 3 was modified further for Focus Area 2.

Greater efficiency in analysis can be gained by modifying Equation 3 by eliminating evaluation of the last two elements because if a pathway does not exist there is no reason to collect data on colonization (P3) and spread (P4) in the new basin. In addition, the third element of Equation 3, ANS transits pathway (P2), is broken down into its own sequence of necessary events to characterize in greater detail those variables being evaluated to determine whether or not a viable pathway exists. In setting aside the last two elements in Equation 3 (P3 and P4), no attempt is therefore made in this report to assess the probability that an ANS will colonize in or spread through the receiving waterway or basin. USACE or others may assess the last two elements of Equation 3 in the future when evaluating specific measures that could be taken to eliminate the probability of transfer at certain aquatic pathways.

Once again, in order to work efficiently in assessing ANS risk for Focus Area 2, the initial assessment focuses narrowly on the question of whether or not a viable aquatic pathway exists. Equation 4 shows how the third element of Equation 3 has been broken down to provide greater resolution for evaluating the pathway itself:

Equation 4 [Modification of Equation 3 – P2 Element]

$P_2 = [P_{2a} \times P_{2b} \times P_{2c}]$

Where:

P_2 = P *ANS transits pathway*
P_{2a} = P *ANS surviving transit to aquatic pathway*
P_{2b} = P *ANS establishing in proxiity to the aquatic pathway*
P_{2c} = P *ANS spreading across aquatic pathway into new basin*

Delaying consideration of the last two elements of Equation 3 and substituting the more detailed consideration of the third element as expressed in Equation 4 yields the following model used in the GLMRIS Focus Area 2 assessments:

Equation 5 [FA2 Modified]

$P_{Viable\ pathway} = [P_0 \times P_{1'} \times P_{2a} \times P_{2b} \times P_{2c}]$

Where:

P_0 = P *Pathway exists*
$P_{1'}$ = P *ANS occurring within either basin*
P_{2a} = P *ANS surviving transit to aquatic pathway*
P_{2b} = P *ANS establishing in proximity to the aquatic pathway*
P_{2c} = P *ANS spreading across aquatic pathway into new basin*

Notice the overall probability is now the "probability a viable pathway exists" ($P_{Viable\ pathway}$) and is no longer the original "probability of establishment" ($P_{Establishment}$) from Equation 3. The probability of establishment for certain aquatic pathways may be assessed in future studies by USACE or others, but likely only for those pathways with an unacceptable rating for the "probability of a viable pathway" existing. Note also that (P_1), ANS has access to pathway from Equation 3 has been renamed ($P_{1'}$), ANS occurring within either basin". This did not change the element being evaluated but made it clearer to team members what "access to the pathway" actually meant.

This model remains consistent with the overall GLMRIS risk assessment approach and the ANSTF methodology, and the refinements enabled the assessors to focus more appropriately on the relevant evidence. At those locations along the basin divide where the first element in Equation 5 (i.e., likelihood that an aquatic pathway exists at up to a one percent annual recurrence interval event) was estimated to be low, no further assessment of that location was necessary. The low rating of this initial element assures that the overall probability of a viable pathway existing (Equation 5), the overall probability of establishment (Equation 3), and the ANS risk potential (Equation 1), will all be low because of the multiplicative nature of the model. This approach assured a more prudent use of public resources in data collection and assessment by minimizing the collection of unnecessary data, and the conduct of unnecessary analyses. It should also be understood that a low rating for probability of a pathway existing (P_0) is not necessarily the same as there being no probability of a pathway existing. At those locations where the probability of a pathway existing (P_0) was determined to be medium or high which includes the Brule Headwaters pathway, the remaining four elements in Equation 5 were evaluated for each ANS of concern specific to that particular location over a 50 year period of analysis.

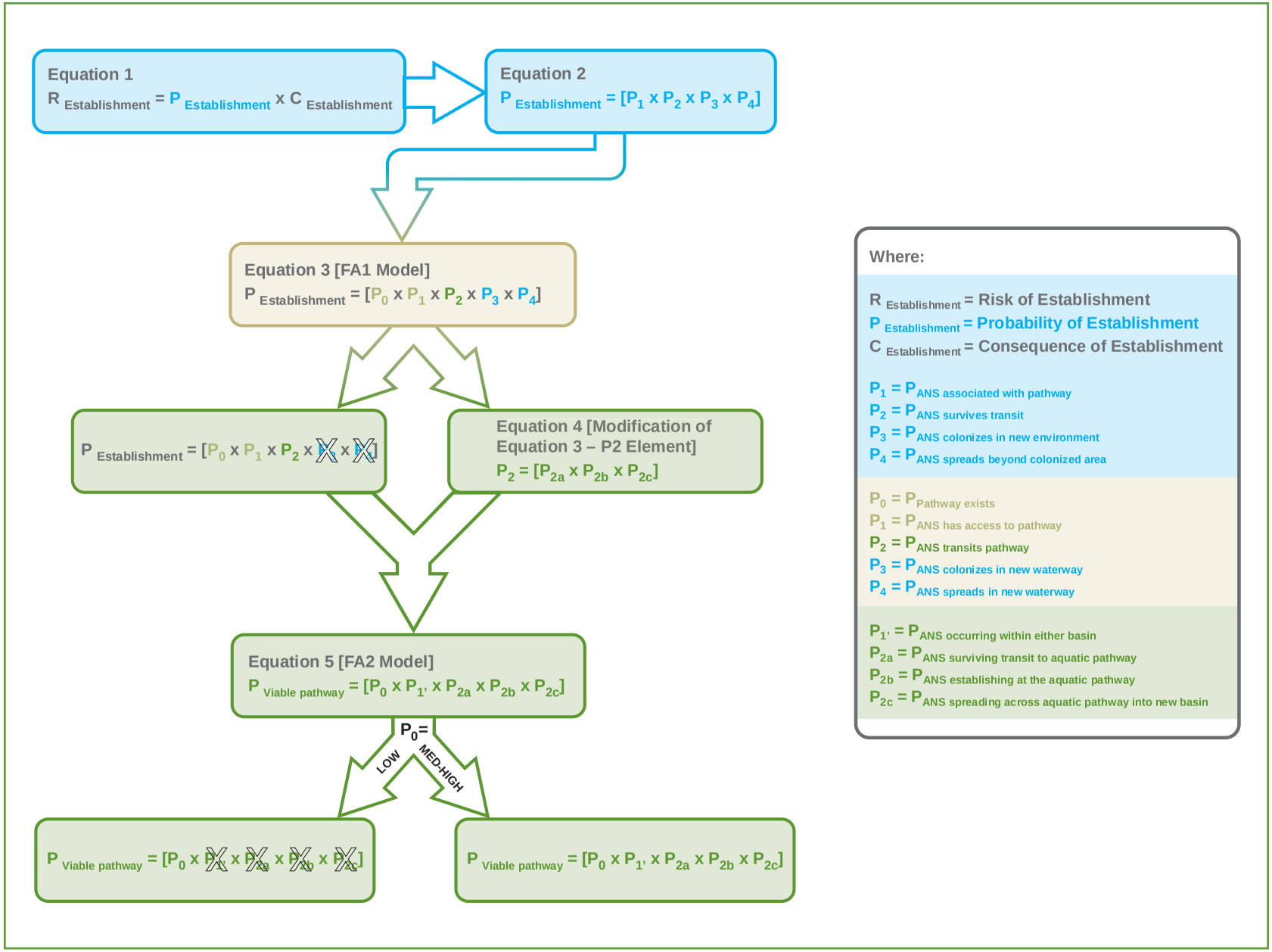


Figure 4. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

2.5 Example Calculation of Overall Aquatic Pathway Viability

As described in Section 2.2, a list of ANS of concern for the Brule Headwaters pathway was developed with input from Federal, State, and local agencies responsible for water resources, and fish and wildlife management in the state of Wisconsin and neighboring states along the Great Lakes and Mississippi River Basin divide. ANS of concern were grouped according to which basin they were currently established in to determine the viability of the aquatic pathway to transfer species across the divide in either direction. The determination of the likelihood of a viable aquatic pathway for each ANS of concern is the product of five probability elements (Equation 5). Thus, the probability of a viable pathway for a particular ANS of concern is equal to the lowest rating determined for each of the five probability elements (Table 5 and Table 6). The overall pathway viability for transferring ANS of concern from the Mississippi River Basin to the Great Lakes Basin was equal to the highest probability of a viable pathway for each ANS of concern in Table 4. In this example, all were rated low and thus the overall pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is "low". The overall pathway viability for transferring species from the Great Lakes Basin is calculated the

Table 5. Example calculation of Pathway Viability for ANS Spreading from Mississippi River Basin to the Great Lakes Basin.

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing in Proximity to Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway Viability Rating**
fish	Asian carp, silver carp, bighead carp, black carp	swimmer	M (RC)	M (RC)	L (RC)	L (MC)	M (RU)	L
fish	inland silverside	swimmer		M (VC)	L (MC)	L (RC)	L (RC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

VC=Very Certain (as certain as going to get), RC=Reasonably Certain (reasonably certain), MC=Moderately Certain (more certain than not), RU=Relatively Uncertain (reasonably uncertain), VU=Very Uncertain (a guess)

Table 6. Example calculation of Pathway Viability for ANS Spreading from Great Lakes Basin to the Mississippi River Basin.

			Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**ANS Establishing in Proximity to Aquatic Pathway?**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway Viability Rating**
fish	threespine stickleback	swimmer	M (RC)	M (VC)	L (RC)	L (MC)	L (MC)	L
pathogen	VHSv	fish pathogen / water column		H (VC)	H (MC)	H (RC)	H (RU)	M
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin								**M**

same way and is shown in Table 5. In this example, the overall pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is “medium”.

The last calculation is to determine the overall pathway viability for interbasin spread of ANS which is calculated by taking the highest of the overall ANS ratings for unidirectional transfer which were calculated in Tables 5 and 6. Thus, in Table 5, the overall probability that a viable aquatic pathway exists is “medium”. The ratings given for each element as well as the overall pathway viability ratings shown in Tables 5 and 6 were coordinated amongst the members of the pathway team until agreement was reached regarding the probability rating (H, M, or L) and the level of certainty (Reasonably Certain, Moderately Certain, Reasonably Uncertain, Very Uncertain).

3 Aquatic Pathway Characterization

This section describes and illustrates the topography and features in the vicinity of the potential pathway near Solon Springs, Wisconsin. It is intended to help inform the biological evaluations contained in Sections 4 and 5 of this report with a compilation of any readily available and applicable information of this area as it may influence local hydrology. Maps, photographs, and figures are included to aid understanding of the hydrologic and hydraulic conditions near the drainage divide. Also, this section identifies any significant data gaps and uncertainties related to this topographic information and hydrologic modeling in the area of interest.

3.1 Location

Brule Headwaters is located approximately 3.5 miles (5.6 km) northeast of Solon Springs, Wisconsin. This area is roughly centered on 46°23’33.58”N, 91°45’39.42”W. Figure 3 shows the location of this site relative to the major cities in the region. Following the retreat of the glaciers, Lake Superior drained southwestward through what are now the Bois Brule and St. Croix River valleys. This created the long, narrow, steep-sided and relatively straight valley which is seen today (Figure 4). The present Brule and St. Croix rivers originate from underground springs within an extensive coniferous wetland. The St. Croix River flows south to the Mississippi River, while the Brule flows north to Lake Superior.

This area is within the Brule River State Forest. Historically, this area has long been used to portage canoes between the Great Lakes and Mississippi River basins. The Historic Brule to St. Croix Portage Trail still runs along the east side of the valley. The trail is also on the National Register of Historic Landmarks and is a little less than two miles (2.6km) in length. The state of Wisconsin in 2012 proposed the purchase of a conservation easement on 67,300 acres (27,235 ha) of forest land in Douglas, Bayfield, Burnett, and Washburn Counties from the Lyme St. Croix Forest Company. The area will remain in private ownership and be sustainably managed for forestry, but would also open much more of this area to tourism and make it available for public recreation such as hunting, fishing, trapping, cross country skiing, bird-watching, and hiking (WDNR, 2012).

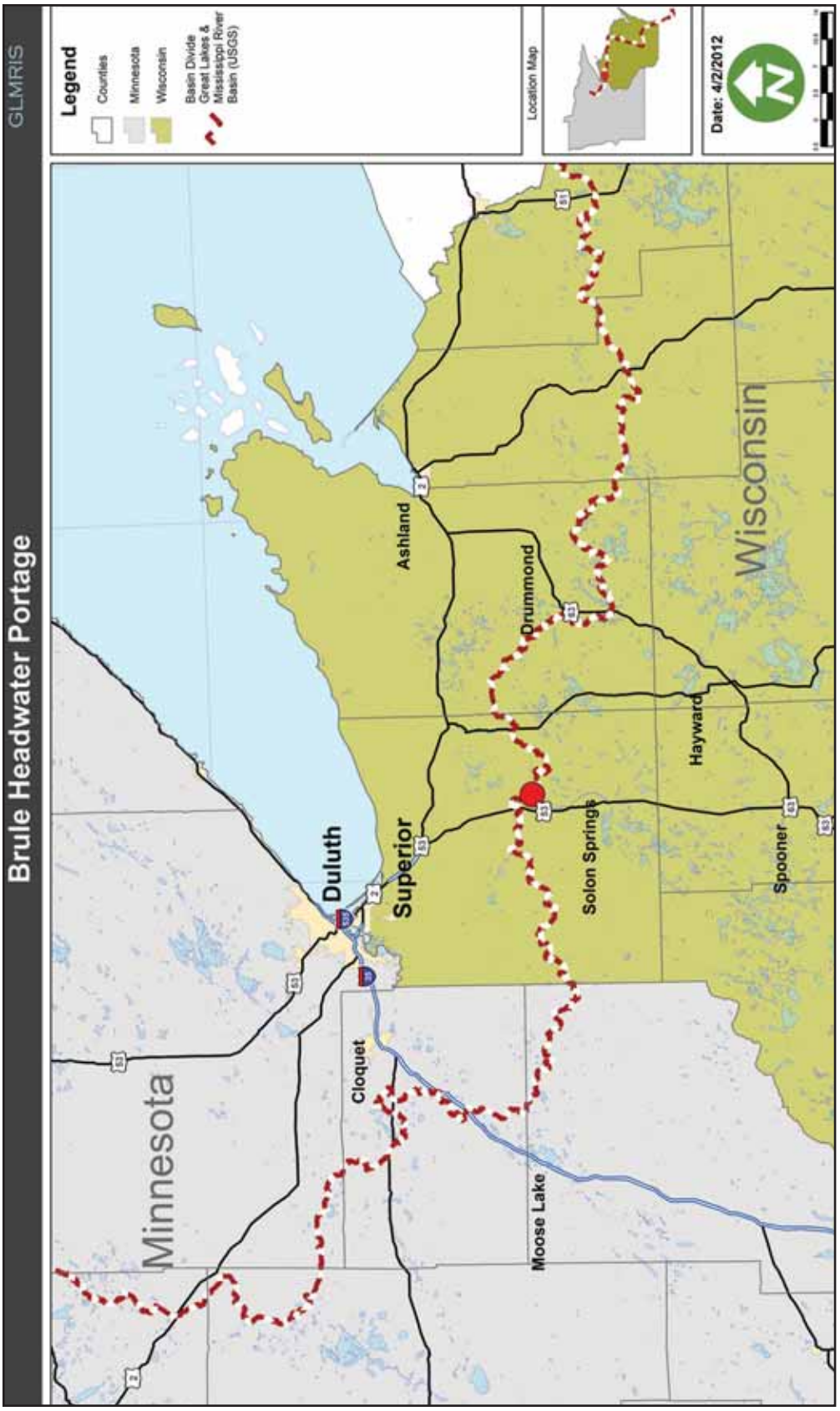


Figure 3. General location of the Brule Headwaters potential pathway, indicated by red dot and Great Lakes-Mississippi River Basin boundary (red-white line). Background imagery courtesy of Bing Maps.

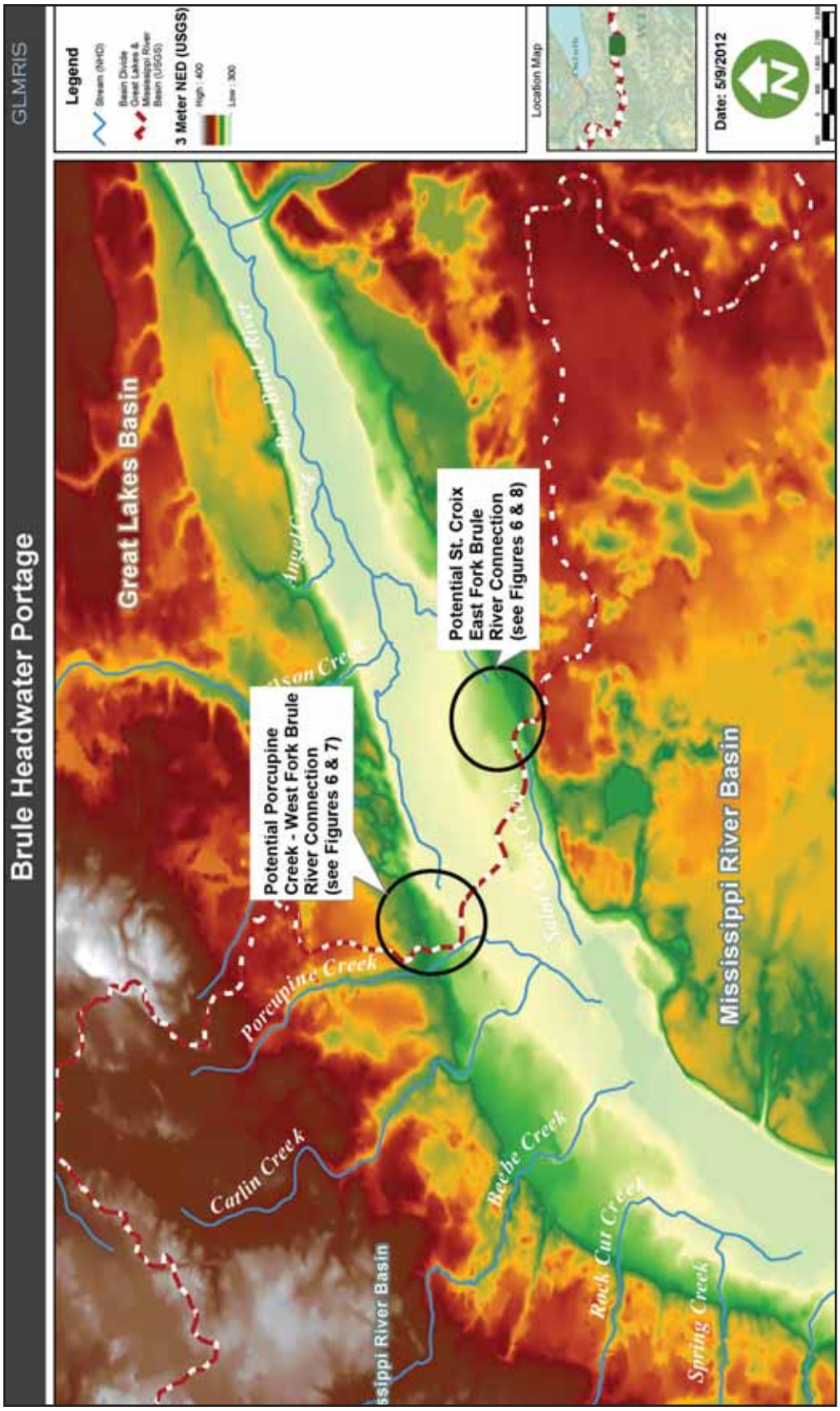


Figure 4. Digital elevation map of area around the two potential connection points between the Great Lakes and Mississippi River Basins via the headwaters of the St. Croix and Bois Brule River, and Porcupine Creek and Bois Brule River, Douglas County, WI. Background imagery courtesy of Bing Maps.

3.2 Climate

Climate is looked at in this section just in terms of identifying any applicable elements of climate (e.g., temperature, rainfall) and how they may influence the likelihood of an aquatic connection forming at the subject pathway that could be utilized by ANS to spread between basins. This area of northwest Wisconsin is classified as continental with large seasonal temperature variance, four distinct seasons, and relatively small or moderate precipitation. Temperatures in winter typically range from 5ºF to 23ºF (-15ºC to -5ºC), while summers are usually around 60º F to 70ºF (15ºC to 21ºC). Normal annual precipitation is about 30 inches (76 cm) and the normal snowfall is around 55 inches (140 cm) (Table 7).

The highest precipitation occurs in the summer months, during July and August. Although rainfall amounts do not always conform to averages, they are suggestive that substantial precipitation does not occur frequently and a much greater amount of precipitation would likely be necessary to cause a surface water connection to form between the basins. This is an area of uncertainty due to a lack of data linking precipitation amounts to the behavior of surface hydrology at the pathway location. In addition, given that annual temperatures reach down to or below the freezing mark on an annual basis, purely climatic conditions will restrict the time during which any ANS dispersal might occur by natural vectors.

3.3 Location Specific Surface Water Features

The information contained in this section is meant to present and interpret the readily available information for this location as it pertains to surface water conditions and any aspects that may influence the behavior of surface water.

The streamlines from the National Hydrography Dataset (NHD) show the headwaters of the Brule and Upper St. Croix Rivers coming within 0.30 miles (0.5 km) of each other. The FEMA mapping was created in 1978 for Solon Springs, Wisconsin. As can be seen in Figure 5 and Figure 6, the FEMA mapping does not indicate that a connection exists between the two basins at the one percent recurrence interval flood event.

A recurrence interval relates any given storm, through statistical analysis, to the historical records of rainfall and runoff for a given area. The recurrence interval is based on the statistical probability that a given intensity storm event will be equaled or exceeded in any given year. For instance, a one percent annual storm is a rainfall event that has a one percent probability, one 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. A ten percent annual return frequency storm (formerly referred to as a

Table 7 - Climate Information for Brule Headwaters vicinity (Midwestern Regional Climate Center (MRCC) – Station Solon Springs, Wisconsin)

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Mean Temperature°F	7.3	14.2	26.4	40.6	53.8	62.8	67.8	65.6	55.6	44.1	28.2	13.3	40.0
Mean Temperature °C	-13.7	-9.9	-8.6	4.7	12.1	17.1	19.8	18.6	13.1	6.7	-2.1	-10.4	4.4
Normal Precip (in)	1.06	0.81	1.67	2.17	3.22	3.95	4.86	4.24	3.56	2.55	2.11	0.95	31.15
Normal Precip (cm)	2.7	2.0	4.2	5.5	8.3	10.0	12.3	10.8	9.0	6.5	5.4	2.4	79.1
Mean Snow (in)	13.1	8.5	9.0	3.6	0.2	0.0	0.0	0.0	0.0	0.6	8.9	11.1	55.0
Mean Snow (cm)	33.3	21.6	22.9	9.1	.5	0	0	0	0	1.5	20.3	28.2	139.7

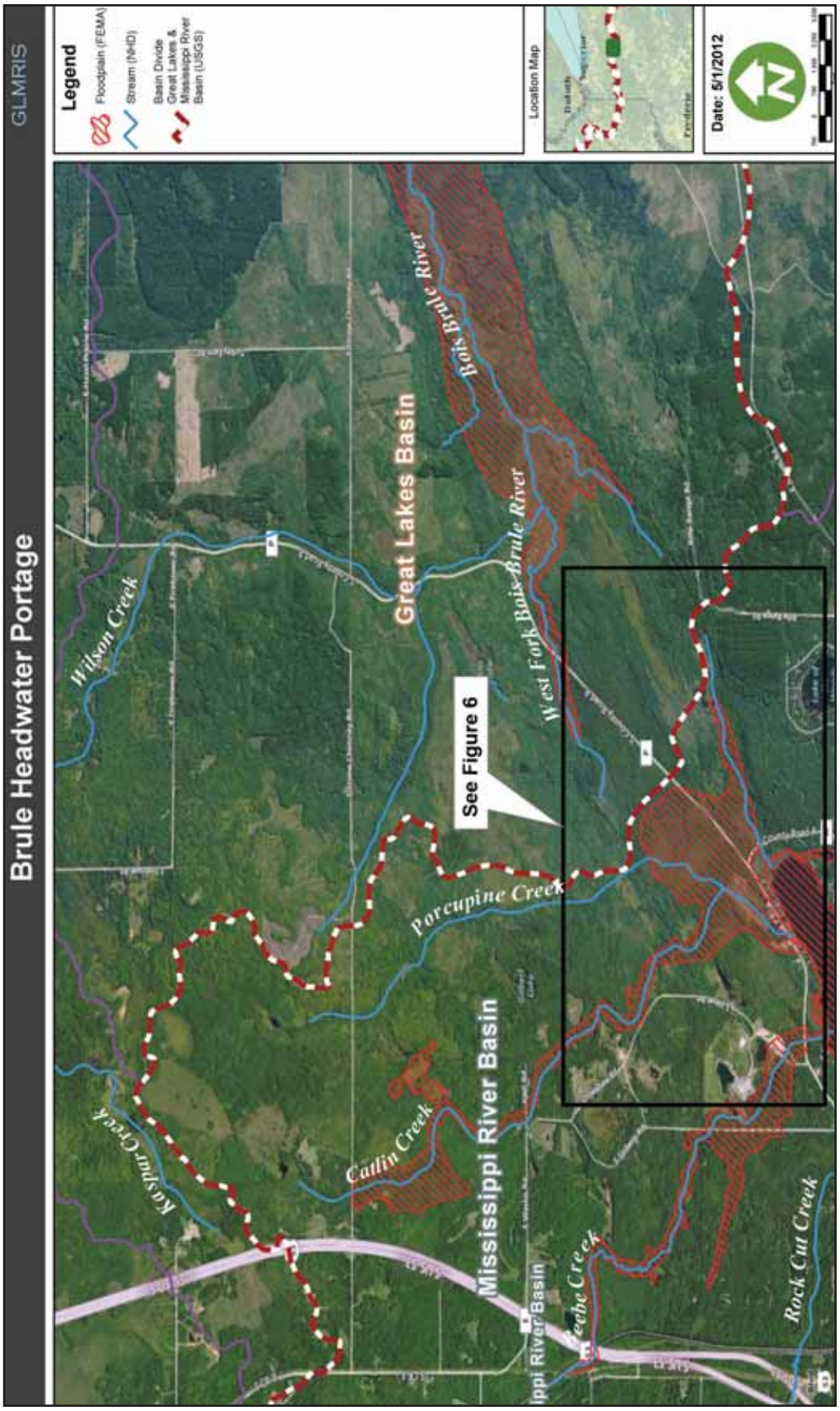


Figure 5. Red shaded area indicating FEMA one percent floodplain. Purple lines indicate HUC-12 boundaries and the Great Lakes and Mississippi River Basin divide is represented by the red-white line. Background imagery courtesy of Bing Maps.

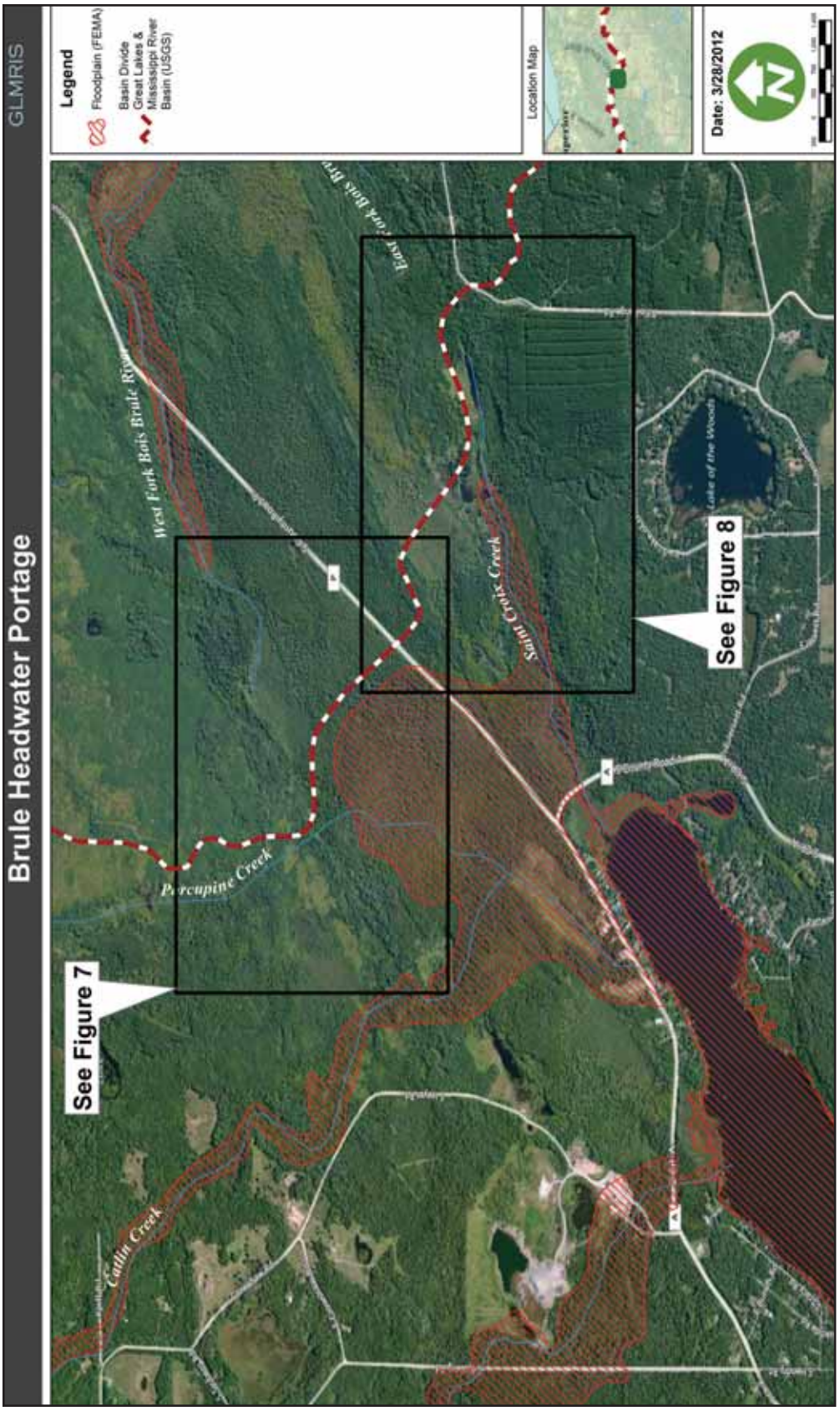


Figure 6. Closer view of the Brule and St. Croix/Porcupine Creek potential connections to provide better detail around potential pathway. Red shaded area indicates FEMA one percent floodplain. The Great Lakes-Mississippi River Basin boundary is represented by red-white line, and the blue lines are streams near the basin divide. Background imagery courtesy of Bing Maps.

ten year event) is a smaller event that has a one in ten chance of being exceed during any given year, and a 0.2 percent annual return frequency storm (formerly referred to as a 500-year event) is a larger event that has a one in 500 chance of being exceeded in any given year.

Brule River State Forest personnel indicated that it is not certain if there is a surface water connection at this site, but that both the Brule River (Great Lakes basin) and the Sr. Croix River (Mississippi River basin) originate in springs from within the Brule Bog. Figure 5 shows the potential connection points along the basin divide.

The team next examined the topography of the area to see what barrier the slope of the land itself might offer to the spread of ANS between the basins. Representative surface elevations are shown in Figure 7 and Figure 8 which also depict representative cross-sections through the areas of interest, based on the best available Geographic Information System (GIS) data. The estimated path of lowest elevation between West Fork Bois Brule River and Porcupine Creek on the west side of the valley floor is illustrated in Figure 7 (yellow line), and the estimated path of lowest elevation between East Fork Bois Brule River and Saint Croix Creek along the east side of the valley floor is shown in Figure 8. Both Figures 7 and 8 provide graphs that illustrate the change of elevation profile along the 12-digit HUC boundary (HUC Profile) and along the estimated path of minimum elevation between streams on both sides of the basin divide. The cross section graph in Figure 7 clearly indicates there is very little difference in elevation along the potential pathway (yellow line) between West Fork Bois Brule River and Porcupine Creek on the west side of the valley floor. However, a potential aquatic connection between East Fork Bois Brule River and Saint Croix Creek along the east side of the valley appears less likely. Even so, there is uncertainty that a pathway would be established here because these cross-sections do not depict any channel(s) or other low elevation conveyances for water that may occur at this location. The cross-sections show the general ground elevations only and their vertical accuracy is limited.

For this pathway, the elevations in Figure 7 and Figure 8 are based on the USGS 10m Digital Elevation Model (DEM) with a vertical accuracy of +/- 13.1232 feet (4 m). This level of accuracy may lead one to conclude that there is a high degree of uncertainty regarding the potential for watershed connections being established during flood events. However, the absolute vertical accuracy (specific elevation) is not nearly as important as the relative, or point-to-point, vertical accuracy (terrain) when evaluating terrain at the divide location to try and predict hydrology. Point-to-point accuracy has been shown to be much greater than this margin of error regarding absolute elevation would indicate. Although the absolute elevation values may vary from the true value (i.e., 800 feet above sea level (243 m)), they tend to vary a comparable amount at adjacent points so that the terrain of the area is actually depicted relatively well. The grid size used to create the DEM can also affect the accuracy of the DEM. The larger the grid cell size (10 m squares vs. 30 m squares), the more block-like and less detailed the terrain appears and thus the less accurately the DEM depicts the actual terrain. The largest grid size used at any of the pathway locations is 10 m squares with some areas having more detailed information. Even though the 10 m cell size does not depict every hummock or hollow in the terrain, it does provide sufficient detail regarding general terrain and relative elevations to provide useful data in evaluating the potential for a hydrologic connection forming across the basin divide.

The NRCS soil surveys were also reviewed to assess potential flooding frequency. The NRCS soil survey maps are based on field exploration of soils in the area and they include frequency classes for both flooding and ponding. They define flooding as “the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding”. A flooding frequency of “frequent” means that there is a 50 percent chance of flooding in any particular year. The flooding frequency map can be seen in Figure 9, which shows the area between Porcupine Creek and West Fork Brule River to be frequently flooded. The NRCS defines ponding as “standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes”. A ponding frequency of “frequent” means that, in any given year, there is a 50

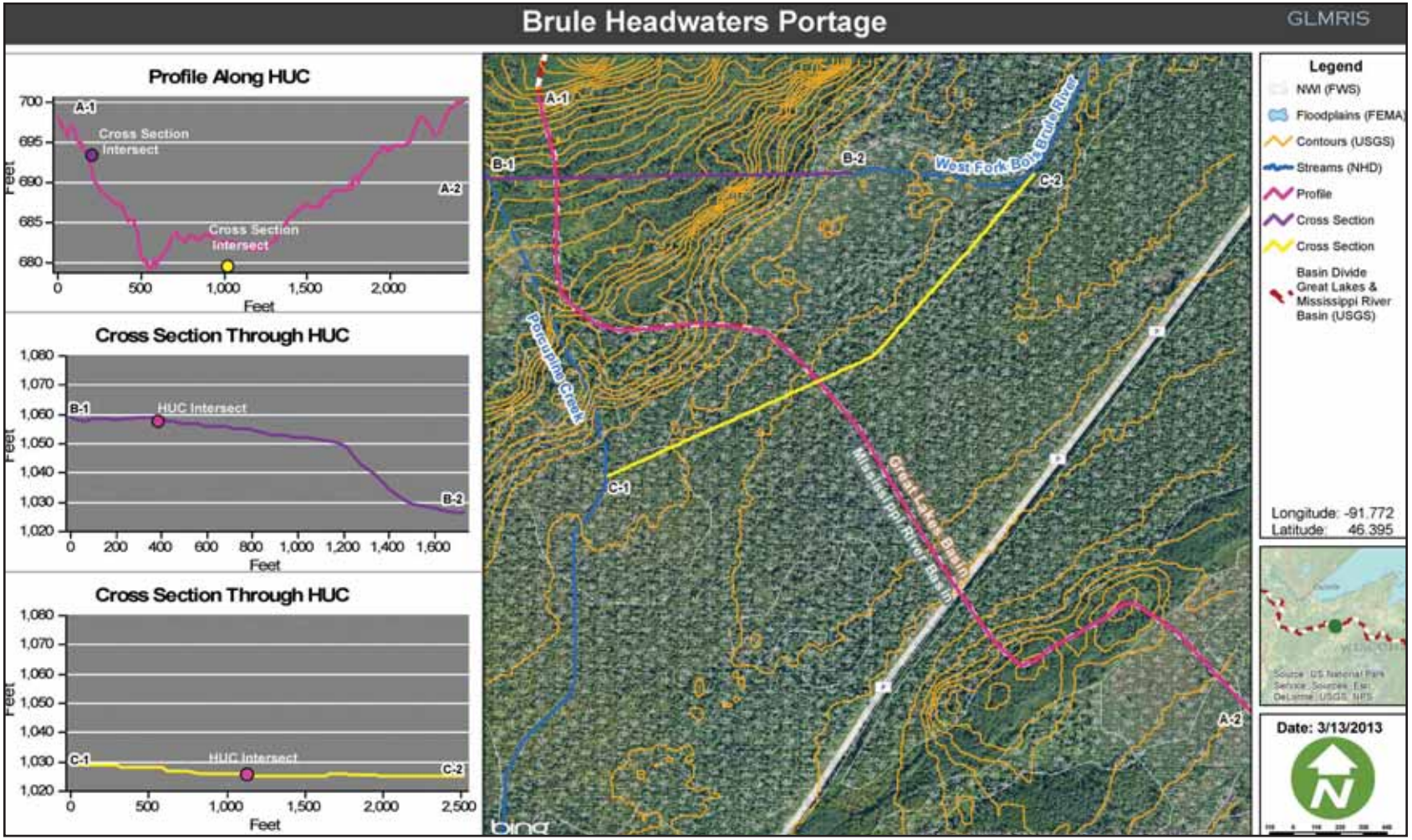


Figure 7. Typical location cross-sections between Porcupine Creek and West Fork Bois Brule River based on USGS 10m DEM, with a vertical accuracy of +/- 13.123ft. The pink line in the aerial photograph and the graph on the top left is the cross section along the basin divide. The yellow and purple lines that intersect the pink line in the photograph and the graphs on the middle and bottom left are the cross sections through the basin divide. The dots in the graphs to the left show the point(s) where the lines intersect each other and contour interval is two feet. The blue lines indicate streams near the basin divide. Note, NWI mapping shows contiguous wetland across basin divide. Background imagery courtesy of Bing Maps.

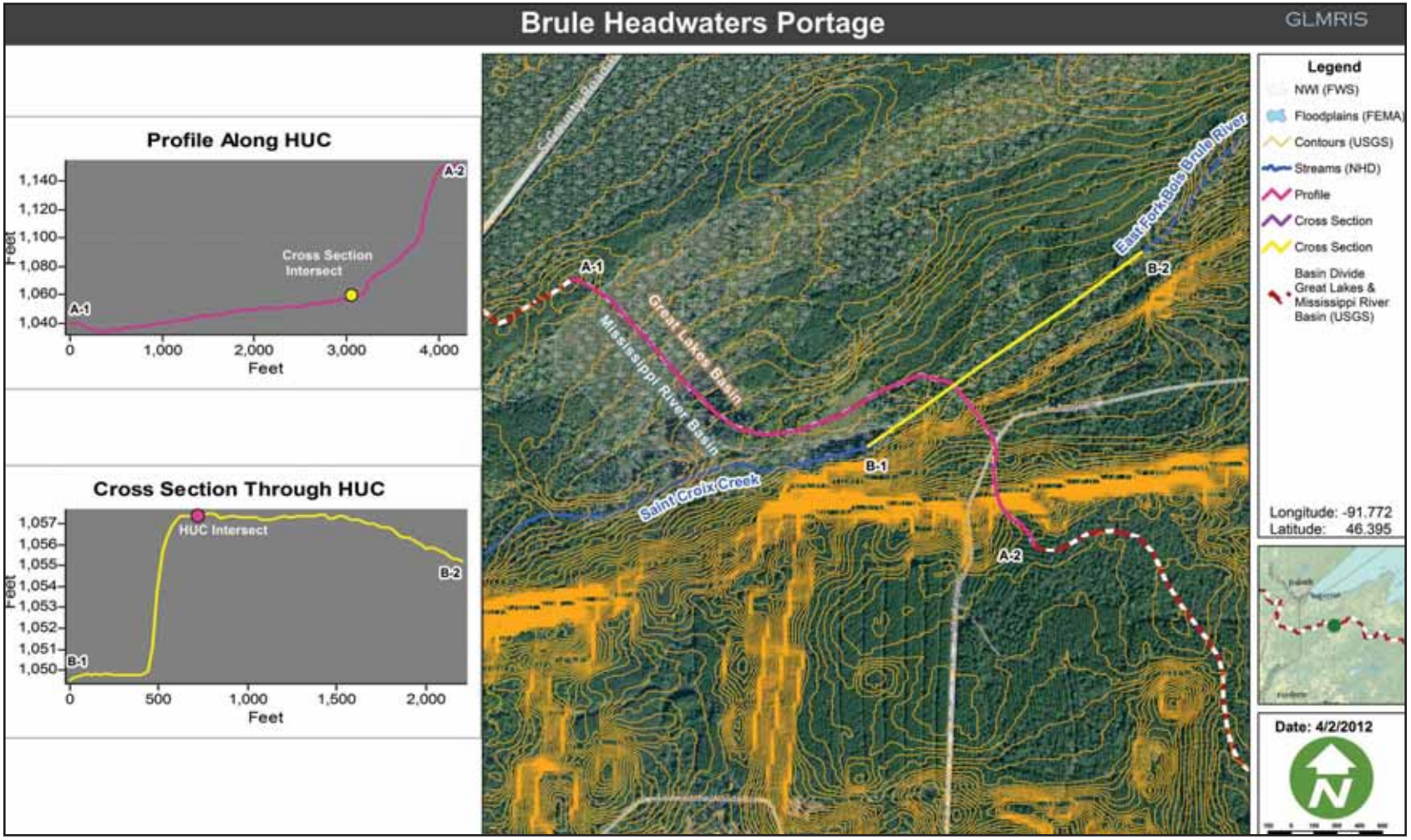


Figure 8. Typical location cross-sections between Saint Croix Creek and East Fork Bois Brule River based on USGS 10m DEM, with a vertical accuracy of +/- 13.123ft. The pink line in the aerial photograph and the graph on the top left is the cross section along the basin divide. The yellow line that intersects the pink line in the photograph and graph on the top left are the cross sections through the basin divide. The blue lines indicate streams near the basin divide. Background imagery courtesy of Bing Maps.

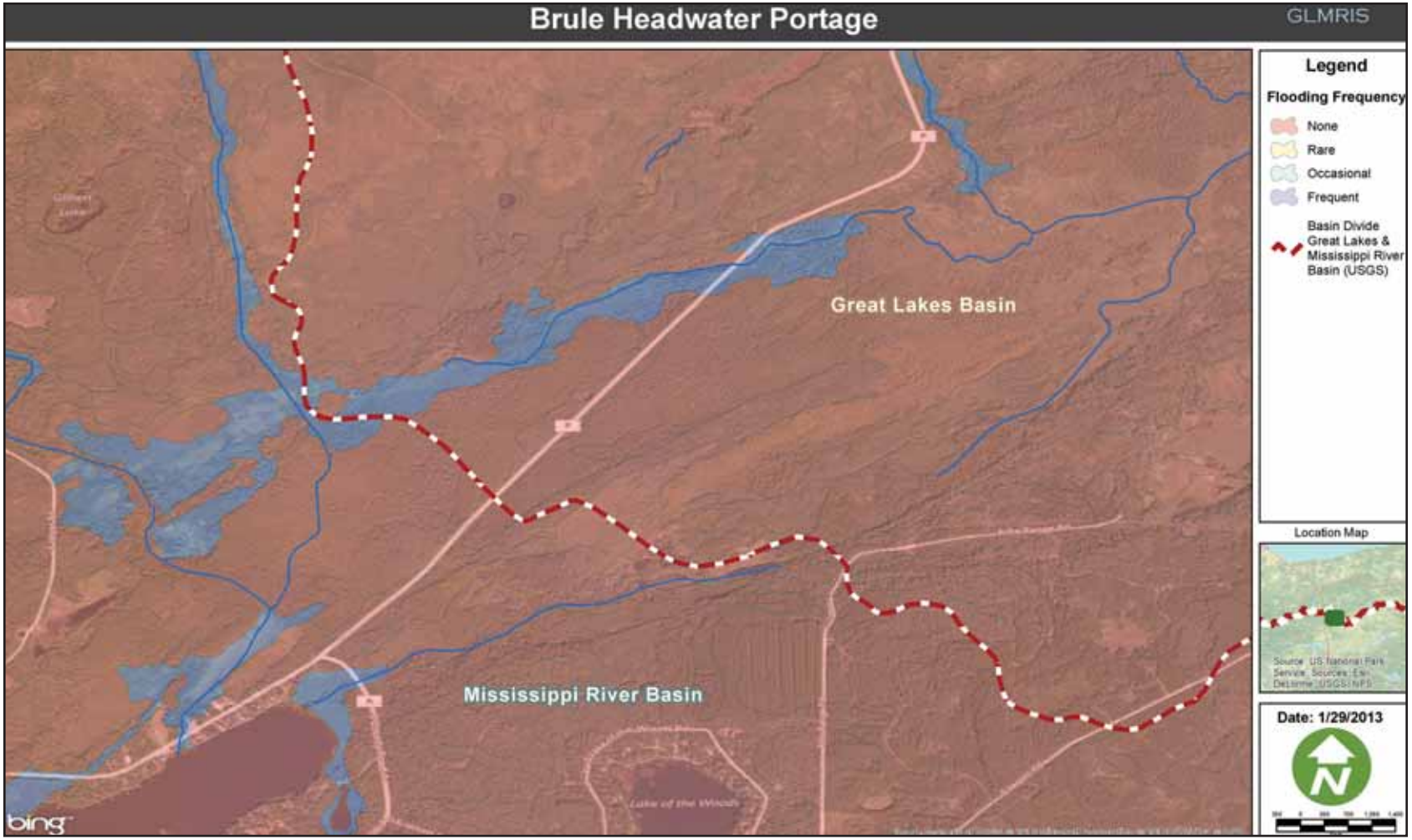


Figure 9. Soil Survey Flooding Frequency map. The blue shaded areas are considered to have occasional to frequent flooding. The red areas are considered to have no significant flooding. Basin divide is between the East Fork Bois Brule River and Saint Croix River. Mapping courtesy of NRCS and background imagery courtesy of Bing Maps and mapping.

percent chance that the ponding will occur. The ponding frequency map can be seen in Figure 10. Permanent water bodies are not assigned a ponding frequency class because they are not soils.

The area shown between Porcupine Creek and West Fork Brule River is shown as frequently ponded and flooded. With Figure 9 and Figure 10 showing both frequent ponding and flooding between these two headwaters, this was then compared to Figure 7 that shows an approximate vertical elevation difference between the two headwaters to be about five feet (lower toward Great Lakes Basin) which makes it more likely for water to flow toward the Great Lakes Basin than toward the Mississippi River Basin. National Wetland Inventory (NWI) mapping on Figure 7 and Figure 8 (lightly shaded areas, reference map legend) also show wetland areas extending across the basin divide to the headwaters of streams in both basins. However, NWI mapping is based off of aerial photo interpretation and is not necessarily conclusive by itself of exact wetland boundaries or conditions. The vertical elevation differences between the East Fork Brule and St. Croix Creek (Figure 4), is much more pronounced and therefore exhibits the least probability of forming a viable aquatic connection between the two basins.

Figure 7 and Figure 8 indicate that there is a potential vertical inaccuracy of +/-13.123 feet (4 m) based off of the USGS 10 meter DEM. This level of accuracy could introduce considerable uncertainty about the potential for watershed connections being established during flood events. However, when looking at the very flat topography of the wetland itself, especially at the southern two potential pathways, a greater level of confidence can likely be attached to these elevations since there is not much real, on-the-ground, vertical elevation change in the wetland itself that could be the cause of this much vertical inaccuracy. A 10 m DEM essentially averages the ground elevation within 900 square foot grid lines across the map, so if the elevation within a 900 foot^2 (83 m^2 area is fairly uniform then the accuracy in the elevation is likely much greater than +/-13 feet (4 m).

A site visit was conducted at the end of July 2010 by hydraulic engineers and biologist from the Detroit District and St. Paul Districts of the USACE, respectively. This visit found no evidence of a direct surface water connection at any of the potential pathway locations. The visit included walking part of the former canoe portage trail and following St. Croix Creek to its source in an upland groundwater fed bog (Figure 11). The team also walked the Brule Bog boardwalk, on the west side of the valley. A typical view from the boardwalk can be seen in Figure 12.

3.4 Groundwater

Groundwater was investigated as part of determining the likelihood a pathway exists because groundwater can serve as a source of baseflow for streams. Water levels in the aquifers typically fluctuate in response to seasonal variations; this is known as recharge and discharge. Groundwater levels commonly rise in spring, when areal recharge is greatest because of snowmelt, spring rain, and minimal evapotranspiration losses. This means that heavier rainfall events, when they coincide with frozen ground conditions, snowmelt, and higher groundwater conditions, may be more likely to facilitate formation of an aquatic connection between the basins. Groundwater levels generally decline in summer because evapotranspiration rates are high, continued discharge to streams, and withdrawals by wells collectively exceed recharge. Thus, groundwater likely plays very little role in any establishment of an aquatic connection. Net recharge to the aquifers also occurs in the fall of most years, due to rainfall and low evapotranspiration rates. The nearest available groundwater data is from USGS Groundwater Watch site 46192109484201 located five miles (eight km) southwest of the pathway site near the outlet of Upper St. Croix Lake. Another USGS Groundwater Watch site (no. 463217091342801) is 13 miles (21 km) northeast of the pathway site. These gages are far enough from the area of interest that they cannot provide direct relevant data about the site's groundwater conditions.

The area is referred to as Brule Bog by the WDNR and can be seen in Figure 14. Groundwater seeps, originating from this bog, appears to be the source for the Brule and Upper St. Croix rivers. Mapping performed by the University of Wisconsin - Stevens Point of the Upper St. Croix Watershed indicates that the groundwater divide is in the same location as the surface water basin divide.

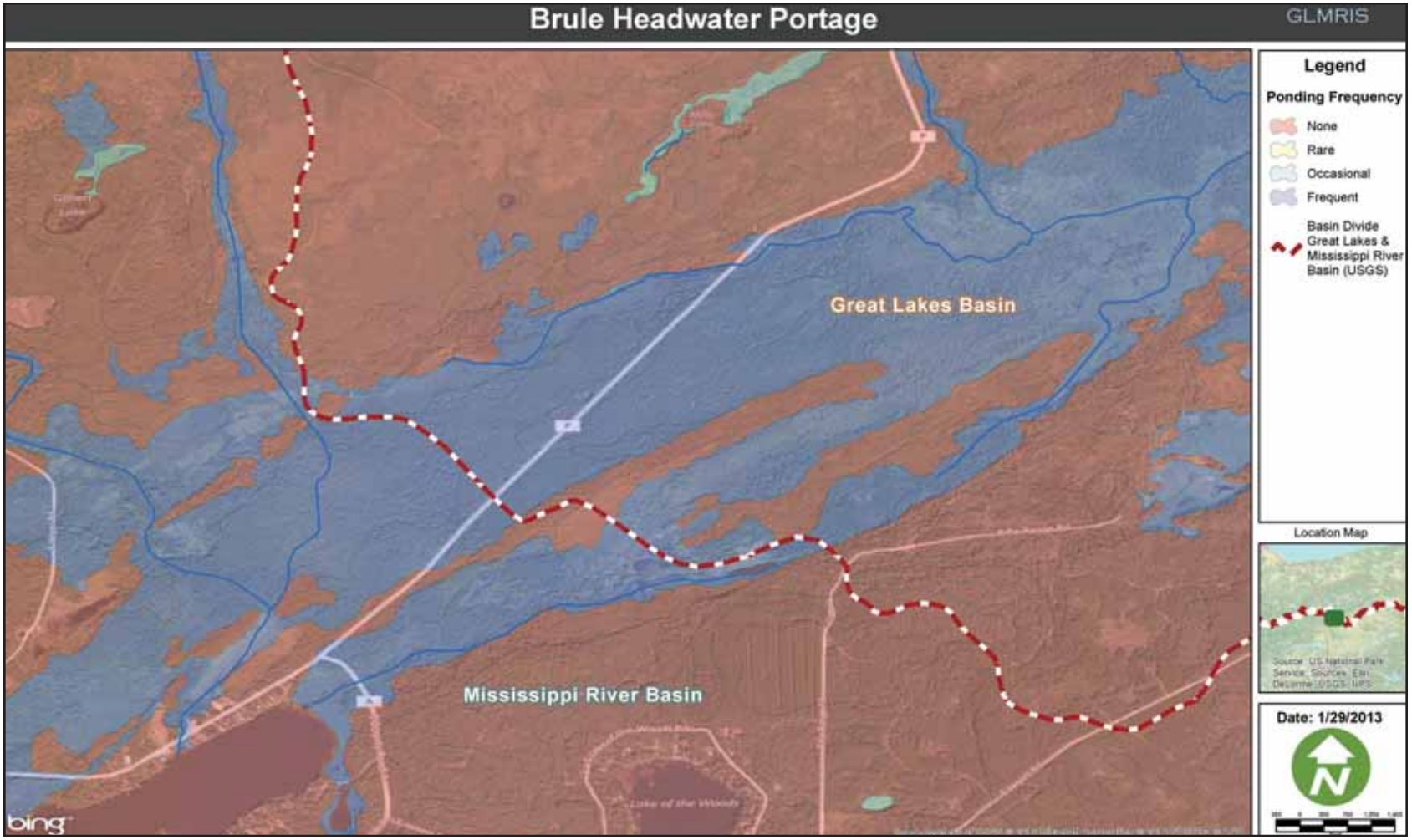


Figure 10. NRCS Soil Survey Ponding Frequency map. The blue shaded areas are considered to have frequent ponding. The red areas are considered to have no significant ponding. The basin divide is east of Porcupine Creek (located generally in the center of the photograph top to bottom). Mapping courtesy of NRCS and background imagery courtesy of Bing Maps and mapping.

Figure 11. Photo of St. Croix River Headwaters (St. Croix Creek) taken during July, 2010 site visit. This is on the east side of the valley. This stream appears as a groundwater seep at this point. The terrain continues to increase in elevation beyond this point. Photo by USACE.

Figure 12. Photo taken from the Brule Bog boardwalk near Porcupine Creek. Photo taken during July, 2010 site visit. There are occasional, small pockets of surface water, but it appears that all of the water movement in this area occurs in the subsurface. Photo by USACE.

According to the Superintendent of Brule State Forest and observations from the site visit in 2011, the base flow in Brule Bog is comprised of groundwater; Brule Bog serves as the headwaters of the Bois Brule River and the Saint Croix River. Therefore, groundwater conditions may affect surface water connections in this area.

3.5 Aquatic Pathway Temporal Characteristics

Characterizing the temporal variability of the pathway's hydrology is potentially an important aspect of understanding the likelihood of an ANS being able to traverse the basin divide as flood events may coincide with species dispersal, reproductive patterns, and abilities to survive and establish populations in various areas. The area of the Brule Headwaters potential aquatic pathway site is partially within an area identified by FEMA to be subject to one percent annual recurrence interval flooding events. However, base flood elevations and flood hazard factors have not been determined. The remaining area of the Brule potential aquatic pathway site is identified to be in an area of minimal flooding, as reflected by the NWI mapping and from county soil survey information that shows this area to be subject to frequent flooding and ponding. No other information was found on the temporal characteristics for this aquatic pathway, although it is probable that the most likely period of greatest flood potential would be spring due to snow melt, especially if in conjunction with heavy rains, rapid warming, and/or with frozen ground conditions. However, considering the lack of heavy rainfall, depth to groundwater, steep topographic features in some areas, and the surface water features from the site visit, the team believes that only relatively infrequent flooding events may possibly cause a surface water connection at the basin divide between the West Fork Brule River and Porcupine Creek. In addition, given that the area is subjected to freezing temperatures on an annual basis (Table 7) for 4-5 months, biological activity and water flow would be further restricted on a temporal basis since the water would be frozen and biological movement of ANS would be restricted.

3.6 Probability Aquatic Pathway Exists

The rating discussed in this section is only for the likelihood of an aquatic connection existing at this potential pathway (P_0) at up to a one percent annual recurrence interval storm. A surface water connection could form between the Great Lakes and Mississippi River Basins at the Brule Headwaters potential aquatic pathway based on the following:

- The flood frequency and ponding frequency maps from the Douglas County Soil Survey indicate that the Brule Pathway is subject to occasional to frequent flooding and ponding.
- The area is a bog environment with a number of shallow groundwater connections and the source of both tributaries to the Great Lakes and Mississippi River watersheds. However, no identifiable surface water connections have been identified.
- The FEMA one percent floodplain does not cross the basin divide, however, NRCS soil surveys indicate occasional to frequent flooding across the basin divide.
- NWI mapping indicates contiguous wetland between both basins at the two potential pathway areas.
- Topographic information best supports a surface water connection being possible between the West Fork Brule River and Porcupine Creek.

Due to the above evidence, the review team rates the probability of a pathway existing as medium in both directions. The applicable criteria for this rating is "a wetland spanning the basin divide which maintains significant ponds that are likely to become inter-connected and connect with streams on both sides of the basin divide from a ten percent annual return frequency storm" (Appendix A).

This rating, however, is considered reasonably uncertain because of the following:

- The flooding and ponding frequency information

from the Douglas County Soil Survey is just one line of evidence and is based on soil characteristics. As a result, this information cannot necessarily be taken as a proof of surface water conditions.

- Conflicting flood data between FEMA and NRCS.
- No visible surface water connections during site visit, or indications of past inundation.
- The vertical elevation inaccuracy of USGS 10m DEM for ground surface profiles at the basin divide.
- NWI mapping is based off aerial photo interpretation, with some ground truthing, and is not necessarily a reliable indicator of wetland boundaries.
- Inability to determine conclusively how much of any aquatic pathway that may form is purely ground water versus surface water.

3.7 Aquatic Pathway Habitat

3.7.1 Terrestrial and Riparian Plants and Land Use

Habitat in and around the pathway location includes primarily coniferous and deciduous forested wetlands. These wetlands are within a narrow valley, surrounded on both sides by uplands. Wetlands within the valley supply water for downstream wetland and stream habitats. Much of the area adjacent to the headwater streams can be characterized as cedar bog. The area at the divide may be slightly higher in elevation, separating St. Croix Creek from the Brule Headwaters (Figure 7 and Figure 8). No direct surface water connection between the headwater streams in either basin was observed other than mostly contiguous forested wetland, with intermittent standing water and hummock-hallow micro-topography. Even in the event a surface water connection was made at the pathway, the vegetative condition and on-the-ground topography would make it torturous to navigate for most actively swimming ANS (Figure 13).

3.7.2 Aquatic Resources

St. Croix Creek is a first-order, coldwater stream originating from wetlands on the Mississippi River side of the divide (Figure 5, Figure 11, and Figure 13). It flows approximately one mile (1.6 km) to its confluence with Upper Lake St. Croix (Figure 5 and Figure 14). Wisconsin DNR has identified St. Croix Creek as a Class I water for brook trout, meaning that it is a high quality trout stream that has sufficient natural reproduction to sustain wild brook trout populations at or near the stream's carrying capacity. Near the divide location, St. Croix Creek generally consists of shallow depths (less than 2 feet (0.6 m) deep at typical low-flow discharge) and narrow widths (less than 10 feet (3 m) wide). Review of aerial photographs suggests that beaver activity has resulted in some shallow ponds along or adjacent to St. Croix Creek. These ponds may persist through the year, but are likely shallow in depth.

Porcupine Creek is also a first order stream similar to, though smaller than, St. Croix Creek. It is not identified as a trout stream by WDNR, but due to proximity likely has similar characteristics as St. Croix Creek. Typical widths and depths would be less than those observed for St. Croix Creek.

St. Croix Creek and Porcupine Creek enter the northern end of Upper Lake St. Croix. Both creeks must flow through culverts prior to their confluence with the lake. St. Croix Lake is a mesotrophic lake characterized by a warmwater fish community. It is approximately 828 acres (335 ha) in size, with a maximum depth of 22 feet (6.7 m). The lake has heavy recreational boat use.

The East and West Forks of the Brule River are coldwater streams originating from wetlands on the Great Lakes side of the divide location. They each flow approximately one to two miles (1.5-3.2 km) to their confluence, forming the Bois Brule River. Wisconsin DNR also identified these two streams as Class I waters for brook trout. Near the divide location, these two streams generally include shallow depths (less than 2 feet (0.6 m) deep at typical low-flow discharge) and narrow widths (less than 10 feet (3 m) wide). The Bois Brule River remains a Class I coldwater trout stream over its entire length, approximately 44 miles (71 km), before flowing into Lake Superior.

Figure 13. Photo of St. Croix Creek taken during August, 2008. Photo taken near the headwaters, looking upstream toward the divide. Photo by USACE.

Figure 14. Photo of St. Croix Creek taken during August, 2008. Photo taken from County Highway A bridge, just upstream of Upper St. Croix Lake. Photo is looking upstream toward the headwaters. Photo by USACE.

3.7.3 Water Quality

Water quality at the divide is high, flowing out from adjacent wetlands and into St. Croix Creek and Bois Brule tributaries. Streams are dominated by year-round cold water and relatively high oxygen.

3.7.4 Aquatic Organisms

Coldwater species dominate the divide location. Fish and invertebrate assemblages would be typical of those capable of sustaining native brook trout. No known Federally-listed threatened or endangered aquatic organisms are known to be at the divide location. No known aquatic invasive species are known to be present at the divide location either, though banded mystery snail (*Viviparus georgianus*), a native species to North America and the Northeast, has been identified just downstream in Upper St. Croix Lake. Due to the high water quality and general health of the aquatic habitats in this area, spread and establishment of ANS in this area are likely to be relatively more difficult as compared to lower quality more disturbed ecosystems.

3.8 Connecting Streams to Great Lakes and Mississippi or Ohio River

Connecting streams to the Mississippi River are either through Porcupine or St. Croix Creeks which all flow into Upper St. Croix Lake. The outflow of this lake is the beginning of Saint Croix River, which then flows into the Mississippi River. Connecting streams to the Great Lakes are either through East Fork Bois Brule River or the West Fork Bois Brule River which flow into Bois Brule River and into Lake Superior.

Dams exist on both the St. Croix and Brule rivers that likely inhibit natural upstream spread of ANS. Table 8 indicates possible barriers to ANS dispersal. On the St. Croix River a major hydroelectric dam at St. Croix Falls, with a height of 56 feet (17 m), prohibits upstream movement of any ANS (Figure 15). The Gordon Dam, also on the St. Croix River just downstream of Upper St. Croix Lake, also is a significant barrier to upstream movement.

On the Brule River only one dam is found. This feature was installed for the purpose of stopping upstream movement of sea lamprey. The dam has a vertical drop of 5.5 feet (1.6 m) under typical low flow conditions (WDNR personal communication). The dam includes a fish passageway to allow for upstream migration of salmonids (Figure 16).

Table 8: Barriers to ANS Dispersal, Including Dam Heights and any Known Fish Passage (NID, 2010).					
Mississippi Connection -					
	1 - Caitlin Creek, Saint Croix River, Mississippi River				
	2 - Porcupine Creek, Saint Croix River, Mississippi River				
	3 - Porcupine Creek, Saint Croix River, Mississippi River				
	4 - Saint Croix Creek, Saint Croix River, Mississippi River				
Connection	**Dam Name**	**River**	**Hydraulic Height of dam (ft) from NID**	**Dam height (ft) from NID**	**Fish passage?**
Mississippi	Saint Croix Dam	Saint Croix River	**8**	**15**	Not able to verify, no FEMA FIS. WDNR believes fish passage not possible
Mississippi	Saint Croix Falls Dam	Saint Croix River	**56**	**60**	Not able to verify, no FEMA FIS. WDNR believes fish passage not possible
Great Lakes Connection -					
	1 - West Fork Bois Brule River, Bois Brule River, Lake Superior				
	2 - East Fork Bois Brule River, Bois Brule River, Lake Superior				
Connection	**Dam Name**	**River**	**Hydraulic Height of dam (ft) from NID**	**Dam height (ft) from NID**	**Fish passage?**
Great Lakes	Brule River Sea Lamprey Barrier (Gobin et al., 2003)	Brule	Not Available	Low Head Dam	Fishway with Sea Lamprey Trap

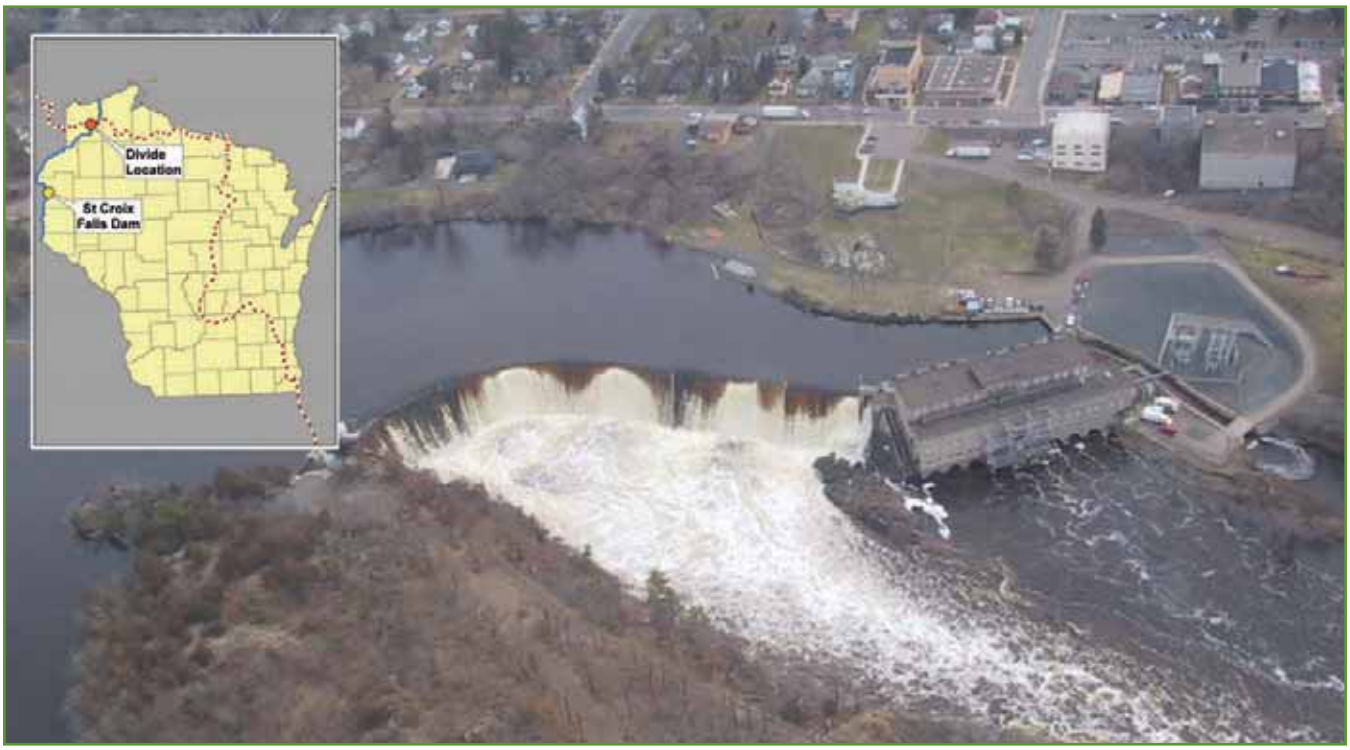


Figure 15. Hydroelectric dam on the St. Croix River at St. Croix Falls, WI. Photo from April 19, 2001. Daily river discharge was 27,500 cfs (778 cms) (USGS 05340500), a discharge between approximately a 50 percent and 20 percent chance flood event. Photo source: NOAA National Operational Hydrologic Remote Sensing Center.

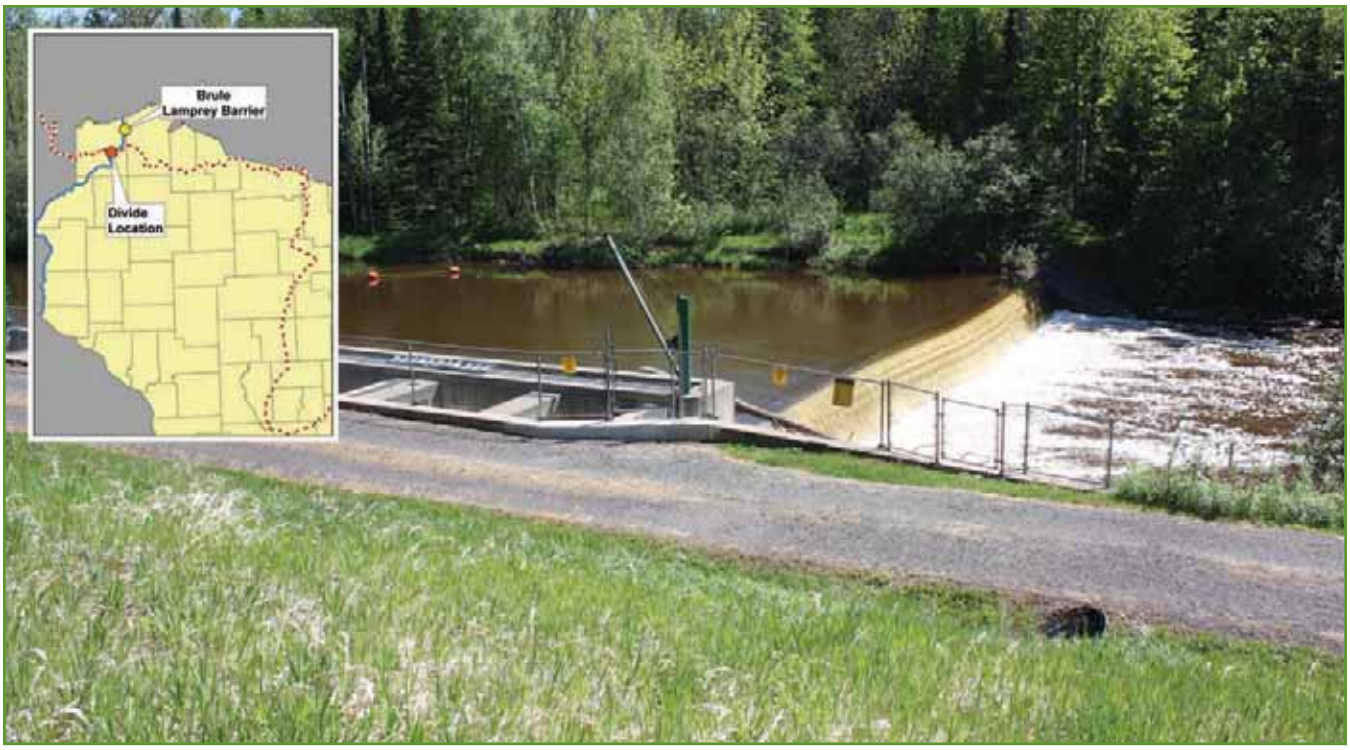


Figure 16. Brule Lamprey Barrier on the Brule River just north of State Highway 13. Photo source: Wisconsin Department of Natural Resources.

4 Aquatic Pathway Viability for ANS of Concern

The potential for species transfer was assessed by the project team for the ANS of concern for Brule Headwaters. This potential was characterized as high, medium, or low for the following categories:

- Probability that pathway exists (Section 3)
- Probability of the target ANS occurring within either basin (Section 4.1)
- Probability target ANS survive transit to reach aquatic pathway (Section 4.2)
- Probability of ANS establishment in proximity to the aquatic pathway (Section 4.3)
- Probability of ANS spreading across aquatic pathway into new basin (Section 4.4)

The criteria for designating probabilities of high, medium, or low are provided under each category. In addition, a certainty rating is also assigned with each probability assessment. Certainty ratings associated with any given probability ratings include:

- Very Certain (As certain as we will get with this effort)
- Reasonably Certain
- Moderately Certain (More certain than not)
- Reasonably Uncertain
- Very Uncertain (An educated guess)
- A team rating is provided based on the professional collaboration of the interagency team of biologists

These characterizations were completed by a team of agency biologists for each species under consideration. A team probability and certainty rating also is provided.

The rating represents the most conservative probability assessment for each category considered. The forms describing the probability and certainty ratings from all agency professionals participating in this assessment is included at Attachment A.

4.1 Probability of the ANS being within either basin

General Considerations for Assigning Probability Ratings:

> **High** - Target ANS exists on connected waterways in close enough proximity to be capable of moving to the aquatic pathway within 20 years.
>
> **Medium** - Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of moving to the aquatic pathway within 20 years.
>
> **Low** - Target ANS is not known to exist on a connected waterway.

Certainty ratings were applied as outlined above.

Asian Carp

Silver carp and bighead carp are established throughout the middle and lower Mississippi River. The furthest upstream that reproducing populations of either silver or bighead carp have been confirmed is Pool 19 of the Upper Mississippi River. This is approximately 400 river miles (644 km) below its confluence with the St. Croix River. However, a bighead carp was collected in the lower St. Croix River in 2011. Silver carp eDNA also was collected below the St. Croix Falls Dam of the St. Croix River during 2011. This technique of using eDNA is useful for detection of the presence of Asian carp DNA in water when species populations are at very low levels of abundance (Jerde et al., 2011; Dejean et al, 2011; and Minamoto et al, 2011). A positive eDNA sample indicates the presence of Asian carp DNA and the potential presence of live fish. At present, eDNA evidence cannot verify whether live Asian carp are present, whether the DNA may have come from a dead fish, or whether water containing Asian carp DNA may have been transported from other sources, such as bilge water. The U.S. Army Corps of Engineers is leading an Asian Carp eDNA Calibration Study (ECALS) with the U.S. Geological Survey and the U.S. Fish and Wildlife Service to reduce the uncertainty surrounding eDNA results and investigate alternative sources and pathways for eDNA detections beyond a live fish.

Although they may not be established within the St. Croix River, individuals of bighead, and potentially silver carp as well, are present. Black carp have a more limited distribution and are less likely to reach the St. Croix River in the near future.

Asian carp need long free-flowing reaches of stream to spawn that is initiated by rising water levels following heavy rains. Bighead and silver carp need 35-40 miles (56-64 km) of open river to successfully spawn (Jennings, 1988; Verigin, 1978; Nico and Jelks, 2011). While silver and bighead carp are highly opportunistic on their diet, bighead carp are primarily zooplanktivorous, whereas silver carp primarily consume smaller phytoplankton and fine particulate organic matter (Dong and Li, 1994; Jirasek et al., 1981; Williamson and Garvey, 2005). Adult black carp are primarily molluscivores. However, they will opportunistically consume a wide variety of food items (USFWS, 2002). Juvenile black carp have a diet more similar to silver and bighead carp, consisting primarily of zooplankton (USACE, 2011b). The diet of juvenile black carp may allow them to survive in areas unsuitable for adults. The habitat of black carp is very similar to the grass carp (*Ctenopharyngodon idella*) (Nico and Jelks, 2005). It is believed that black carp should be able to colonize the same areas of the United States where the grass carp have established (USFWS, 2002).

Team rating: **Medium**
Team certainty rating: Reasonably Certain

Inland Silverside

Inland silversides has not been collected in the St. Croix River. Recently, its most northern known occurrence in the Mississippi River Basin is on the Kankakee River in Will County, Illinois, where they were collected in

1996 (USGS, 2011). The species was stocked in Turtle Lake in Ramsey County, Minnesota in 1950, but that population failed. There is no evidence that the species has expanded beyond these areas, and these areas are a large distance from the St. Croix River and its headwaters.

Team rating: **Medium**
Team Certainty rating: Moderately Certain

Northern snakehead

The closest established population of northern snakehead is in Lee County, Arkansas. While this is in the Mississippi River watershed, this population does not seem to be spreading at a high rate at this time (USGS, 2011). A single specimen of giant snakehead (*Channa micropeltes*) was collected in the Rock River by the WDNR (a watershed not directly connected with the Portage Downstream pathway). This specimen was unintentionally released. However, the species is considered to be tropical to sub-trocpical and not able to survive winter temperatures encountered in the Rock River (Courtenay, Jr. and Williams, 2004). These areas are also hundreds of miles from the St. Croix River and its headwaters.

Team rating: **Medium**
Team Certainty rating: Moderately Certain

Viral Hemorrhagic Septicemia virus

Viral hemorrhagic septicemia virus has been reported throughout the Great Lakes Basin, including Lake Superior (USGS, 2011). It has been found in many species of fish including brown trout (*Salmo trutta*), northern pike (*Esox lucius*), and common carp (*Cyprinus carpio*). These fish are established in Lake Superior, as well as the Brule River leading to the divide. The virus has also been found in 28 different host fish species in the Great Lakes Basin and that it can survive without a host in the water column (WDNR, 2012b). While other host fish species are known to exist in the pathway system, the brown trout was selected as the most likely host species for VHSv because of the cold water trout stream characteristics of the river and life cycle capabilities of the brown trout. Viral hemorrhagic septicemia virus and a necessary host species, the brown trout, are in the pathway.

Viral hemorrhagic septicemia virus can infect a wide range of host fish causing a variety of external and internal pathology including death of the host fish. Variables such as host fish species and water temperature can impact the pathology of the virus. Seemingly healthy individuals that have been previously infected with VHSv can have chronic infections and be carriers of the disease (Skall et al., 2005). This virus has been reported from throughout the Great Lakes Basin including Lake Michigan and was found in Lake Winnebago in 2007, but not since (USGS, 2011).

Team rating: **High**
Team certainty rating: Reasonably Certain

Ruffe and tubenose goby

The ruffe and tubenose goby are located within the Great Lakes and are associated with river mouths and estuaries of large river systems entering the Great Lakes. The ruffe exists in northern Lake Michigan in Green Bay, but is not widespread and there are no high density populations in Lake Michigan (Bowen and Goehle, 2011). Ruffe occur at the mouth of the Brule River, while tubenose goby at the mouth of the Poplar River about 10 miles (16 km) to the west.

The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravels but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). The ruffe has a high reproductive rate and spawns in clean water. Females produce up to 200,000 eggs in the first batch, and up to 6,000 eggs per subsequent batch (Global invasive species database, 2012). The ruffe's ability to swim upstream during high flow events and pass over dams is questionable. The ruffe is an aggressive species that possesses the ability to feed in darkness, cold temperatures, and turbid conditions.

The tubenose goby is a benthic species that consumes a wide variety of invertebrates (USGS, 2011). They are found in the open waters and estuaries of slow flowing rivers and are often quite abundant in backwaters and lakes and seem to prefer dense vegetation. The tubenose goby's introduced range covers three Great Lakes including Lake Superior, Erie, and Huron (USGS, 2011). It has been collected in the lower reaches of larger

Great Lakes rivers and estuaries, but no tubenose goby have been collected locally in upper Great Lakes river tributaries to date. Tubenose gobies have exhibited a much slower rate of expansion in the Great Lakes than the round goby (*Neogobius melanostomus*), also an invasive species in the Great Lakes and now located within both the Great Lakes Basin and the Mississippi River Basin. The tubenose goby's nearest locations are in Lake Superior and Lake Huron.

Team rating: **High**
Team certainty rating: Reasonably Certain

Threespine stickleback

The threespine stickleback is found in each of the Great Lakes and has been collected in some inland river systems (USGS, 2011). They occur at the mouth of the Brule and Lake Superior. Literature indicates this species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers.

Team rating: **High**
Team certainty rating: Reasonably Certain

4.2 Probability ANS surviving transit to aquatic pathway

The interagency team was asked to answer two questions relative to an ANS being able to survive transit from its current known location within either basin to the Brule Headwaters pathway according to the criteria specified in the following two subsections for each individual ANS of concern.

4.2.1 Probability of ANS Surviving Transit to Aquatic Pathway through Connecting Streams.

General considerations for assigning probability ratings:

High - Target ANS are established in relatively close proximity to the location and have ample opportunity, capability, and motivation to successfully navigate through the connecting streams to arrive at the subject pathway within 10 to 20 years.

Medium - Target ANS are established at locations in close enough proximity to the location and have limited capability to survive movement through the connecting streams to arrive at the subject pathway within 20 to 50 years.

Low - Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations through the connectin streams to arrive at the subject pathway within next 50 years.

The same certainty ratings identified above also apply here.

Asian Carp, Inland Silverside, and Northern Snakehead

The exact dispersal capability of Asian carps remains unknown. Juvenile, sexually immature Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over barriers, such as dams, to continue their upstream movement (D. Chapman, personal communication, September 12, 2011; N. Caswell, U.S. Fish and Wildlife Service, September 12, 2011). The gradient needed to prevent juvenile fish from moving upstream is unknown. It is important to note that young Asian carp tend to move laterally away from the river in which they were spawned and not back upstream (D. Chapman, personal communication, September 12, 2011). It has also been observed that Asian carp, as small as advanced fingerlings, have traveled up to 37 miles (60 km) though tributaries of the lower Missouri River. These tributaries were located laterally to the Missouri river segment in which these fish hatched (D. Chapman-USGS, personal communication, September 12, 2011). Adult, sexually mature Asian carp have occasionally been found in very small streams, which appear scarcely large enough to support the fishes at low water (D. Chapman, personal

communication, September 12, 2011). The age of these fish when they arrived at these locations is unknown. While ongoing research by Indiana Department of Natural Resources and Purdue University may suggest that tagged Asian carp have no interest in ascending some of the smaller rivers, more long term studies are needed, and even these may not help explain the seemingly random movements of young that have been witnessed in Midwestern rivers and their tributaries (Coulter and Goforth, 2012; D. Chapman, personal communication, September 12, 2011).

Movement of invasive fish species from the Mississippi River Basin up to the divide location would not occur by these fish swimming unaided (i.e., other vectors). Direct passage of all fish species upstream of the St. Croix Falls dam on the St. Croix River, via swimming, would not occur because of the high hydraulic head (56 feet (17 m); Figure 16). This eliminates the potential for all fish to move on their own account from the Mississippi River through the St. Croix River past St. Croix Falls. Although northern snakehead can move across wet terrestrial areas, the area around St. Croix Falls Dam is a gorge, thus preventing overland movement around the dam for this species. The Gordon Dam, with a hydraulic height of approximately eight feet (2.4 m), would also slow, if not stop the movement of fish up to the divide location. The invasive species outlined here would not be able to move to the divide locations without the aid of anthropogenic means.

Team rating: **Low for all species**
Team certainty rating: Very Certain for all species

VHSv

Brown trout, northern pike and common carp, all potential carriers of VHSv, have been identified in Lake Superior. The entire length of the Brule River is known as exceptional trout water, and movement of fish are known to occur between Lake Superior and the Brule River. A dam does exist on the Brule River, but includes a fish ladder that passes salmonids. As a result, it appears highly likely that brown trout, and thus VHSv, would have access to the divide location.

Team rating: **High**
Team certainty rating: Reasonably Certain

Ruffe and Tubenose Goby

The ability for either ruffe or tubenose gobby to swim upstream through a high-gradient coldwater river is questionable, especially since it prefers still or slow moving water (Fishbase, 2011). The Brule includes high-gradient rapids that may be natural barriers to these species. The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel areas, but has a tolerance for different habitats and environmental conditions (Gray and Best, 1989). Ballast water transport has been the key means for the spread of ruffe in the Great Lakes (USFWS, 1996). Natural rates of dispersion are not well known and ruffe have not spread beyond Green Bay in the nine years since its detection in that area, and populations have been trending down (Bowen and Goehle, 2011). It is also unlikely these species would be able to successfully move in appreciable numbers past the Brule River lamprey barrier dam. The fish ladder at this location is designed to be passable to salmonids, but these species are much stronger swimmers and capable of leaping between the step pools provided in the fish passageway. Ruffe and tubenose goby, which are primarily lake species, have not been collected in smaller, cold headwater streams. There is no indication in the literature that either fish species would seek to inhabit the colder headwaters of the upper Brule River.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Threespine Stickleback

The threespine stickleback has been found in the Great Lakes and in smaller river systems including Dutchmans Creek in Douglas County, Wisconsin (Stevens, 2011). Great Lakes populations tend to be potadromous (truly migratory but within fresh water only) and only occupy the lower reaches of streams during spring spawning. Movement up the Brule, a high gradient, coldwater stream may be difficult. The Brule Lamprey Barrier also would be an essentially impassable barrier under most conditions.

Team rating: **Low**
Team certainty rating: Reasonably Certain

4.2.2 Probability of ANS

Surviving Transit to Aquatic Pathway through Other Means

The ratings in this section do not influence the overall pathway rating outlined in this report, and are only included to point out potential other pathways (e.g., anthropogenic) and their potential influence on the same list of ANS as evaluated in Section 4.2.1. Any further analysis of these non-aquatic pathways outside of this study should develop a separate list of ANS that will likely differ from those which may exploit the aquatic pathway.

General considerations for assigning probability ratings:

> **High** - Target ANS are established in relatively close proximity to the location and have ample opportunity, capability, and motivation to successfully navigate through a non-aquatic pathway to arrive at the subject pathway within 10 to 20 years.
>
> **Medium** - Target ANS are established in close enough proximity to the location and have limited capability to survive movement through a non-aquatic pathway to arrive at the subject pathway within 20 to 50 years.
>
> **Low** - Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations through a non-aquatic pathway to arrive at the subject pathway within next 50 years.

Asian Carp

Although transit to the watershed divide by anthropogenic means is possible, Wisconsin state regulations prohibit transport and possession of Asian carp. This reduces opportunities for transfer. Since fishing and boating do not occur at the emergent wetland divide and the wetland complex appears to have limited standing water, it is highly unlikely that any species of Asian carp will arrive at the divide by anthropogenic means, such as livewell, bait bucket or aquarium releases.

Team rating: **Medium**
Team certainty rating: Moderately Certain to Reasonably Certain

Inland Silverside

Similar to the discussion for Asian carp, transit up to the watershed divide by anthropogenic means is possible. The inland silverside is one of four groups of restricted, non-native fish species in Wisconsin. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the WDNR. This should reduce the potential for human transfer. But, it would not eliminate the risk of transport. Given its small size, the inland silverside could be in a bait bucket and mistakenly released. However, there is no source population of inland silverside anywhere near the upper watershed. Given limited expansion to date, and the failed stocking of this species within a nearby Minnesota lake, it is highly uncertain if anthropogenic movement could result in the species being near the divide in the next 40 years.

Team rating: **Low**
Team certainty rating: Moderately Certain

Northern Snakehead

Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, education efforts by Minnesota and Wisconsin have aimed to reduce aquarium releases, and other methods of human transfer. Since fishing and boating do not occur in the basin divide wetland, it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as livewell or aquarium releases. They could arrive at lakes near or adjacent to the divide. However, intentional release by humans of the northern snakehead in the divide location appears unlikely. Moreover, the likelihood of human release would likely occur with the same level of potential on either side of the divide and all along the divides approximately 1,500 miles (2,414 km), making the issue of anthropogenic release less specific to the Brule Headwaters location.

Team rating: **Low**
Team certainty rating: Moderately Certain

VHSv

It is uncertain how much public use occurs in the headwaters area, but it is likely to be limited. The most likely vector for human transport of VHSv would be through transport of fish, but could also include contaminated water or equipment. Given the remoteness of the divide location, it is unclear how often access would occur by humans with fish (e.g., fishing bait or fish collected with a creel) or fishing gear that could transport VHSv. However, fishing does occur on both sides of the divide and given the adjacent fishing access, transit to the Brule bog watershed divide by anthropogenic means is possible. In addition, the announced intention (2012) by the state of Wisconsin to purchase conservation easements on 67,300 acres (27,235 ha) in four counties (including Douglas County), and to open the areas up to various recreational uses may result in increased potential for anthropogenic vectors to transport various ANS to the forested wetland habitats of the Brule aquatic pathway (WDNR, 2012). Given the range of potential fish hosts, and how fish can be moved by humans, a risk rating of high was applied even if fisherman do not normally frequent the divide location.

Team rating: **High**
Team certainty rating: Reasonably Uncertain

Ruffe and Tubenose Goby

Use of the Brule headwaters by fishermen or recreational boaters appears to be low. As such the probability for ANS to be transported to the proximity of the basin divide at this location by anthropogenic means also would appear low. The ruffe and tubenose goby are listed among the “established non-native fish species” (see WI NR 40.02(17)), which is one of four groups of restricted non-native fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the WDNR. While it is possible that either species could arrive at the divide by anthropogenic means, such as bait bucket transfer or aquarium releases, it is unlikely as these two fish species are not normally used as live bait for river fishing or aquarium species. Given this, human movement to the divide location appears remote.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Threespine Stickleback

The threespine stickleback is listed among the “established nonnative fish species” (see WDNR 40.02(17)), which is one of four groups of restricted non-native fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the WDNR. However, this does not preclude human transport. It is believed that bait-bucket transport has aided in the movement of the threespine stickleback in the past. Given its remoteness, fishing, and recreation boating is probably limited at the divide. It appears unlikely that the species would arrive at the divide by anthropogenic means.

Team rating: **Low**
Team certainty rating: Reasonably Certain

4.3 Probability of ANS Establishment in Proximity to the Aquatic Pathway

General Considerations for Assigning Probability Ratings:

High - Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range, and there are no known predators or conditions that would significantly impede survivability or reproduction.

Medium - Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.

Low - Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive. There is very limited available habitat area suitable for ANS cover, sustainable food supply, and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

Asian Carp

Silver and bighead carp are fast growing species that are capable of surviving in a wide range of water temperatures and reproducing quickly, provided suitable habitat is available. Life history habitat requirements generally include diverse needs for current areas, backwater habitats, deep overwintering holes, and other habitat types needed for survival (Nico, et al., 2005).

Habitat at the divide location is a coldwater stream originating from a cedar bog. Habitat conditions include year-round cool temperatures, shallow depths (often less than a foot deep), and a narrow channel (less than 10 feet (3 m)). Some shallow aquatic area is available in adjacent wetland ponds, but these ponds experience shallow depths and ice cover. It is unlikely that Asian carp could survive in these shallow ponds beyond short periods of time (i.e., days or weeks) given the severe winters and extensive ice cover. Though Asian carp are capable of surviving in water with poor water quality (including low dissolved oxygen). it is not believed that Asian carp would be able to live long-term in these shallow-water areas. Successful spawning and recruitment is highly unlikely and would prevent establishment of actual populations at the divide, as all species of Asian carp require lowland rivers to complete their life cycles (Nico and Jelks, 2011). Physical space within the aquatic habitat at the divide location would not be adequate for this species to establish a population. Ultimately, Asian carp would not be able to establish a sustainable population directly at the pathway divide.

If present, Asian carp might be able to survive in Upper Lake St. Croix which is only a mile or so downstream of the divide location. However, it is uncertain whether Asian carp could move up to the pathway divide during a flood. To pass from Upper Lake St. Croix to the divide location, Asian carp would have to either swim through a small culvert running underneath a County highway, or swim over the highway during flood conditions.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Inland Silverside

The divide location would likely be unable to support the species because of cold winter temperatures. Hubbs et al. (1971) inferred that the native inland range for the inland silverside does not extend beyond the confluence of the Ohio and Mississippi Rivers because it cannot withstand winters farther north. Richards (1977) however showed that the inland silverside can survive for at least two weeks at 35º F (1.5º C). Stoeckel and Heidinger (1988) demonstrated that inland silversides can be maintained over winter in aquaculture systems at temperatures above 59º F (15º C), when they were fed a prepared diet. They also demonstrated that inland silversides have a high mortality during extended periods of cold during the winter in unheated ponds and reservoirs. The adjacent St. Croix River may have more suitable habitat, but the site may be too far north for the species to survive, which is supported by the lack of successful populations being reported this far north, even after intentional stocking.

Team rating: **Low**
Team certainty rating: Moderately Certain

Northern Snakehead

The northern snakehead's native range (latitude 24-53º N) and temperature tolerance 32-86º F (0-30ºC) indicates a species that, if introduced, could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams, 2004). Northern snakeheads prefer shallow ponds and marshes with aquatic vegetation, which is similar to the aquatic habitat within and downstream of the wetland divide. As a result of the northern snakehead's ability to survive cold water environments, it was rated medium for establishment at/near the pathway.

Team rating: **Medium**
Team certainty rating: Moderately Certain

VHSv

Aquatic habitat on both sides of the divide is considered suitable for brown trout, which is a potential carrier of VHSv. Viral hemorrhagic septicemia virus is capable of persisting outside of a host for several days in the water column (WDNR, 2012b). The virus demonstrates a rapid reproductive cycle and is capable of utilizing many different host species. It is highly likely that VHSv could be successful in establishing in fish populations already in the Mississippi River Basin.

Team rating: **High**
Team certainty rating: Reasonably Certain

Ruffe and Tubenose Goby

The ruffe and tubenose goby are primarily lake species. Survival of a viable, reproducing population of ruffe and tubenose goby within the Brule Bog at the divide is unlikely due to physical habitat present.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Threespine Stickleback

The Brule Bog divide is considered unsuitable for the threespine stickleback. Great Lakes populations tend to be potadromous and only occupy the lower reaches of streams during spring spawning. Otherwise they tend to remain in the lake. Regular movement between Lake Superior and the divide location appears extremely unlikely. Survival of a viable, reproducing population of threespine stickleback at the divide also is unlikely.

Team rating: **Low**
Team certainty rating: Reasonably Certain

4.4 Probability of ANS Spreading Across Aquatic Pathway into the New Basin

General Considerations for Assigning Probability Ratings:

> **High** - Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
>
> **Medium** - There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
>
> **Low** - There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

Asian Carp

It is unlikely that Asian carp could pass through the divide at this location. Based on the hydraulic characteristics, it is unlikely that Asian carp could become established at or near the pathway location (see Section 4.3), and even if they did it also appears unlikely that carp could pass through the cedar bog, which would be wet but with intermittent water depth and flow. Even during heavy rains, the bog would likely not have adequate depth to facilitate movement, particularly of adult fish, across the divide.

Team rating: **Low**
Team certainty rating: Reasonably Uncertain

Inland Silverside

It is unlikely that inland silverside could pass through the divide at this location due to hydraulic characteristics and water temperatures. Based on the hydraulic characteristics, it appears unlikely that silverside could

pass through the cedar bog, which would be wet but with intermittent water depth and flow. Even during heavy rains, the bog would likely not have adequate depth throughout to facilitate movement.

Team rating: **Low**
Team certainty rating: Moderately Certain

Northern Snakehead

As an air breather that has even been known to move short distances over land, it is likely this species could move across the Brule River divide. The probability rating for this category, if northern snakehead were present, is medium.

Team rating: **Medium**
Team certainty rating: Moderately Certain

VHSv

Given the characteristics at the divide it appears unlikely that one species of fish carrying VHSv would be able to move across the divide, even during dramatic floods. However, given its wide range of potential hosts, that trout are naturally found in both sides of the divide, and VHSv can live for several days outside of its host, this rating is identified as high.

Team rating: **High**
Team certainty rating: Reasonably Certain

Ruffe and Tubenose Goby

It is unlikely that ruffe and tubenose goby could pass through the divide at this location. Based on the hydraulic characteristics, it appears unlikely that fish could pass through the cedar bog, which would be wet but with intermittent water depth and flow.

Team rating: **Low**
Team certainty rating: Reasonably Certain

Threespine Stickleback

Sufficient habitat at or near the potential pathway is available to provide for all necessary life stages for the threespine stickleback. Although crossing of the divide would be difficult for any fish species, the stickleback has the highest likelihood of being able to cross this divide of any fish considered. This species is found in small streams. If a surface water connection becomes available even if only a couple feet wide, the stickleback could potentially cross.

Team rating: Medium
Team certainty rating: Moderately Certain

5 Overall Aquatic Pathway Viability

As discussed in Sections 2.4 and 2.5, the determination of the likelihood of a viable aquatic pathway occurring at the Brule Headwaters location for each ANS of concern is the product of five probability elements (Equation 5). Thus, the probability of a viable pathway for a particular ANS of concern is equal to the lowest rating determined for each of the five probability elements (Table 9 and Table 10). The pathway viability for transferring ANS of concern from the Mississippi River Basin to the Great Lakes Basin was equal to the highest probability of a viable pathway for each ANS of concern in Table 9. At the Brule Headwaters location, all species currently within the Mississippi River Basin were rated “low” and thus the pathway viability for transferring species from the Mississippi River Basin to the Great Lakes Basin is “low”. The pathway viability for transferring species from the Great Lakes Basin is calculated the same way and is shown in Table 10. At the Brule Headwaters location, the pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is “medium”. The last calculation is to determine the overall pathway viability for interbasin spread of ANS which is calculated by taking the highest of the overall ANS ratings for unidirectional transfer which were calculated in Tables 9 and 10. Thus, the overall probability that a viable aquatic pathway exists at the Brule Headwaters Pathway is “medium” because of the threat posed by VHSv toward the Mississippi River Basin. However, caution should be exercised with this rating. Viral hemorrhagic septicemia virus is a very unique species that, because of its life history and persistence, makes it highly susceptible to transfer. Given its unique life history characteristics, this species is also highly likely to be transported across the

Table 9: Pathway Viability for ANS Spreading from the Mississippi River Basin to the Great Lakes Basin. Uncertainty rating in parantheses

			Form 1	Form 2	Form 3a	Form 4	Form 5	
Group	Common Name	Mode of Dispersal	Pathway Exists? (Sect. 3.6)	Within Either Basin? (Sect. 4.1)	Survive Independent Transit to Pathway? (Sect. 4.2.1)	Established in proximity to Aquatic Pathway? (Sect. 4.3)	Cross Path-way into New Basin? (Sect. 4.4)	Aquatic Pathway Viability Rating
fish	Asian Carp silver carp, bighead carp, black carp	swimmer	M (RU)	M (RC)	L (VC)	L (RC)	L (RU)	L
fish	inland silverside	swimmer		M (MC)	L (VC)	L (MC)	L (MC)	L
fish	northern snakehead	swimmer		M (MC)	L (VC)	M (MC)	M (MC)	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin								**L**

Table 10: Pathway Viability for ANS Spreading from the Great Lakes Basin to the Mississippi River Basin. Uncertainty rating in parantheses

			Form 1	Form 2	Form 3a	Form 4	Form 5	
Group	Common Name	Mode of Dispersal	Pathway Exists? (Sect. 3.6)	Within Either Basin? (Sect. 4.1)	Survive Independent Transit to Pathway? (Sect. 4.2.1)	Established in Proximity to Aquatic Pathway? (Sect. 4.3)	Cross Path-way into New Basin? (Sect. 4.4)	Aquatic Pathway Viability Rating
fish	VHSv	fish pathogen/ water column	M (RU)	H (RC)	H (RU)	H (RC)	H (RC)	M
fish	ruffe and tubenose goby	swimmer		H (RC)	L (RC)	L (RC)	L (RC)	L
fish	threespine stickleback	swimmer		H (RC)	L (RC)	L (RC)	M (MC)	L
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin								**M**

basin divide by anthropogenic means. However, this did not factor into the rating for this report. Recreational fisherman and boat users can easily move this species accidentally between water bodies of both basins. While this pathway assessment did not address this likelihood, it is possible that this probability for human transfer across the divide is equal to or greater than the probability for transfer of VHSv through this potential aquatic pathway by host fish, such as brown trout.

6 Conclusions

Movement of ANS other than VHSv across the Brule Headwaters pathway appears remote. The likelihood of transfer between the two basins is likely greater for anthropogenic vectors than by natural means at this divide location. There were are a number of actions identified in the course of this pathway assessment (Section 7) that might be taken within either basin that individually or cumulatively could reduce or eliminate the probability of ANS transfer. The main data gap for the assessment of this location is lack of a clear understanding of the flooding required to provide an adequate hydraulic connection for biotic transfer to occur. It appears that the potential for transfer is limited by the lack of a clear

surface water connection. More detailed survey data of the divide location may provide further information on the nature of the hydraulic connection for this pathway at different flood levels. For ANS other than VHSv to arrive at the divide in numbers substantial enough to establish a population, movement to this location would likely require human facilitation or similar mechanisms. There could therefore be an equal potential that ANS could be transported across the basin divide and into the adjacent basin at other locations along the basin divide.

7 Opportunities

While it is not the purpose of this assessment to produce and evaluate an exhaustive list of potential actions to prevent ANS transfer at this location, some opportunities were still identified that, if implemented, could prevent or reduce the probability of ANS spread between the basins at the Brule Headwaters site. Structural opportunities are not likely the most appropriate option to prevent ANS spread at this location, although the placement of low berms or structures at key locations could be explored, if desired or if future conditions warrant. The following list of opportunities is not specific to the USACE, but incorporates a wide range of possible applicable authorities, capabilities, and jurisdictions at the Federal, state, and local levels. These are as follows:

- There are broad categories of technology for potential active measures to prevent ANS transfer at this location or in connecting downstream waters, such as:
    - Chemical deterrents in order to reduce habit suitability at or near the pathway.
    - Biological control measures that prevent ANS reproduction or prevent the ability of ANS to establish a sustainable population in the vicinity of the pathway.
    - Physical removal of ANS at their current locations within each basin.
    - Increase commercial and recreational harvest, specifically of bighead and silver carp, in the Mississippi River Basin.
- New or improved regulations or ordinances prohibiting the establishment of drainage ways that would connect the Mississippi River tributaries with Great Lakes tributaries (e.g., ditch construction, culvert installation).
- Take ANS transfer potential into account for proposed water resource projects (e.g., ecosystem restoration, dam removal, stream restoration, water management);
- Site-specific elevation surveys and hydrologic and hydraulic investigations to better correlate precipitation events to surface flows in order to gain an improved understanding of the full potential of an aquatic pathway existing at Brule;
- Where possible, maintain pristine habitats as whole, intact ecosystems to help prevent any ANS establishment at or near the basin divide;
- Public education near the pathway and at downstream locations to:
    - Prevent bait bucket transfers of ANS
    - Prevent transfer via boating and recreational equipment
    - Prevent transfer due to religious or cultural ceremonies
    - Improve identification and reporting of ANS to the appropriate authorities
- Support research on the biology of ANS so transfer potential can be better understood.
    - Life history
    - Habitat requirements and tolerances
    - History of invasiveness
- Improve and increase field sampling and monitoring

for the presence of ANS to support better informed water resource management decisions within the state and region:

- Develop an integrated ANS sampling and analysis plan for execution during times when ANS would be expected to be present in an area, such as during flood events.

- Target, encourage, and train recreational fishermen, boaters and other direct users of the surface waters of the state of Wisconsin to identify, report, collect, and deliver ANS to the appropriate agencies.

- Prevent introductions of additional ANS within the region.

  - Improve regulations for bilge releases

  - Improve regulations on the pet industry

  - Impose regulations on the live bait industry

  - Improve regulations on the aquaculture industry

None of the opportunities identified above are exclusive of the others. In fact, any single measure to prevent ANS transfer through Brule Headwaters would likely benefit from corresponding development and implementation of one or more of the other opportunities identified. The results of this assessment may also aid in the implementation of, and future updates to, the Wisconsin ANS comprehensive management plan.

8 References:

ANSTF. (1996). *Generic Nonindigineous Aquatic Organisms Risk Analysis Review Process for Estimating Risk Associated with the Introduction of Nonindigineous Aquatic Organisms and How to Manage for that Risk*. Report to the Aquatic Nuisance Species Task Force. Risk Assessment and Management Committee, Aquatic Nuisance Species Task Force (October 21, 1996).

Bowen, A.K. and M.A. Goehle, (2011). Surveillance for ruffe in the Great Lakes, 2011. http://www.fws.gov/midwest/alpena/documents/2011-GL-Ruffe-Report.pdf.

Coulter, A. and R. R. Goforth. (2012). An assessment of silver and bighead carp (*Hypopthalmichthys spp.*) movements and spawning activities in the Wabash River Watershed, Indiana – Phase I Annual Report. Department of Forestry and Natural Resources, Purdue University, Indiana.

Courtenay, Jr., W.R., and J. D. Williams. (2004). Snakeheads (Pisces, Channidae)— A Biological Synopsis and Risk Assessment. USGS Circular 1251.

Dejean, T., A. Valentini, A. Duparc, S. Pellier-Cuit, F. Pompanon, P. Taberlet, C. Miaud. (2011). Persistence of environmental DNA in freshwater ecosystems. *PLoS One* 6(8): e23398.

Dong, S., and Li, D. (1994). Comparative studies of the feeding selectivity of silver carp, *Hypophthalmichthys molitrix*, and bighead carp, *Aristichthys nobilis*. *Journal of Fish Biology 44:621-626*.

Fishbase. (2011). Froese, R. and D. Pauly. Editors. World Wide Web electronic publication: www.fishbase.org.

Global Invasive Species Database. Accessed May 24, 2012: http://www.issg.org/database/species/ecology.asp?si=544&fr=1&sts=sss&lang=EN.

Gobin, W., W. Newton, J. Accola, and J. H. Downs. (2003). Brule River Sea Lamprey Barrier's Role in the Sea Lamprey Control Effort. Wisconsin Department of Natural Resources. Western Lake Superior Fish Management Team. (December, 2003). Accessed via website on April 23, 2012: http://dnr.wi.gov/fish/lakesup/lampreybarrier.htm.

Gray, J. A. B., and A. C. G. Best. (1989). Patterns of excitation of the lateral line of the ruffe. *Journal of the Marine Biological Association of the United Kingdom 69:289-306*.

Great Lakes Commission. (2011). Website accessed February 21, 2012: http://www.great-lakes.net/envt/flora-fauna/invasive/pdf/vhs_glc_factsheet_2011.pdf.

Hubbs, C. H. B. Sharp, and J. F. Schneider. (1971). Developmental rates of Menidia audens with notes on salt tolerance. *Transactions of the American Fisheries Society 100:603-610*.

Jennings, D.P. (1988). Bighead carp (*Hypophthalmichthys nobilis*): a biological synopsis. U.S. Fish and Wildlife Service, Washington, DC. *U.S. Fish and Wildlife Service Biological Report 88(29):1-47*.

Jerde, C. L., A. R. Mahon, L. Chadderton, and D. M. Lodge. (2011). "Sight-unseen" detection of rare aquatic species using environmental DNA. *Conservation Letters 00: 1-8*.

Jirasek, J., Hampl, A. and Sirotek, D. (1981). Growth morphology of the filtering apparatus of silver carp (*Hypophthalmichthys molitrix*). Gross anatomy state. *Aquaculture 26:41-48*.

Minamoto, T., H. Yamanaka, T. Takahara, M.N. Honjo, Z. Kawabata. (2011). Surveillance of fish species composition using environmental DNA. *Limnology*. DOI: 10.1007/s10201-011-0362-4.

Nico, L.G. and H.L. Jelks. (2011). The Black Carp in North America: An Update. *American Fisheries Society Symposium* 74: 89-104. Bethesda, Maryland.

Nico, L.G., J.D. Williams, and H.L. Jelks. (2005). *Black Carp: biological synopsis and risk assessment of an introduced fish*. American Fisheries Society, Special Publication 32, Bethesda, Maryland.

NID. (2010). U.S. Army Corps of Engineers, 2010 National Inventory of Dams: http://nid.usace.army.mil.

NOAA. (2011). Great Lakes Nonindiginous Aquatic Species Information System (GLANSIS). National Oceanic and Atmospheric Administration. http://www.glerl.noaa.gov/res/Programs/glansis/watchlist.html.

Richards, K. R. (1977). Evaluation of the Mississippi silversides as a forage fish in Colorado. Master's thesis. Colorado State University, Fort Collins.

Skall, H.F., N. J. Olesen, and S Mellergaard. (2005). Viral haemorrhagic septicaemia virus in marine fish and its implications for fish farming – a review. *Journal of Fish Diseases 28: 509–529*.

Stevens, P. (2011). Wisconsin DNR Fisheries. Personal Communication (October 18, 2011).

Stoeckel, J. N. and R. C. Heidinger. (1988). Overwintering of the Inland Silverside in Southern Illinois. *North American Journal of Fisheries Management 8(1), 127-131*.

USACE. (2010). Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization. Great Lakes and Ohio River Division. United States Army Corps of Engineers.

USACE. (2011a). GLMRIS *Focus Area 2 Study Pla*n. Great Lakes and Ohio River Division. United States Army Corps of Engineers.

USACE. (2011b). Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study.

USFWS, (1996). Ruffe control plan. Submitted to the Aquatic Nuisance Species Task Force by the Ruffe Control Committee. Available at: http://www.fws.gov/midwest/ashland/ruf_cont.html.

USFWS. (2002). Black Carp Invasive Species Program Fact sheet. United States Fish and Wildlife Service. Retrieved from: http://www.fws.gov/southeast/hotissues/Black_Carp_FS.pdf.

USGS. (2009b). Viral Hemorrhagic Septicemia (VHSv) Briefing Paper.

USGS. (2011). Website, accessed February 21, 2012: http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2656.

UW-Stevens Point. (2011) Creating regional watershed based groundwater, hydraulic, and nutrient models for local-scale use in the Upper St Croix - Eau Claire Rivers Watershed. UW-Stevens Point Center for Watershed Science and Education. February 2011.

Verigin, B.V., A.P. Makeyeva, and M.I. Zaki Mokhamed. (1978). Natural spawning of the silver carp (*Hypophthalmichthys nobilis*), the bighead carp (Aristichthys nobilis), and the grass carp (*Ctenopharyngodon idella*) in the Syr-Dar'ya River. *Journal of Ichthyology 18(1):143-146*.

WDNR. (2012a). The Brule-St. Croix Legacy Forest Easement Factsheet. Website accessed May 21, 2012: http://dnr.wi.gov/files/pdf/Brule-StCroix_Legacy_Forest.pdf.

WDNR. (2012b). VHS 101 Fact Sheet. Wisconsin Department of Natural Resources. Website accessed April 10, 2012: http://dnr.wi.gov/fish/vhs/vhsfacts.html#3a.

Williamson, C. J. and Garvey, J. E. (2005). Growth, fecundity, and diets of newly established silver carp in the middle Mississippi River. *Transactions of the American Fisheries Society 134: 1423–1430*.

Appendix A

Evaluation Forms for Each Indicator Species Selected for the Brule River Divide

Brule Headwaters

May, 2013

Brule Headwaters/Douglas County, WI - Asian Carp

1. Probability of aquatic pathway existence

Aquatic Pathway Team		Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
		USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
		USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
		NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
		Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	Medium	RC		
		USACE, Detroit - Biologist	Medium	RC		
		WDNR - Fisheries Research Scientist	Medium	RC		
		Team Rating	**Medium**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) are established throughout the middle and lower Mississippi River. The furthest upstream that reproducing populations of either silver or bighead carp have been confirmed is Pool 19 of the Upper Mississippi River. This is approximately 400 river miles below its confluence with the St. Croix River. However, a bighead carp was collected in the lower St. Croix River in 2011. Silver carp eDNA also was collected below the St. Croix Falls Dam of the St. Croix River during 2011. This technique of using eDNA is useful for detection of the presence of Asian carp DNA in water when species populations are at very low levels of abundance (Jerde et al., 2011; Dejean et al, 2011; and Minamoto et al, 2011). A positive eDNA sample indicates the presence of Asian carp DNA and the possible presence of live fish. Although they may not be established within the St. Croix River, individuals of bighead, and potentially silver carp as well, are present. Black carp have a more limited distribution and are less likely to reach the St. Croix River in the near future.

Brule Headwaters/Douglas County, WI - Asian Carp

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team		Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
		USACE, St. Paul - Biologist	Low	VC	Medium	MC
		USACE, Detroit - Biologist	Low	VC	Medium	MC
		WDNR - Fisheries Research Scientist	Low	VC	Medium	RC
		Team Ratings	**Low**	**VC**	**Medium**	**MC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

Movement of Asian carp from the Mississippi River Basin up to the divide location would not occur by swimming on it's own. Direct passage of all fish species upstream of the St. Croix Falls dam on the St. Croix River, via swimming, would not occur because of the high hydraulic head (56 feet). This eliminates the potential for all fish to move on their own account from the Mississippi River through the St. Croix River past St. Croix Falls. The Gordon Dam, with a hydraulic height of approximately 8 feet, would also slow, if not stop the movement of fish up to the divide location. The invasive species outlined here would not be able to move to the divide locations without the aid of anthropogenic means.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Although transit to the watershed divide by anthropogenic means is possible, Wisconsin state regulations prohibit transport and possession of Asian carp. This reduces opportunities for transfer. Since fishing and boating do not occur at the emergent wetland divide and the wetland complex appears to have limited standing water, it is highly unlikely that any species of Asian carp will arrive at the divide by anthropogenic means, such as livewell, bait bucket or aquarium releases.

The probability of Asian carp arriving at the pathway through anthropogenic means is higher due to the large area upstream of the St. Croix Falls Dam, including many lakes with high recreational use in both MN and WI. There are several connected lakes close to the divide that have fair recreational use. Asian Carp may be able to get past St. Croix Falls Dam on the St. Croix River, which could potentially move them closer to the divide location. Their is great uncertainty with how quickly asian carp may spread to this geographic area. However, given recent findings in the lower St. Croix, it would appear there is potential that asian carp could move to the St. Croix River headwaters lakes within the next 40 years, hence the rating as medium.

Brule Headwaters/Douglas County, WI - Asian Carp

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	Low	RC		
		USACE, Detroit - Biologist	Low	RC		
		WDNR - Fisheries Research Scientist	Low	RC		
		Team Ratings	**Low**	**RC**		

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: Silver and bighead carp are fast growing species that are capable of surviving in a wide range of water temperatures and reproducing quickly, provided suitable habitat is available. Life history habitat requirements generally include diverse needs for current areas, backwater habitats, deep overwintering holes, and other habitat types needed for survival (Nico, et al., 2005).

Habitat at the divide location is a coldwater stream originating from a cedar bog. Habitat conditions include year-round cool temperatures, shallow depths (often less than a foot deep), and a narrow channel (less than 10 feet). Some shallow aquatic area is available in adjacent wetland ponds, but these ponds experience shallow depths and extensive ice cover during winter. It is unlikely that Asian carp could survive in these shallow ponds beyond short periods of time (i.e., days or weeks) given the severe winter conditions. Though Asian carp are capable of surviving in water with poor water quality (including low dissolved oxygen) it is not believed that Asian carp would be able to live long-term in these shallow-water areas.

Successful spawning and recruitment is highly unlikely and would prevent establishment of actual populations at the divide, as all species of Asian carp require lowland rivers to complete their life cycles (Nico and Jelks, 2011). Physical space within the aquatic habitat at the divide location would not be adequate for this species to establish a population. Ultimately, Asian carp would not be able to establish a sustainable population directly at the pathway divide.

If present, Asian carp might be able to survive in Upper Lake St. Croix which is only a mile or so downstream of the divide location. However, it is uncertain whether Asian carp could move up to the pathway divide during a flood. To pass from Upper Lake St. Croix to the divide location, Asian carp would have to either swim through a small culvert running underneath a County highway, or swim over the highway during flood conditions.

Brule Headwaters/Douglas County, WI - Asian Carp

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	Medium	RU		
		USACE, Detroit - Biologist	Medium	RU		
		WDNR - Fisheries Research Scientist	Low	RC		
		Team Ratings	**Medium**	**RU**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: It is unlikely that Asian carp could pass through the divide at this location. Based on the hydraulic characteristics, it is unlikely that Asian carp could become established at or near the pathway location, and even if they did it also appears unlikely that carp could pass through the cedar bog, which would be wet but with intermittent water depth and flow. Even during heavy rains, the bog would likely not have adequate depth to facilitate movement, particularly of adult fish, across the divide.

Brule Headwaters/Douglas County, WI - Inland Silverside (*Menidia beryllina*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
	USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
	NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
	Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Inland Silverside (*Menidia beryllina*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	Medium	MC		
	USACE, Detroit - Biologist	Medium	MC		
	WDNR - Fisheries Research Scientist	Medium	VC		
	Team Rating	**Medium**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Inland silversides (*Menidia beryllina*) has not been collected in the St. Croix River. Recently, its most northern known occurrence in the Mississippi River Basin is on the Kankakee River in Will County, Illinois, where they were collected in 1996 (USGS, 2009a). The species was stocked in Turtle Lake in Ramsey County, Minnesota in 1950 but that population failed. There is no evidence that the species has expanded beyond these areas, and these areas are a large distance from the St. Croix River and its headwaters. There are also many dams between existing populations and the divide location, meaning the likelihood of reaching the divide location in the next 20 years is extremely low.

Brule Headwaters/Douglas County, WI - Inland Silverside (*Menidia beryllina*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, St. Paul - Biologist	Low	VC	Low	MC
	USACE, Detroit - Biologist	Low	VC	Low	MC
	WDNR - Fisheries Research Scientist	Low	VC	Low	VC
	Team Ratings	**Low**	**VC**	**Low**	**MC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

Movement of inland silverside from the Mississippi River Basin up to the divide location would not occur by swimming on it's own. Direct passage of all fish species upstream of the St. Croix Falls dam on the St. Croix River, via swimming, would not occur because of the high hydraulic head (56 feet). This eliminates the potential for all fish to move on their own account from the Mississippi River through the St. Croix River past St. Croix Falls. The Gordon Dam, with a hydraulic height of approximately 8 feet, would also slow, if not stop the movement of fish up to the divide location. The invasive species outlined here would not be able to move to the divide locations without the aid of anthropogenic means.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Transit up to the watershed divide by anthropogenic means is possible. The inland silverside is one of four groups of restricted, non-native fish species in Wisconsin. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the DNR. This should reduce the potential for human transfer. However, it would not eliminate the risk of transport. Given its small size, the inland silverside could be in a bait bucket and mistakenly released. However, there is no source population of inland silverside anywhere near the upper watershed. Given limited expansion to date, and the failed stocking of this species within a nearby Minnesota lake, it is highly uncertain if anthropogenic movement could result in the species being near the divide in the next 50 years.

Brule Headwaters/Douglas County, WI - Inland Silverside (*Menidia beryllina*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	Low	MC		
	USACE, Detroit - Biologist	Low	MC		
	WDNR - Fisheries Research Scientist	Low	VC		
	Team Ratings	**Low**	**MC**		

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The divide location would likely be unable to support the species because of cold winter temperatures. Hubbs et al. (1971) inferred that the native inland range for the inland silverside does not extend beyond the confluence of the Ohio and Mississippi Rivers because it cannot withstand winters farther north. Richards (1977) however showed that the inland silverside can survive for at least two weeks at 35°F (1.5°C). Stoeckel and Heidinger (1988) demonstrated that inland silversides can be maintained over winter in aquaculture systems at temperatures above 59°F (15°C), when they were fed a prepared diet. They also demonstrated that inland silversides have a high mortality during extended periods of cold during the winter in unheated ponds and reservoirs. The adjacent St. Croix River may have more suitable habitat, but the site may be too far north for the species to survive, which is supported by the lack of successful populations being reported this far north, even after intentional stocking.

Brule Headwaters/Douglas County, WI - Inland Silverside (*Menidia beryllina*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	Low	MC		
		USACE, Detroit - Biologist	Low	MC		
		WDNR - Fisheries Research Scientist	Low	RC		
		Team Ratings	**Low**	**MC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: It is unlikely that Inland Silverside could pass through the divide at this location due to hydraulic characteristics and water temperatures. Based on the hydraulic characteristics, it appears unlikely that silverside could pass through the cedar bog, which would be wet but with intermittent water depth and flow. Even during heavy rains, the bog would likely not have adequate depth throughout to facilitate movement.

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
	USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
	NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
	Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any location where untreated surface water flow across the divide is deemed likely to occur and connect headwater streams in both basins from any storm up to the 1% annual return frequency storm.

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	Medium	VC		
	USACE, Detroit - Biologist	Medium	VC		
	WDNR - Fisheries Research Scientist	Medium	VC		
	Team Rating	**Medium**	**MC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: The closest established population of northern snakehead (Channa argus) is in Lee County, Arkansas. While this is in the Mississippi River watershed, this population does not seem to be spreading at a high rate at this time. These areas are also hundreds of miles from the St. Croix River and its headwaters. There are also many dams between existing populations and the divide location, meaning the likelihood of reaching the divide location in the next 20 years is extremely low.

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, St. Paul - Biologist	Low	VC	Low	MC
	USACE, Detroit - Biologist	Low	VC	Low	MC
	WDNR - Fisheries Research Scientist	Low	VC	Low	RC
	Team Ratings	**Low**	**VC**	**Low**	**MC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

Movement of northern snakehead from the Mississippi River Basin up to the divide location would not occur by these fish swimming unaided (i.e., other vectors). Direct passage of all fish species upstream of the St. Croix Falls dam on the St. Croix River, via swimming, would not occur because of the high hydraulic head (56 feet (17 m); Figure 15). This eliminates the potential for all fish to move on their own account from the Mississippi River through the St. Croix River past St. Croix Falls. Although northern snakehead can move across wet terrestrial areas, the area around St. Croix Falls Dam is a gorge, thus preventing overland movement around the dam for this species. The Gordon Dam, with a hydraulic height of approximately 8 feet, would also slow, if not stop the movement of fish up to the divide location. The invasive species outlined here would not be able to move to the divide locations without the aid of anthropogenic means.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Many species of snakehead, including the northern snakehead, have been popular aquarium fish. However, education efforts by Minnesota and Wisconsin have aimed to reduce aquarium releases, and other methods of human transfer. Since fishing and boating do not occur in the basin divide wetland, it is highly unlikely that the northern snakehead will arrive at the divide by anthropogenic means, such as livewell or aquarium releases. They could arrive at lakes near or adjacent to the divide. However, intentional release by humans of the northern snakehead in the divide location appears unlikely. Moreover, the likelihood of human release would likely occur with the same level of potential on either side of the divide and all along the divides approximately 1,500 miles (2,414 km), making the issue of anthropogenic release less specific to the Brule Headwaters location.

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	Medium	MC		
	USACE, Detroit - Biologist	Medium	MC		
	WDNR - Fisheries Research Scientist	Medium	MC		
	Team Ratings	**Medium**	**MC**		

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The northern snakehead's native range (24-53^{o} N) and temperature tolerance 32-86^{o}F (0-30 ^{o}C) indicates a species that, if introduced, could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams, 2004). Northern snakeheads prefer shallow ponds and marshes with aquatic vegetation, which is similar to the aquatic habitat within and downstream of the wetland divide. Because of the northern snakehead's ability to survive cold water
environments, it was rated medium for establishment at/near the pathway.

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise	Rating	Certainty		
		USACE, St. Paul - Biologist	Medium	MC		
		USACE, Detroit - Biologist	Medium	MC		
		WDNR - Fisheries Research Scientist	Low	MC		
		Team Ratings	**Medium**	**MC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: As an air breather that has even been known to move short distances over land, it is likely this species could move across the Brule River divide. The probability rating for this category, if northern snakehead were present, is medium. However, it is uncertain if or how quickly the northern snakehead could reach the pathway.

Brule Headwaters/Douglas County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
	USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
	NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
	Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is any

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	High	VC		
	USACE, Detroit - Biologist	High	RC		
	WDNR - Fisheries Research Scientist	High	RC		
	Team Rating	**High**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: VHSv has been reported throughout the Great Lakes Basin, including Lake Superior (USGS, 2009a). VHSv has been found in many species of fish including brown trout (*Salmo trutta*), northern pike (*Esox lucius*), and common carp (*Cyprinus carpio*). These fish are established in Lake Superior, as well as the Brule River leading to the divide. While other host fish species are known to exist in the pathway system, the brown trout was selected as the most likely host species for VHSv because of the cold water trout stream characteristics of the river and life cycle capabilities of the brown trout. VHSv and a necessary host species, the brown trout, are in the pathway.

Brule Headwaters/Douglas County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, St. Paul - Biologist	High	RU	High	RC
	USACE, Detroit - Biologist	High	RU	High	RC
	WDNR - Fisheries Research Scientist	High	RU	Low	RC
	Team Ratings	**High**	**RU**	**High**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

Brown trout, northern pike and common carp, all carriers of VHSv, have been identified in Lake Superior. The entire length of the Brule River is known as exceptional trout water, and migrations of fish are known to occur between Lake Superior and the Brule River. A dam does exist on the Brule River, but includes a fish ladder that passes salmonids. As such, it appears highly likely that brown trout, and thus VHSv, would have access to the divide location.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

It is uncertain how much public use occurs in the headwaters area, but it is likely to be limited. The most likely vector for human transport of VHSv would be through transport of fish, but could also include contaminated water or equipment. Given the remoteness of the divide location, it is unclear how often access would occur by humans with fish (e.g., fishing bait or fish collected with a creel) or fishing gear that could transport VHSv. However, fishing does occur on both sides of the divide and given the adjacent fishing access, transit to the Brule bog watershed divide by anthropogenic means is possible. Given the range of potential fish hosts, and how fish can be moved by humans, a risk rating of high was applied even if fisherman do not normally frequent the divide location.

Brule Headwaters/Douglas County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	High	RC		
	USACE, Detroit - Biologist	High	RC		
	WDNR - Fisheries Research Scientist	Medium	RC		
	Team Ratings	**High**	**RC**		

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Aquatic habitat on both sides of the divide is considered suitable for brown trout, which is a potential carrier of VHSv. VHSv is capable of persisting outside of a host for several days in the water column. The virus demonstrates a rapid reproductive cycle and is capable of utilizing many different host species. It is highly likely that VHSv could be successful in establishing in fish populations already in the Mississippi River Basin.

Brule Headwaters/Douglas County, WI - Viral Hemmorhagic Septicemia virus (VHSv)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	High	MC		
		USACE, Detroit - Biologist	High	RC		
		WDNR - Fisheries Research Scientist	High	RC		
		Team Ratings	**High**	**RC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Given the characteristics at the divide it appears unlikely that fish carrying VHSv would be able to migrate across the divide, even during dramatic floods. However, given its wide range of potential hosts, that trout are naturally found in both sides of the divide, and VHSv can live for several days outside of its host, this rating is identified as High.

Brule Headwaters/Douglas County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
	USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
	NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
	Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise	Rating	Certainty		
	USACE, St. Paul - Biologist	High	RC		
	USACE, Detroit - Biologist	High	RC		
	WDNR - Fisheries Research Scientist	Medium	RC		
	Team Rating	**High**	**RC**		

2. How do you rate the probability of ANS occuring within either basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.
Low	Target ANS is not known to exist on a connected waterway.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The ruffe (*Gymnochephalus cernuus*) and tubenose goby (*Proterorhinus marmoratus*) are located within the Great Lakes and are associated with river mouths and estuaries of large river systems entering the Great Lakes. Ruffe occur at the mouth of the Brule River, while tubenose goby at the mouth of the Poplar River about 10 miles (16 km) to the west.

Brule Headwaters/Douglas County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, St. Paul - Biologist	Low	RC	Low	RC
	USACE, Detroit - Biologist	Low	RC	Low	RC
	WDNR - Fisheries Research Scientist	Low	RC	Low	RC
	Team Ratings	**Low**	**RC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

The ability for either ruffe or tubenose gobby to swim upstream through a high-gradient coldwater river is questionable. The Brule includes high gradient rapids that may be natural barriers to these species. It is also unlikely these species would be able to successfully migrate in appreciable numbers past the Brule River lamprey barrier dam. The fish ladder at this location is designed to be passable to salmonids, but these species are much stronger swimmers and capable of leaping between the step pools provided in the fish passageway. Ruffe and Tubenose Goby, which are primarily lake species, have not been collected in smaller, cold headwater streams. There is no indication in the literature that either fish species would seek to inhabit the colder headwaters of the upper Brule River

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

Use of the Brule headwaters by fishermen or recreational boaters appears to be low. As such the probability for ANS to be transported to the proximity of the basin divide at this location by anthropogenic means also would appear low. The ruffe/tubenose goby are listed among the "established non-native fish species" (see WI NR 40.02(17)), which is one of four groups of restricted non-native fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the DNR. While it is possible that either species could arrive at the divide by anthropogenic means, such as bait bucket transfer or aquarium releases, it is unlikely as these two fish species are not normally used as live bait for river fishing or aquarium species. Given this, human movement to the divide location appears remote.

Brule Headwaters/Douglas County, WI - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise	Rating	Certainty
	USACE, St. Paul - Biologist	Low	RC
	USACE, Detroit - Biologist	Low	RC
	WDNR - Fisheries Research Scientist	Low	RC
	Team Ratings	**Low**	**RC**

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The ruffe and tubenose gobies are primarily lake species. Survival of a viable, reproducing population of ruffe and tubenose goby within the Brule Bog at the divide is unlikely due to physical habitat present.

Brule Headwaters/Douglas County, WI - Northern Snakehead (*Channa argus*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise	Rating	Certainty		
		USACE, St. Paul - Biologist	Medium	MC		
		USACE, Detroit - Biologist	Medium	MC		
		WDNR - Fisheries Research Scientist	Low	MC		
		Team Ratings	**Medium**	**MC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: As an air breather that has even been known to move short distances over land, it is likely this species could move across the Brule River divide. The probability rating for this category, if northern snakehead were present, is medium.

Brule Headwaters/Douglas County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

1. Probability of aquatic pathway existence

Aquatic Pathway Team	Expertise Position title or team role	Rating Flow into GLB	Certainty	Rating Flow into MRB	Certainty
	USACE, Detroit - Hydraulic Engineer	Low	RC	Low	RC
	USACE, St. Paul - Hydraulic Engineer	Low	RC	Low	RC
	NRCS - Hydraulic Engineer	Medium	RU	Medium	RU
	Team Ratings	**Medium**	**RU**	**Medium**	**RU**

1. How do you rate the likelihood of the existence of a viable aquatic pathway at the subject location? Assume a viable aquatic pathway is

Qualitative Rating	Qualitative Rating Category Criteria
High	Perennial streams and wetlands or intermittent stream known/documented to convey significant volumes of water across the basin divide for days to weeks multiple times per year.
Medium	Intermittent stream capable of maintaining a surface water connection to streams on both sides of the basin divide continuously for multiple days from a 10% annual return frequency storm; or, location of wetland spanning basin divide which maintains significant ponds that are likely to become inter connected and connect with streams on both sides of the basin divide from a 10% annual return frequency storm.
Low	Intermittent stream or marsh forming a surface water connection between streams on either side of the basin divide from larger than a 1.0% annual return frequency storm.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The headwaters of both the Bois Brule River, which flows north to Lake Superior, and the St. Croix River, flowing south towards the Mississippi, share a HUC-12 watershed. A site visit in 2010 found no evidence of a direct connection. The visit included walking part of the former canoe portage trail and following part of the Upper St. Croix to its source in an upland groundwater fed bog. No FEMA mapping is available for the area. Annette Humpal of the NRCS found information in the NRCS soil surveys that indicate this area is "frequently flooded".

Brule Headwaters/Douglas County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)						
2. Probability of ANS occurring within either basin						
Aquatic Pathway Team	**Expertise Position title or team role**		**Rating**	**Certainty**		
	USACE, St. Paul - Biologist		High	RC		
	USACE, Detroit - Biologist		High	RC		
	WDNR - Fisheries Research Scientist		High	RC		
	Team Rating		**High**	**RC**		
2. How do you rate the probability of ANS occuring within either basin?						
Qualitative Rating	**Qualitative Rating Category Criteria**					
High	Target ANS exists on connected waterways in close enough proximity to be capable of migrating to the aquatic pathway within 20 years.					
Medium	Target ANS exists on connected waterways, but based on current proximity and mobility, is considered incapable of migrating to the aquatic pathway within 20 years.					
Low	Target ANS is not known to exist on a connected waterway.					
	Symbol					
Very Certain	VC	As certain as I am going to get.				
Reasonably Certain	RC	Reasonably certain.				
Moderately Certain	MC	More certain than not.				
Reasonably Uncertain	RU	Reasonably uncertain				
Very Uncertain	VU	A guess				

Remarks: The threespine stickleback (*Gasterosteus aculeatus*) is found in each of the Great Lakes and has been collected in some inland river systems (USGS, 2009a). They occur at the mouth of the Brule and Lake Superior. Literature indicates this species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers.

Brule Headwaters/Douglas County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

3. Probability of ANS surviving transit to aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	3A Rating	Certainty	3B Rating	Certainty
	USACE, St. Paul - Biologist	Low	RC	Low	RC
	USACE, Detroit - Biologist	Low	RC	Low	RC
	WDNR - Fisheries Research Scientist	Low	RC	Low	RC
	Team Ratings	**Low**	**RC**	**Low**	**RC**

3A. How do you rate the probability of ANS surviving transit to aquatic pathway through connecting streams?

3B. How do you rate the probability of ANS surviving transit to aquatic pathway through other means?

Qualitative Rating	Qualitative Rating Category Criteria
High	Target ANS are established in relatively close proximity to location and have ample opportunity, capability and motivation to successfully navigate through the aquatic pathway and/or through other means to arrive at the subject pathway within 10-20 years.
Medium	Target ANS are established at locations in close enough proximity to location and have limited capability to survive migration through the aquatic pathway or through other means to arrive at the subject pathway within 20-50 years.
Low	Target ANS are not in proximity to the pathway, and/or it is highly unlikely that they could survive transit from current locations by aquatic pathway or other means to arrive at subject pathway within next 50 years.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: 3A. Probability of ANS Surviving Transit to Aquatic Pathway Through Connecting Streams.

The threespine stickleback has been found in the Great Lakes and in smaller river systems including Dutchmans Creek in Douglas County, Wisconsin (Stevens, 2011). Great Lakes populations tend to be potadromous and only occupy the lower reaches of streams during spring spawning. Movement up the Brule, a high gradient, coldwater stream may be difficult. The Brule Lamprey Barrier also would be an essentially impassable barrier under most conditions.

Remarks: 3B. Probability of ANS Surviving Transit to Aquatic Pathway Through Other Means

The threespine stickleback is listed among the "established nonnative fish species" (see WDNR 40.02(17)), which is one of four groups of restricted nonnative fish species. Fish species in this restricted group may not be possessed, transported, transferred, or introduced without a permit from the DNR. However, this does not preclude human transport. It is believed that bait-bucket transport has aided in the movement of the threespine stickleback in the past. Given its remoteness, fishing and recreation boating is probably limited at the divide. It appears unlikely that the species would arrive at the divide by anthropogenic means.

Brule Headwaters/Douglas County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

4. Probability of ANS establishing in proximity to the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, St. Paul - Biologist	Low	RC		
	USACE, Detroit - Biologist	Low	RC		
	WDNR - Fisheries Research Scientist	Low	RC		
	Team Ratings	**Low**	**RC**		

4. How do you rate the probability of ANS establishing in proximity to the aquatic pathway?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are plentiful in close proximity to support all life stages from birth to adult, abiotic conditions align with native range and there are no known predators or conditions that would significantly impede survivability or reproduction.
Medium	Limited and disconnected areas and sources of food and habitat suitable to the ANS are available in proximity, abiotic conditions are within latitude limits of native range, but only a portion of the healthy individuals arriving at location can be expected to effectively compete and survive.
Low	Habitat and abiotic conditions in proximity are outside the range where ANS has been known to survive; there is very limited availability habitat area suitable for ANS cover, sustainable food supply and reproduction; or native predators or competition with native species would likely prevent establishment of a sustainable population.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: The Brule Bog divide is considered unsuitable for the threespine stickleback. Great Lakes populations tend to be potadromous and only occupy the lower reaches of streams during spring spawning. Otherwise they tend to remain in the lake. Regular movement between Lake Superior and the divide location appears extremely unlikely. Survival of a viable, reproducing population of threespine stickleback at the divide also is unlikely.

Brule Headwaters/Douglas County, WI - Threespine Stickleback (*Gasterosteus aculeatus*)

5. Probability of ANS spreading across aquatic pathway into the new basin

Aquatic Pathway Team		Expertise Position title or team role	Rating	Certainty		
		USACE, St. Paul - Biologist	High	RC		
		USACE, Detroit - Biologist	High	RC		
		WDNR - Fisheries Research Scientist	Medium	MC		
		Team Ratings	**High**	**RC**		

5. How do you rate the probability of ANS spreading across aquatic pathway into the new basin?

Qualitative Rating	Qualitative Rating Category Criteria
High	Sources of food and habitat suitable to the ANS are available, and the species has demonstrated capabilities to significantly expand range from locations where initially introduced.
Medium	There are limited sources of food and suitable habitat, and/or the species has demonstrated limited ability to spread significant distances beyond areas where it has been introduced.
Low	There are severely limited sources of food and suitable habitat, and/or the species has demonstrated very limited ability to spread beyond areas where it has been introduced.

	Symbol	
Very Certain	VC	As certain as I am going to get.
Reasonably Certain	RC	Reasonably certain.
Moderately Certain	MC	More certain than not.
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess

Remarks: Sufficient habitat at or near the potential pathway is available as well as within the Mississippi River Basin to provide for all necessary life stages for the threespine stickleback.