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

South Aniwa, Wisconsin

US Army Corps of Engineers®
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Executive Summary

The probability of a viable aquatic pathway being able to form at the South Aniwa location was determined to be “low” in either direction (i.e., toward Great Lakes or Mississippi River Basin), meaning it is unlikely that a surface water connection exists or could form at this location on a perennial or intermittent basis except during a flood somewhere in excess of the one percent annual recurrence interval event. The watershed divide at this location is 1.3 miles (2.1 kilometers) southwest of Aniwa, Wisconsin, and the border of Marathon and Shawano Counties bisects the site. The nearest headwater streams to the site are Aniwa Creek within the Mississippi River Basin, and an unnamed intermittent tributary to Packard Creek within the Great Lakes Basin. The most likely connection point to Aniwa Creek is nearly a mile (1.6 km) to the northwest of the 12-digit hydrological unit code boundary, and the most likely connection to the unnamed tributary of Packard Creek is about a half mile (0.8 km) to the southwest of the boundary. Existing flood mapping shows that the one percent recurrence interval floodplain does cross the basin divide from the Mississippi River Basin, but equivalent floodplain mapping is not currently available for Shawano County. However, National Wetland Inventory mapping from the U.S. Fish and Wildlife Service was available for Shawano County and was therefore mapped alongside the floodplain map for Marathon County. Although the National Wetland Inventory mapping shows there to be contiguous wetland and/or floodplain between the two basins, field observations found that contiguous wetlands do not exist between the basins as it is bisected by development and a county roadway that does not have any culverts. There is no evidence of any existing or intermittent surface water connection between the Mississippi River and Great Lakes Basins east or south of the site. There is a possibility that surface water from a flood in excess of the one percent storm event could bring surface waters (e.g., wetlands) from both basins into closer proximity. However, a lack of culverts underneath the County Road would prevent an actual connection from establishing.

S. Aniwa Report

May, 2013

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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
CMP. . . . . Corrugated Metal Pipe
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
INDNR . . . . Indiana Department of Natural Resources
MNDNR . . . Minnesota Department of Natural Resources
NAS . . . . . Nonindigenous Aquatic Species
NCDC . . . . National Climatic Data Center
NEPA. . . . . National Environmental Policy Act
NHD. . . . . National Hydrography Dataset
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
RCP. . . . . Reinforced Concrete Pipe
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
WRDA . . . . Water Resources Development Act

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 South Aniwa location, in Marathon and Shawano Counties, Wisconsin. This location is one of 18 locations identified in the Great Lakes and Mississippi River Interbasin Study Other Pathways Preliminary Risk Characterization (USACE, 2010) 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). 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. The South Aniwa, Wisconsin location is shown as location number 15 on Figure 1 in eastern Wisconsin.

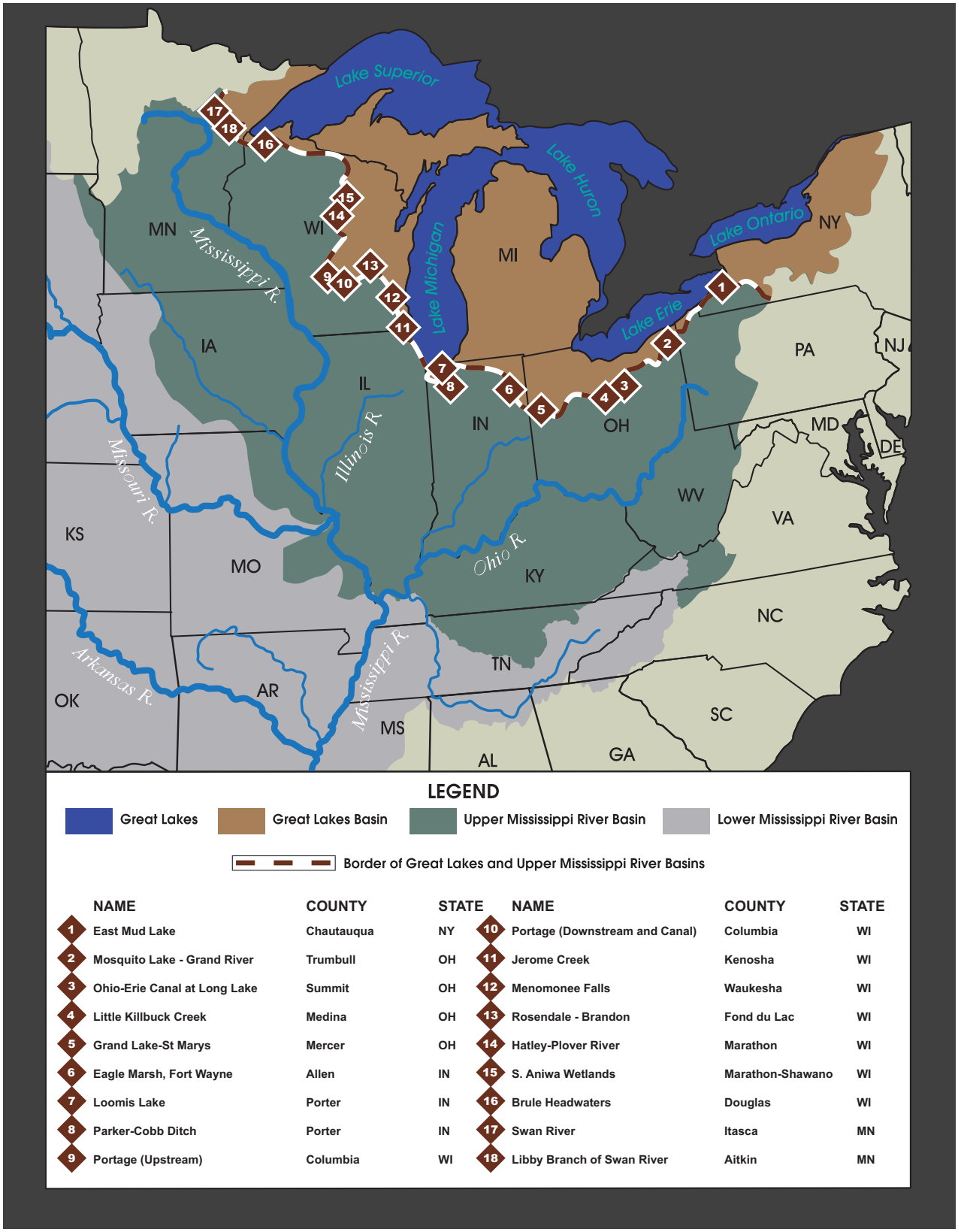
The GLMRIS is a very large and complicated task involving multiple USACE Districts and Divisions. Program Management of the study is conducted by the Great Lakes and Ohio River Division. The study considers all aquatic nuisance species (ANS) of concern, however, the proximity of Asian carp in the Mississippi River Basin to the basin divide near two locations lends 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 and addresses the CAWS. 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 of interbasin spread of ANS through the South Aniwa, Wisconsin location. It is also intended to meet the four objectives identified in the USACE 2011 plan for any sites ultimately rated as medium or high for probability of a pathway existing:

- A definitive determination of whether the South Aniwa, Wisconsin location should be included in the inventory of locations where a viable surface water connection between headwater



	NAME	COUNTY	STATE
1	East Mud Lake	Chautauqua	NY
2	Mosquito Lake - Grand River	Trumbull	OH
3	Ohio-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).

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 that a viable aquatic pathway exists at South Aniwa, Wisconsin 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 South Aniwa, Wisconsin; and

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

1.2 Summary of 2010 Preliminary Risk Characterization for South Aniwa, Wisconsin

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. Only one location, Eagle Marsh in Fort Wayne, Indiana, was determined to pose such 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 (INDNR) until a more complete assessment and remedy could be implemented. 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), Natural Resources Conservation Service (NRCS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and the natural resource agencies in the states of Minnesota, Wisconsin, Indiana, Ohio, Pennsylvania, and New York. The preliminary report identified 18 potential aquatic pathways between the Great Lakes and Mississippi River Basins where interbasin transfer of ANS appeared possible, and therefore were recommended for further investigation

The South Aniwa site was characterized in 2010 as a rural wetland area in the headwaters of the Plover and Embarrass Rivers where an overlap of the mapped flood hazard area was found across the Great Lakes and Mississippi River Basin divide. This overlap indicated at that time that a surface water connection might be possible at a one percent recurrence interval storm 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 recurrence interval 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 recurrence interval storm (formerly referred to as a ten year event) is a smaller event that has a one in ten chance of being exceeded during any given year, and a 0.2 percent annual recurrence interval 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.

Although the preliminary risk characterization did not identify the South Aniwa pathway as a location where there is a near term risk for the interbasin spread of ANS, there was some uncertainty regarding whether or not an aquatic pathway could form between the basins. The preliminary effort therefore recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the USGS, NRCS, Wisconsin Department of Natural Resources (WDNR), 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 NRCS representatives) were briefed on the preliminary risk characterization results. A detailed site visit to observe potential connection locations was conducted and the available topographic mapping and flood hazard information was 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.

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 Federal, State, and local, and national hydrologists and biologists to assess conditions at each potential aquatic pathway (USACE, 2011a). The results of this assessment reflect the collective experience, expertise, and focused effort of these experts from USACE, NRCS, and WDNR. The results also reflect the guidance, input, review comments, and concurrence of the multi-organization Agency Technical Review which was comprised of experts from USACE, Michigan Department of Environmental Quality, and Illinois Department of Natural Resources.

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 Great Lakes Fishery Commission (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 external partner agencies, including NOAA and the 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 tolerably 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 South Aniwa 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 (e.g., anthropogenic, movement by animals) that may enable ANS to transit across the aquatic pathway or across the basin divide but that are not included within this 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 NAS 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 the USFWS the following definitions were established for the purposes of the GLMRIS. All nonindigenous 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 nonindigenous 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 nonindigenous aquatic species in this report.

2.3.1 Lists of Nonindigenous 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 nonindigenous 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.

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 psuedoharengus*	alewife	GL	swimmer
crustacean	*Apocorophium lacustre*	a scud	MS	ballast water
algae	*Bangia atropupurea*	red macro-algae	GL	ballast / recreational 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 / recreational 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 / recreational boating
fish	*Gasterosteus aculeatus*	threespine stickleback	GL	swimmer
plant	*Glyceria maxima*	reed sweetgrass	GL	recreational boating & trailers
fish	*Gymnochephalus cernuus*	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

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, habitats, and distributions and dispersal status.

No assessment of specific ANS was completed, it was determined that there was a low likelihood of an aquatic pathway existing at up to a one percent annual recurrence interval storm event.

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 as High, Medium, or Low based on the available evidence. They are also qualitatively assigned a level of certainty (Very Certain, Reasonably Certain, Moderately Certain, Reasonably Uncertain, Very Uncertain). 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 proximity 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” 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 (P1), ANS has access to pathway from Equation 3 has been renamed (P1'), 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 storm even) 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 (Po) is not necessarily the same as there being no probability of a pathway existing. At those locations where the probability of a pathway existing (P0) was determined to be medium or high, 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.

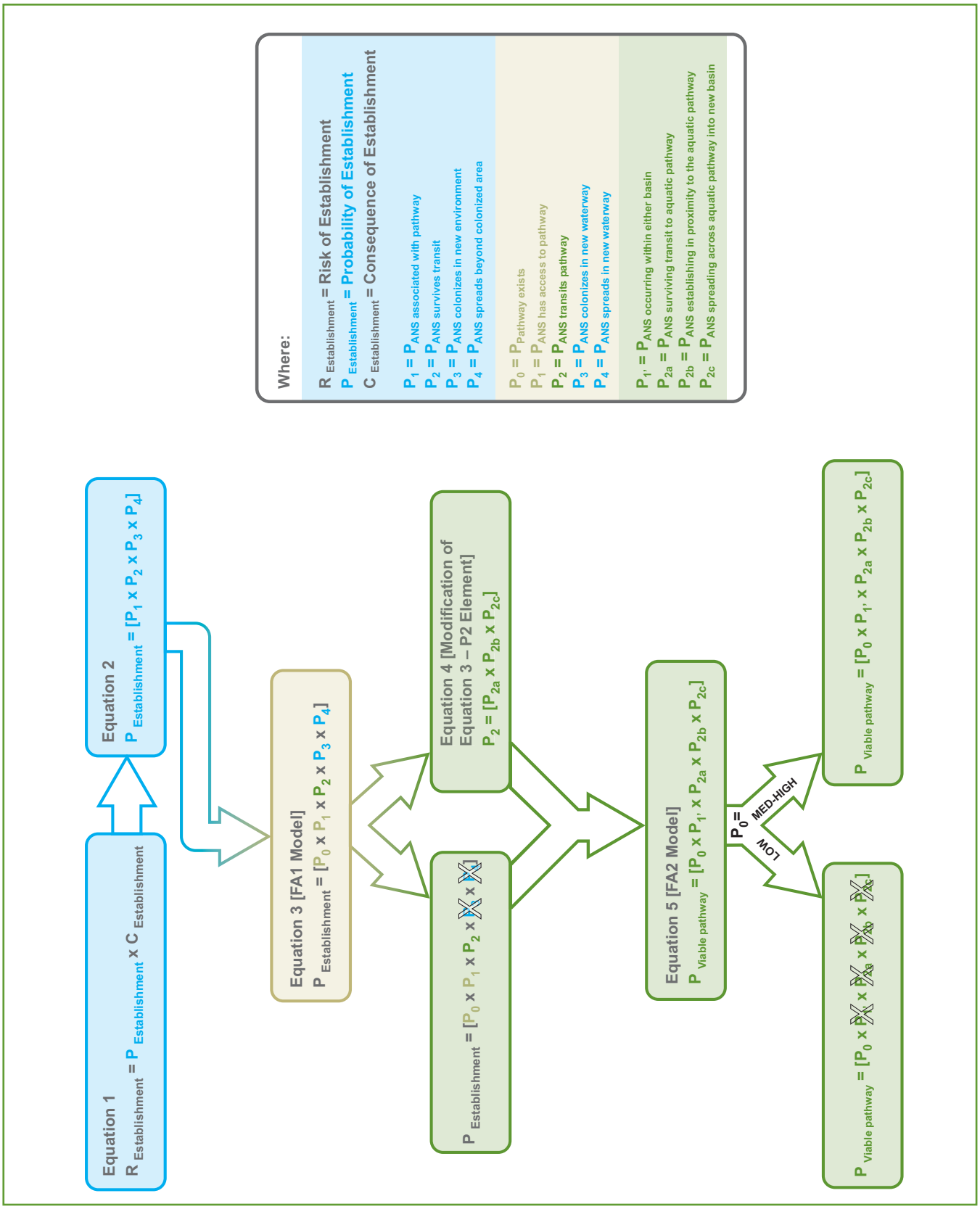


Figure 2. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

3 Aquatic Pathway Characterization

This section describes and illustrates the topography and features in the vicinity of the potential pathway and is intended to present the compilation of the readily available and applicable information for this area as it may influence local hydrology. Maps, photographs, and figures are included to aid understanding of the significant hydrologic and hydraulic conditions at and in proximity to the drainage divide. Also, this section identifies any significant data gaps and uncertainties related to the available topographic information and hydrologic modeling in the area of interest.

3.1 Location

The South Aniwa potential pathway is located approximately 1.3 miles (2.1 km) southwest of Aniwa, Wisconsin at 44°59'17.82"N, 89°13'28.34"W (Figure 2). This location is near the border of Marathon and Shawano Counties, in a rural area dominated by forests, pastureland, and some agriculture. It is near the intersections of County Road Z and Crescent Drive.

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 eastern 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 9ºF to 27ºF (-12.7ºC to -2.8ºC), while summers are usually around 60º F to 70ºF (15.5ºC to 21ºC). Normal annual precipitation is about 30 inches (76 cm) and the normal snowfall is around 60 inches (152 cm). See Table 2 for National Climatic Data Center (NCDC) data, from 1971-2000.

The highest precipitation accumulation occurs in the summer months, primarily during June and July. Although rainfall amounts do not always conform to averages, they are suggestive that substantial precipitation does not occur frequently. 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 migration might occur by natural vectors.

Table 2 - Climate Information for S. Aniwa Wetlands, 1971-2000 (Source: Midwestern Regional Climate Center – Station Wausau FAA Airport, WI) .

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Mean Temperature°F	13.0	19.0	30.2	44.0	56.8	65.5	70.1	67.9	58.6	47.0	32.4	18.7	43.6
Mean Temperature °C	-10.5	-7.2	-1	6.6	13.7	18.6	21.2	19.9	14.7	8.3	0.2	-7.4	6.4
Normal Precip (in)	1.09	0.90	1.92	2.84	3.54	4.18	4.12	4.53	4.08	2.63	2.20	1.33	33.36
Normal Precip (cm)	2.7	2.3	4.8	7.2	8.9	10.6	10.4	11.5	10.3	6.7	5.6	3.4	84.7
Mean Snow (in)	13.8	8.9	10.8	3.8	0.1	0.0	0.0	0.0	0.0	1.0	7.1	13.6	59.1
Mean Snow (cm)	35	22.6	27.4	9.7	0.3	0	0	0	0	2.5	18	34.5	150

3.3 Location Specific Surface Water Features

The information contained in this section is intended 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 nearest headwater streams to the site are Aniwa Creek within the Mississippi River Basin and an unnamed intermittent tributary to Packard Creek within the Great Lakes Basin (Figure 4). The most likely potential connection point at Aniwa Creek is nearly a mile to the northwest of the 12-digit hydrologic unit cod (HUC) boundary, and the most likely potential connection to the unnamed tributary of Packard Creek is about a half mile to the southwest of the boundary. Packard Creek flows to the Middle Branch Embarrass River that flows to the Wolf River and Lakes Poygan and Butte des Morts, then to Lake Winnebago and the Lower Fox River, and eventually to Lake Michigan. Aniwa Creek drains to the Plover River into the Wisconsin River and the Mississippi River.

As shown in Figure 4, Federal Emergency Management Agency (FEMA) mapping is available for Marathon County and it shows the one percent floodplain crossing the 12-digit HUC boundary between the Mississippi and Great Lakes Basins in several locations at and just west of the border with Shawano County. The FEMA floodplains in this area are based on the USGS Flood-Prone Area Maps dating from the late 1960s and early 1970s. However, there is no FEMA mapping available for Shawano County. Therefore, Figure 4 depicts the areas located within the National Wetlands Inventory (NWI) in Shawano County at this location along with the location of the unnamed tributary to Packard Creek that begins just south of County Road Zz to illustrate the area where a potential surface water connection between the basins might form.

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 5 which also depicts representative cross-sections through the areas of interest based on the best available Geographic Information System (GIS) data. This figure shows a profile along the HUC boundary to depict the slight 'saddle point' along the basin divide and cross sections that cut through the HUC boundary through this saddle point to depict the potential flow paths between the basins. This saddle point is the location of the basin divide and the point at which a hydrologic connection is most likely to be established. The cross-sections show the general ground elevations only and their vertical accuracy is limited. However, a slight rise to the ground surface elevation of approximately 10 feet (3m) is evident as one approaches the basin divide from either basin (purple line in Figure 5). The closest Great Lakes Basin stream to the pathway is the Middle Branch Embarrass River located approximately 1.7 miles (2.7 km) east of the HUC intersect. The area due south of County Road Zz consists of discontinuous wetlands, with the closest stream in that direction being about 3 miles (4.8 km) away.

Figure 5 indicates that the vertical accuracy for each elevation point in the USGS 10 meter Digital Elevation Model (DEM) across the divide location is +/-13.123 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 be off from the true value (i.e., 800 feet (244 m) above sea level), 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 blocky 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

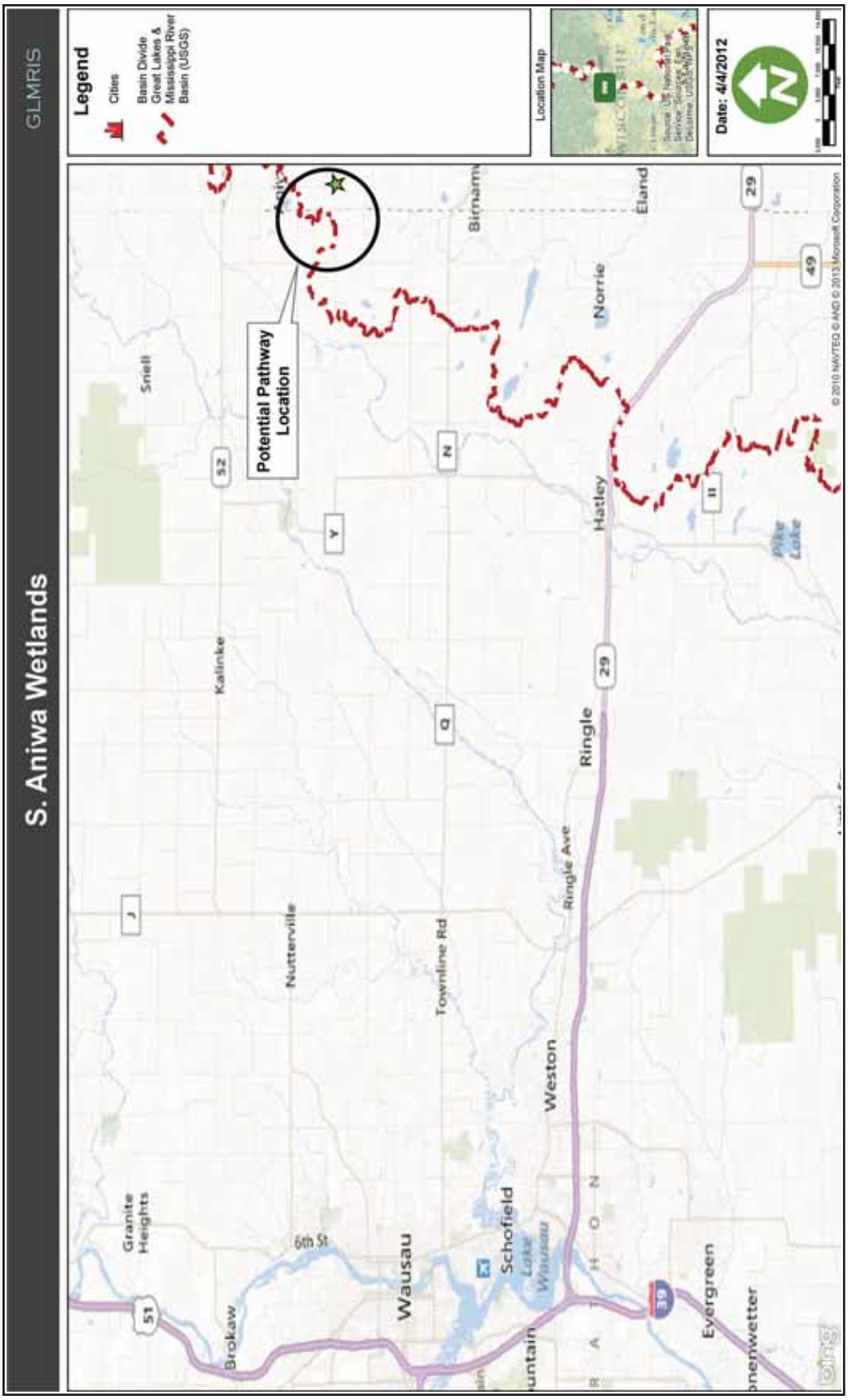


Figure 3: General location of S. Aniwa potential pathway. The location is indicated by the circled area and the approximate location of Great Lakes – Mississippi River Basin boundary is shown by the red-white line. Background imagery courtesy of Bing Maps.

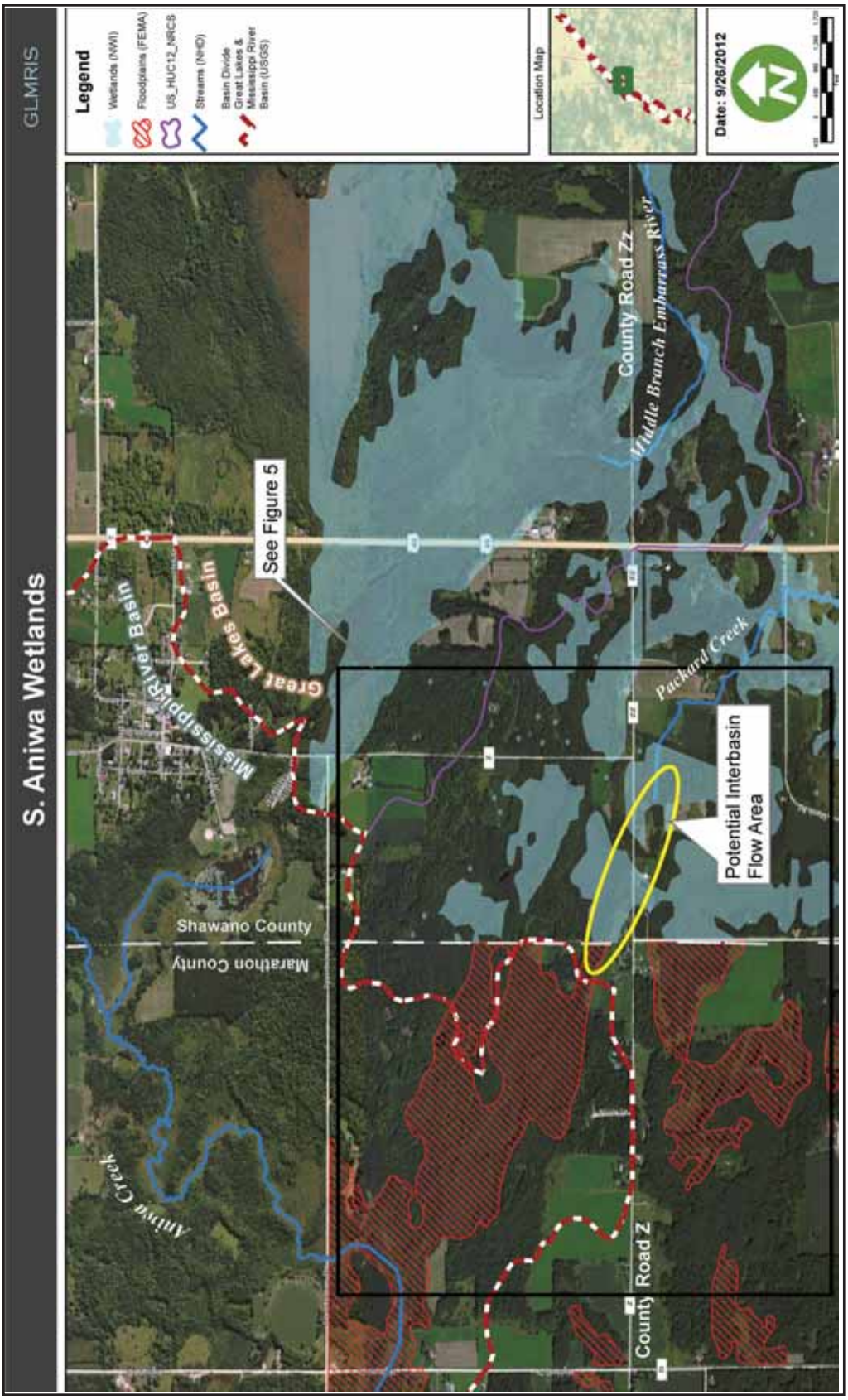


Figure 4: Map of S. Aniwa potential pathway vicinity. Purple line is HUC-12 boundary from the NHD. Red shaded area is FEMA Q3 Base Flood areas for one percent annual floodplain. The approximate basin divide is shown by the red/white line. Area of interest is that part of the floodplain that extends into the adjacent basin and across County Road Zz, as indicated on the figure. Background image courtesy of Bing Maps.

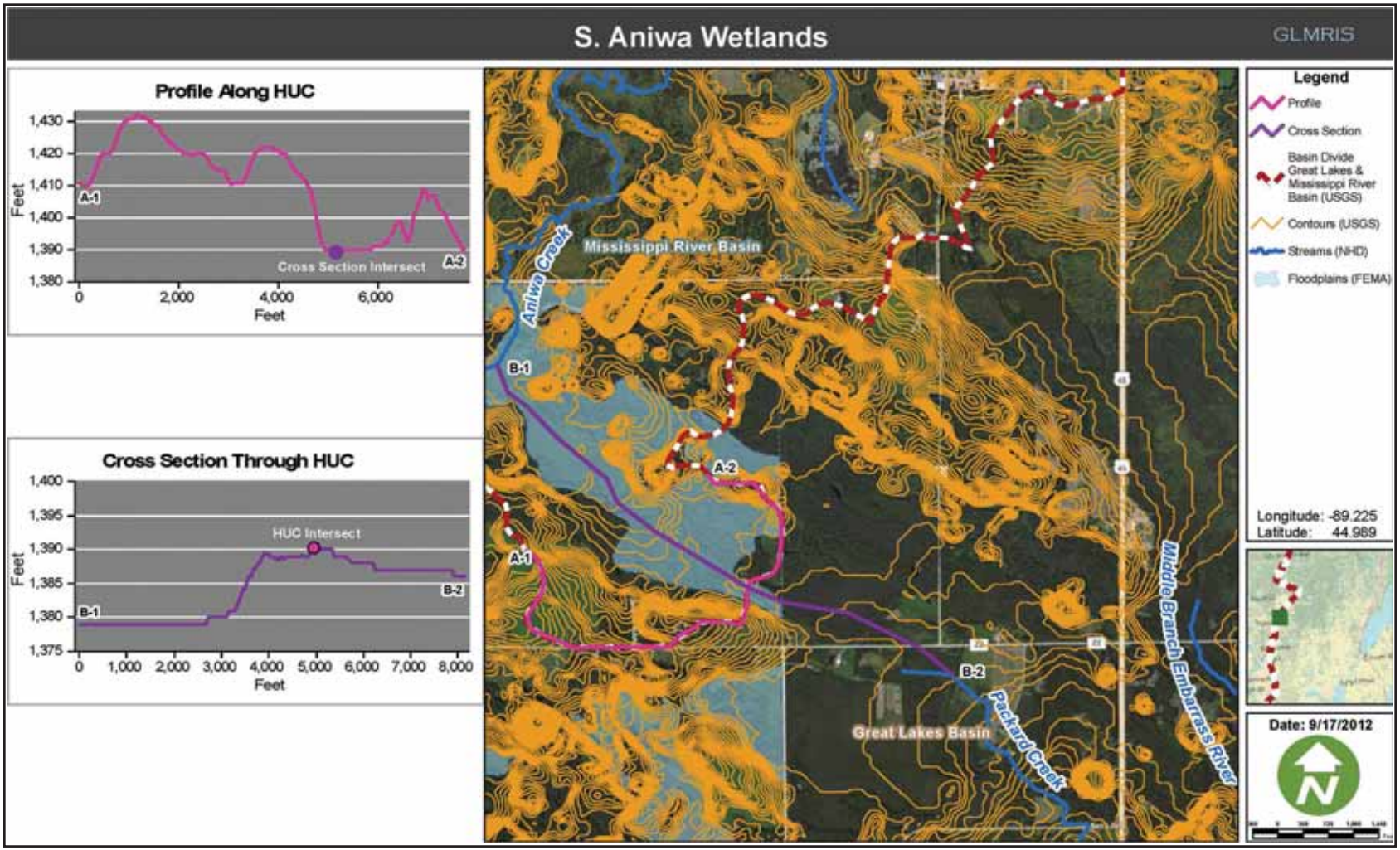


Figure 5: Typical location cross-sections, based on USGS 10m DEM, with a vertical accuracy of +/- 13.123ft. The pink line in the figure and on the graph on the top left is the profile along the basin divide. The purple line that intersects the pink line in the figure and bottom left graph is the cross section through the basin divide connecting with the nearest tributary in either basin. Background imagery courtesy of Bing Maps.

the potential for a hydrologic connection forming across the basin divide.

Evaluation of the NWI from the USFWS on-line mapper indicates that the potential pathway location is part of an at least 75-acre (30.3 ha) palustrine forested wetland with a "saturated" water regime (PFO2B) that traverses between the two basins (NWI, 2011). This wetland unit is shown to extend from the Mississippi River Basin side of the divide to the south and across County Road Zz, thereby appearing to directly link the two basins with contiguous wetland (Figure 6). However, during a site visit on June 7, 2011 no evidence of any surface water connection (e.g., wetland, stream, ditch) was found between the two basins where the NWI map shows there to be a wetland, and buildings being located in this area indicate that conditions are not too wet to preclude some development along County Road Zz. Perhaps most importantly, no culverts were found under County Road Zz that could link any surface water flows between the two basins, although there is a slight swale/ditch that runs along County Road Zz (Figure 7). Although there is some uncertainty on the exact location of the boundaries for the FEMA mapping, NWI mapping, and the basin divide location (e.g., due to resolution, age of data, aerial photo interpretation, and the fact that the flood and NWI mapping is not available in both counties), site observations found no evidence of any surface water connections (e.g., channels, drift patterns, water marks) to streams, ditches, or wetlands on either side of the basin divide.

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, USGS Groundwater Watch site 450242089065401, is seven miles (11 km) north of the pathway site. Although no groundwater data in the immediate vicinity of the pathway is available, groundwater conditions are not believed to increase the likelihood of creating or maintaining a surface water connection between these watersheds.

3.5 Aquatic Pathway Temporal Characteristics

Characterizing the temporal variability of the site's hydrology is potentially an important aspect of understanding the likelihood of an ANS being able to traverse the basin divide as certain flood events may coincide with species migration, reproductive patterns, and abilities to survive and establish populations in various areas. Surface water conditions in this area vary over time due to seasonal differences in flora, temperature, and precipitation amounts and intensity. Significant areas in proximity to the basin divide at this location are shown as wetland according to the NWI, indicating that inundation may be likely in these areas for a sufficient amount of time to allow wetland conditions (e.g., wetland vegetation, hydric soils) to develop. In addition, temperature data (Section 3.2) indicate that shallow surface water likely remains frozen from the end of November through mid March during most years, and this period generally corresponds to time of least precipitation during any given year. Periods of heaviest precipitation generally occur from May through September.

Based on the FEMA mapping, it appears possible for Aniwa Creek to overflow its banks and cause some backflow of water from the Mississippi River Basin across the divide into the Great Lakes Basin. However, as shown in Figure 5, County Road Zz is visibly elevated

Figure 6: View of potential pathway showing FEMA one percent flood mapping (red) for Marathon County adjacent to NWI mapping (blue) for Shawano County. Both map layers are not available for both counties. Even though the two layers are estimates of different features (i.e., flood prone area versus wetlands), they do none-the-less match up fairly well at the county line. Although the NWI shows wetland extending across County Road Zz, there are no culverts under this road that would allow such a connection and the mapping was either originally incorrect or it is now out of date (NWI, 2011). Background imagery courtesy of Bing Maps.

Figure 7: View of ditch near the watershed divide looking East along County Road Zz, about 0.1 mile (161 m) east of Crescent Drive. The road grade is several feet above the surrounding terrain at this point and no maintained roadside ditch exists. Photo from USACE

through the area where those waters would need to cross to connect with the unnamed tributary to Packard Creek in the Great Lakes Basin. The NRCS Web Soil Survey indicates that the soils in the potential interbasin flow area have a flooding frequency classification of "none" (Figure 8) and a ponding frequency classification of "frequent" or "none" (Figure 9). Given the large flat area between the basin divide and County Road Zz, it is likely that any interbasin flow that might occur from up to a one percent annual recurrence interval flood at this location could likely be stored north of County Road Zz until it infiltrated into the soil or evaporated.

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) up to a one percent annual recurrence interval storm. The low probability rating assigned to the existence of an aquatic pathway at this site does provide a high level of confidence that ANS will not be able to use this site to traverse between the basins. A surface water connection between the Great Lakes and Mississippi River Basins is unlikely based on these four key points:

- There is at least a 1.5 mile (2.4 km) distance between the nearest mapped surface water features on either side of the basin divide; Aniwa Creek to the north and the unnamed tributary to Packard Creek to the southeast. Along this path are wide expanses of very flat ground with no discernible ditches or conduits to facilitate flow across the basin divide.

- NRCS flooding frequency mapping for this area is classified as "none."

- NRCS ponding frequency mapping for this area indicates that the soils are classified as "frequent" or "none".

- County Road Zz, which is elevated several feet above the ground on either side, is an impediment to interbasin flow of surface water, and site

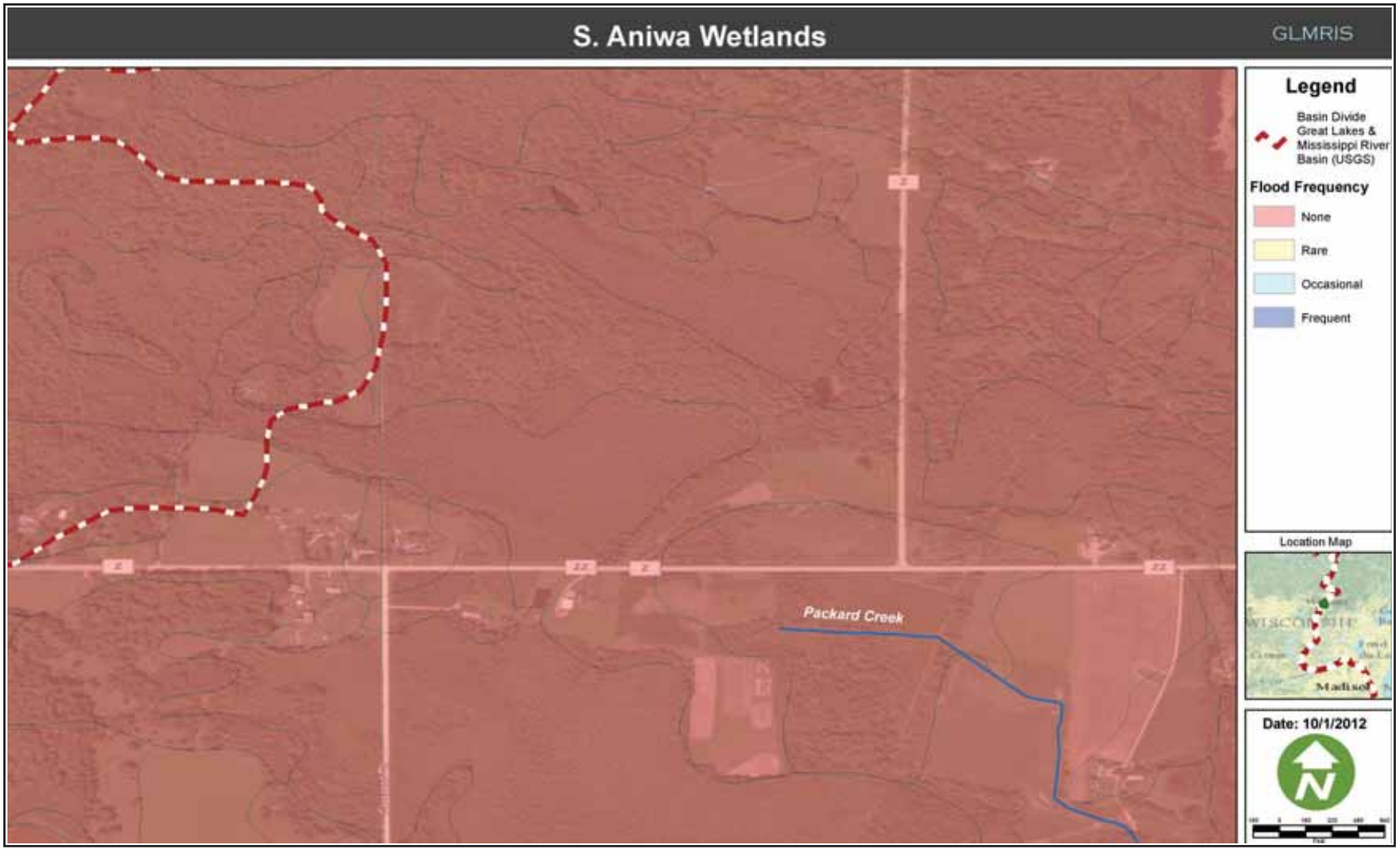


Figure 8: NRCS Web Soil Survey Map of Soil Flood Frequency Classes for the potential County Road Zz interbasin flow area. Red shading indicates a flood frequency classification of “none”. Background imagery courtesy of Bing Maps.

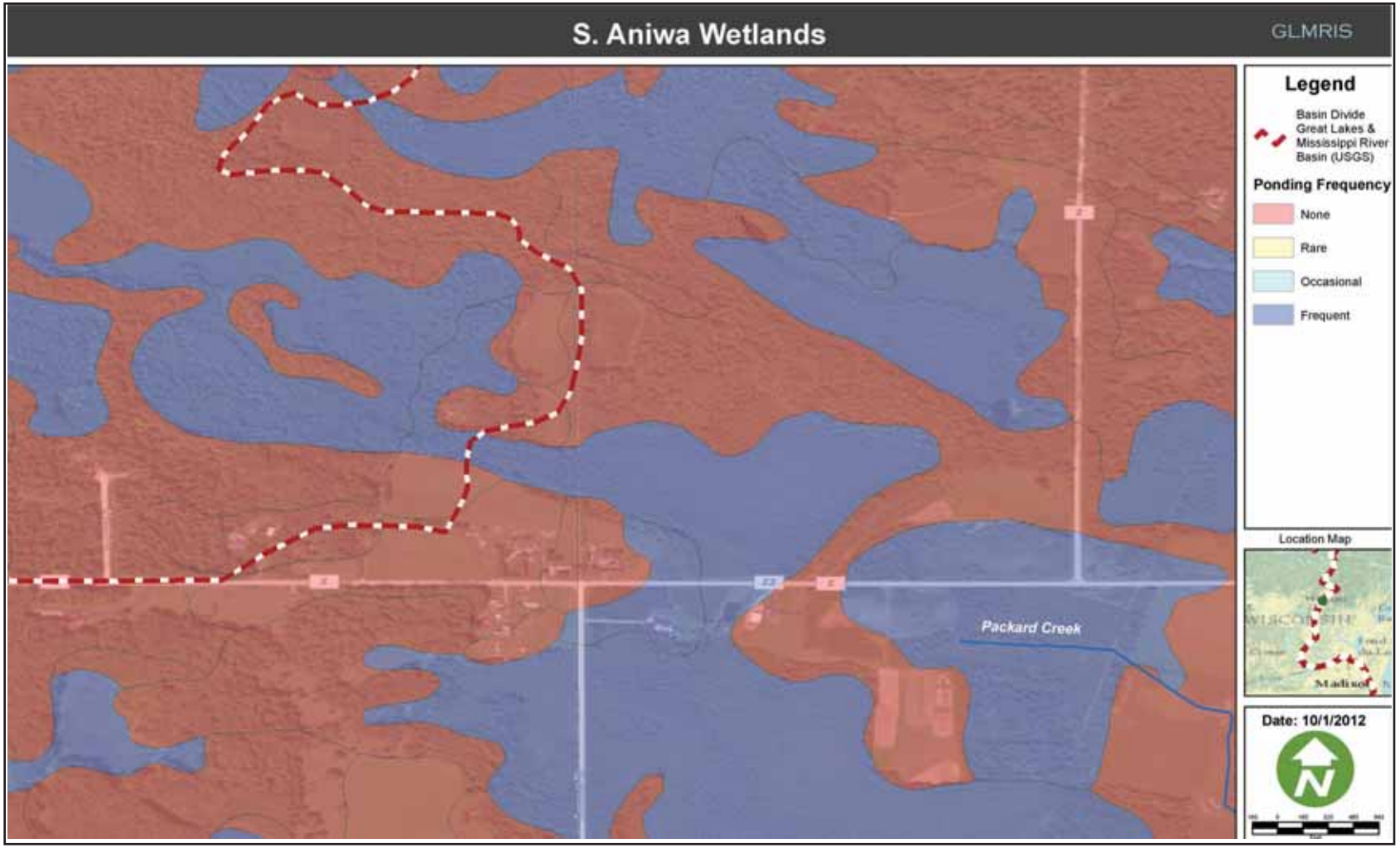


Figure 9: NRCS Web Soil Survey Map of Soil Ponding Frequency Classes for the potential County Road Zz interbasin flow area. Red shading indicates a flood frequency classification of “none”. Purple shading indicates a ponding frequency classification of “frequent”. Background imagery courtesy of Bing Maps.

reconnaissance confirmed there are no drainage conduits under this roadway within the subject area. The substantial amount of land area below the elevation of County Road Zz to the north would provide significant storage capacity in the event of a flood event and would significantly reduce the likelihood of an interbasin connection between surface waters establishing at this location.

- NRCS flood frequency mapping for this area is classified as "none."

Due to the above evidence, it is very unlikely that a surface water connection exists or could form at this location on a perennial or intermittent basis, from a one percent annual recurrence interval storm. Consequently, the probability of the existence of an aquatic pathway (P_0) at South Aniwa is rated low in either direction and supports the ratings assigned during the preliminary assessment in 2010 (Appendix A). There are intermittent streams at this location leading into both basins, but a surface water connection would not form between them from less than a one percent annual rrecurrence interval storm.

This rating is considered "moderately certain" because of the following:

- The vertical accuracy of USGS 10m DEM for ground surface profiles at the basin divide.
- The lack of updated base flood mapping provided by FEMA to determine extreme storm events and any site-specific data that would correlate precipitation amounts to surface water flows.
- Potentially conflicting information between the FEMA one percent floodplain mapping and the NWI mapping, where only the latter shows that aquatic conditions (i.e., wetlands) may extend south and across County Road Zz.

4 Overall Aquatic Pathway Viability

As discussed in Section 2.4, at those locations along the basin divide where the first element in Equation 5 (i.e., likelihood that an aquatic pathway exists) was estimated to be low, no further assessment of that location was necessary (Table 3). 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.

Table 3: Summary of individual probability elements and overall aquatic pathway viability for ANS Spreading between the Mississippi River and Great Lakes Basins at South Aniwa, WI location.

	Form 1 P_0	Form 2 P_1	Form 3 P_{2a}	Form 4 P_{2b}	Form 5 P_{2c}	$P_{viable\ pathway}$
Direction of Movement	**Pathway Exists?**	**ANS Occuring Within Either Basin?**	**ANS Surviving Transit to Pathway?**	**Establish in Proximity to Aquatic Pathway? (Sect. 4.3)**	**ANS Spreading Across Aquatic Pathway into New Basin?**	**ANS/Pathway Viability Rating**
MRB[1] to GLB[2]	L (MC)[4]	NN[3]	NN	NN	NN	L
GLB to MRB	L (MC)	NN	NN	NN	NN	L
Overall Pathway Viability for Spread of ANS Between MRB and GLB:						**L**

[1]MRB: Mississippi River Basin
[2]GLB: Great Lakes Basin
[3]NN: Not Necessary
[4]MC: Moderately Certain - Initial field rating was "reasonably certain," but USACE and NRCS concurred that the certainty should be reduced to moderately certain due to lack of updated flood mapping and site specific data, as well as some potentially conflicting information between FEMA and NWI mapping.

5 Conclusions

During the site visit in June of 2011, no channels or other evidence of an aquatic connection was observed between the two basins. A review of all available data, as well as collaboration with USGS, NRCS, and WDNR, led the interagency pathway team to conclude that there is little likelihood of a surface water connection existing on a perennial basis, or of one being able to form on an intermittent basis from up to a one percent annual recurrence interval storm. Thus the probability that an aquatic pathway exists was rated “low” and the overall aquatic pathway viability at South Aniwa, WI was also rated “low”.

6 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 Nuissance Species Task Force. October 21, 1996.

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Water Resources Development Act of 2007 [Section 3061(d): P.L. 110-114; amends Section 345: P.L. 108-335; 118 Stat. 1352].

Appendix A

Evaluation Forms for the S. Aniwa Pathway

S. Aniwa Report

May, 2013

South Aniwa, Marathon/Shawana Counties, WI

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
		Team Ratings	**Low**	**RC**	**Low**	**RC**

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: During the site visit on 7-Jun-2011, no evidence of a surface water connection extending into the Great Lakes basin was observed. The FEMA mapping shows the 100-yr floodplain crossing the HUC boundary, from the Mississippi basin into the Great Lakes, but it does not extend to include any surface waters or floodplains for the Great Lakes basin.