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

Loomis Lake, Indiana

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Executive Summary

The divide between the Great Lakes and the Mississippi River Basins extends north-south just to the east of Loomis Lake, located just north of the city of Valparaiso, Indiana. However, Loomis Lake drains into both basins through a culverted primary spillway (to the Mississippi River Basin) and through an auxiliary spillway at Proffitts Dam (to the Great Lakes Basin). The auxiliary spillway at Proffitts Dam is used periodically to discharge excessive lake water into the headwaters of Damon Run, which is part of the Salt Creek Watershed draining to the Little Calumet River. The lake's drainage to the Mississippi River Basin is through an underground 900-foot (274 m) long culvert to the adjacent Flint Lake which then empties into Crooked Creek through two 24-inch (61 cm) diameter corrugated metal pipes. Crooked Creek is a tributary of the Kankakee River.

This site was determined to be capable of conveying water across the basin divide toward the Mississippi River Basin continuously for multiple days from a ten percent annual recurrence interval storm event through the underground culvert from Loomis Lake to the adjacent Flint Lake. However, it is unlikely if not impossible for water to flow in the opposite direction from Flint Lake into Loomis Lake because Loomis Lake is perched approximately 17-feet (5.2 m) higher in elevation than Flint Lake. The probability of a flow connection from the Great Lakes Basin to the Mississippi River Basin was rated as "medium" and the probability of a flow connection from Mississippi River Basin to Great Lakes Basin was rated "low".

As a result of this medium rating for the existence of a pathway at Loomis Lake, the viability of the aquatic pathway for specific ANS of concern was then evaluated by looking at the biological requirements and capabilities of the nine ANS listed in the adjacent table.

That evaluation concluded that any ANS from the Great Lakes that made its way up the headwaters of Damon Run to the base of Proffits Dam would be unable to then scale the auxiliary spillway and enter Loomis Lake during the brief periods when water flows through the auxiliary spillway. Likewise, the evaluation concluded that any ANS attempting to access the Loomis Lake aquatic pathway from the Mississippi River Basin would be unable to access the Lake because it would have to navigate its way up the headwaters of Crooked Creek to the twin 24-inch (61 cm) diameter outfall pipes from Flint Lake, jump the roughly one foot (30 cm) difference in elevation from the creek into one of the discharge pipes, swim up the pipe into Flint Lake, and then swim up a primary spillway conduit from Loomis Lake during a time when it is fully inundated and the water velocity is estimated to be 7.5 feet per second (2.3 meters per second). Also, the ANS would need to pass through primary and secondary trash racks to access Loomis Lake. Consequently, the viability of the Loomis Lake aquatic pathway to facilitate the interbasin spread of ANS was deemed to be low by an interagency team because it was found to be unlikely for any of the species of concern to this location to be able to reach Loomis Lake solely through the aquatic pathway.

However, should an ANS be introduced into Loomis Lake or Spectacle Lake, it would then likely be able to spread into either basin through the primary spillway from Loomis Lake into Flint Lake, or during larger flood events from Loomis Lake through the auxiliary spillway into the headwaters of Damon Run. One way ANS could be introduced to either Spectacle Lake or Loomis Lake is through the release of live bait, which may inadvertently contain ANS. Another is by ANS attachment to recreational boats and other portable marine equipment while in one basin, which are then transported over land and placed in either lake. Direct human release of imported aquaria fish or other exotic species into Loomis or Spectacle Lakes could also result in the spread of ANS into the Mississippi

Aquatic Nuisance Species of Concern

Species	Common Name
Hypophthalmichthys molitrix	Silver Carp
Hypophthalmichthys nobilis	Bighead Carp
Mylopharyngodon piceus	Black Carp
Channa argus	Northern Snakehead
Gasterosteus aculeatus	Threespine Stickleback
Gymnocephalus cernua	Ruffe
Proterorhinus semilunaris	Tubenose Goby
Neoergasilus japonicus	Parasitic Copepod
Novirhabdovirus sp	Viral Hemorrhagic Septicemia Virus (VHSv)

River Basin and perhaps the Great Lakes Basin. So while the viability of the aquatic pathway at Loomis Lake to facilitate the interbasin spread of ANS is low, it is in a unique geographic location where development and implementation of some site specific measures may be appropriate.

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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
GLB . . . . . Great Lakes Basin
GLFC. . . . . Great Lakes Fishery Commission
GLMRIS. . . Great Lakes and Mississippi River Interbasin Study
HUC. . . . . Hyrdologic Unit Codes
IBI . . . . . Index of Biological Integrity
IDEM . . . . . Indiana Department of Environmental Management
ITSI . . . . . Indiana Trophic State Index
INDNR. . . . Indiana Department of Natural Resources
MRB. . . . . Mississippi River Basin
NAS . . . . . Nonindigenous Aquatic Species
NEPA. . . . . National Environmental Policy Act
NOAA. . . . . National Oceanic and Atmospheric Administration
NRCS . . . . Natural Resources Conservation Service
QHEI . . . . . Qualitative Habitat Evaluation Index
TP . . . . . Total Phosphorus
USACE . . . U.S. Army Corps of Engineers
USFWS . . . U.S. Fish and Wildlife Service
USGS . . . . U.S. Geological Survey
VLACD. . . . Valparaiso Lakes Area Conservation District
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 Loomis Lake location in Porter County, Indiana. This 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/).

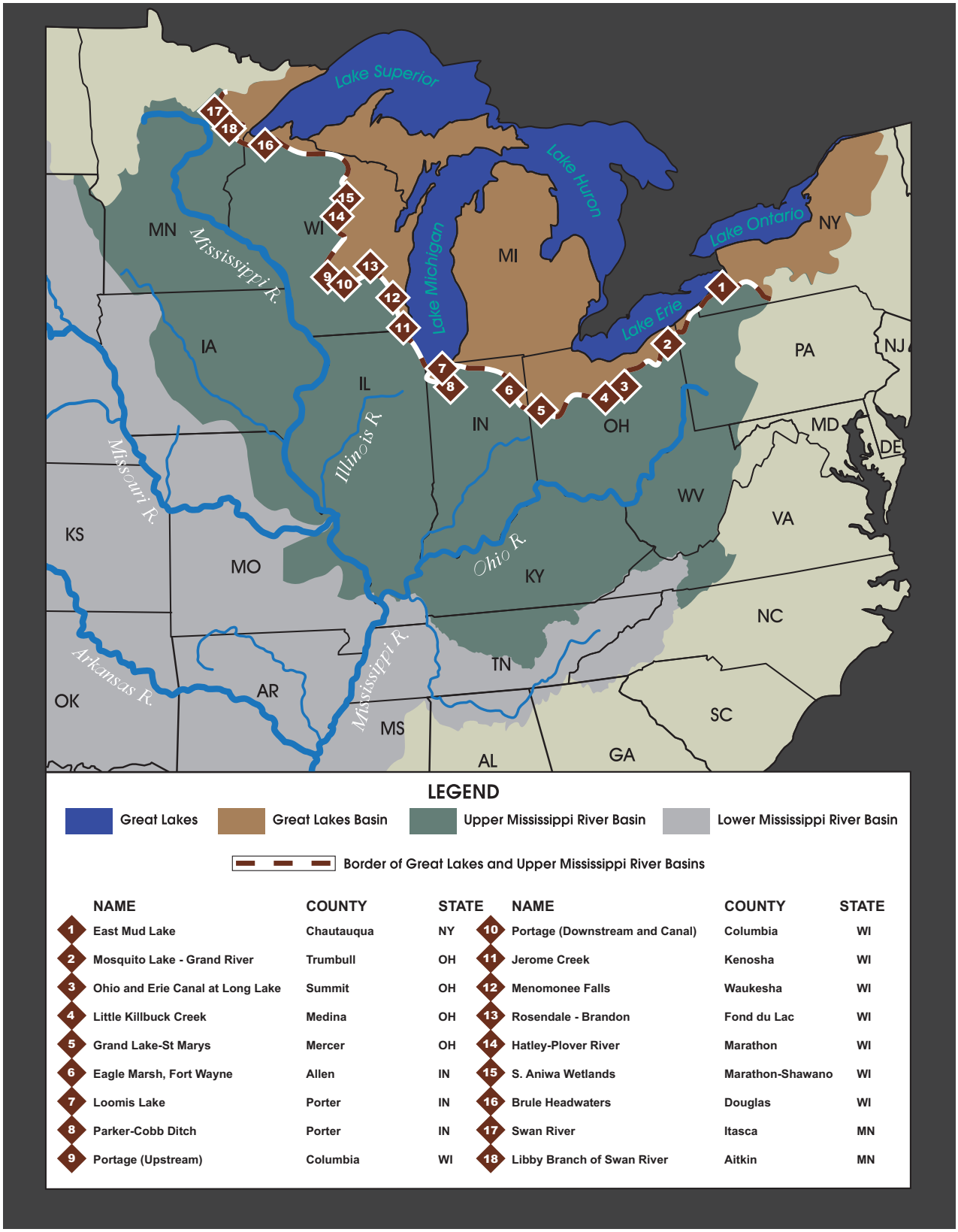
The dashed line in Figure 1 depicts the nearly 1,500-mile (2,414 kilometer) basin divide from the New York - Pennsylvania state line to north eastern Minnesota, and it depicts each of the 18 potential aquatic pathway locations that were previously identified. The Loomis Lake location is shown as site number 7 in northeast Indiana (Figure 1).

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 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 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 from up to a one percent annual recurrence interval flood event, 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.

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 return frequency storm (formerly referred to as a 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



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

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

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.

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 Loomis Lake 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 Loomis Lake, Indiana location should be included in the inventory of locations where a viable surface water connection between headwater streams on both sides of the drainage divide exists or is likely to form between the Great Lakes and the 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 Loomis Lake, Indiana location and will enable the interbasin spread of ANS;

- Identification of the means, constraints, and likelihood of the interbasin spread of ANS via the potential aquatic pathway at the Loomis Lake 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 Loomis Lake location.

1.2 Summary of 2010 Preliminary Risk Characterization for Loomis Lake, Indiana

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), Natural Resources Conservation Service (NRCS), 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 assigning the individual qualitative 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 tolerably 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 (INDNR) until a more complete assessment and remedy could be implemented.

Although the preliminary risk characterization did not identify the Loomis Lake 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 interconnected nature of the Valparaiso Lakes, the presence of a culvert between Loomis and Flint Lakes, and lack of readily available hydrological evidence found during the preliminary study effort to discern the relative frequency and potential magnitude of a potential aquatic pathway at this location. The preliminary effort therefore recommended that a more detailed assessment be conducted at this location. This was subsequently done in collaboration with the County Surveyors, INDNR, USFWS, USGS, and other government agencies. The following actions were taken:

- Federal, State, and local stakeholders (i.e., USGS, INDNR, County Surveyor, and local NRCS representatives) were briefed on the preliminary risk characterization results. Detailed site visits were conducted to observe the location and the available modeling,

- Meeting with stakeholders at Loomis Lake to observe conditions and compile and review available information on the design, relationship, and operations of Loomis and Flint Lake.

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

- An evaluation of habitat and abiotic conditions in proximity to the location relative to the needs and preferences of ANS in proximity to the Loomis Lake, Indiana location.

- Revise ANS transfer ratings for each location based upon a more detailed evaluation of ANS transfer potential via the aquatic pathway in both directions.

- Identify measures that could be implemented at the local or state level to mitigate significant potential associated with the interbasin spread of ANS.

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 USACE, NRCS, INDNR, and the city of Valparaiso. The results also reflect the guidance, input, review comments, and concurrence of the multi-organizational Agency Technical Review of experts from USFWS and Illinois Department of Natural resources. In addition, the Michigan Departments of Natural Resources and Environmental Quality participated on the ATR team and jointly concluded their reviews by stating that “we have reviewed the Loomis Lake 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 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 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 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 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.

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.

2.3.3 List of ANS of Specific Concern at the Loomis Lake Location

The Loomis Lake 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 Loomis Lake aquatic pathway team reviewed the information on the initial 119 species to assess if any were in close enough proximity to the Loomis Lake location to be of concern. In addition, 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 Agency Technical Review as high risk potential invaders not yet in either basin (NOAA, 2011). Mapping was produced, using available USGS occurrence data, to show the relative known location of any ANS to Loomis Lake. Any occurrences of ANS within a 25-mile (40 km) radius of Loomis Lake are shown on Figure 2. All of the ANS in close proximity are currently in the Lake Michigan watershed. All locations of ANS occurrences in Lake Michigan are detailed in Figure 3.

Each 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 potential pathway relative to the known location of those ANS being considered. Based on concerns from local agencies in several states about the potential for spread of viral hemorrhagic septicemia virus (VHSv, Novirhabdovirus spp), the project team elected to include it on the list of species of concern for this study at Loomis Lake. Although VHSv has been found in both basins (though infrequently and very localized in the Mississippi River Basin), minimizing the spread of VHSv remains a priority for local stakeholders (Great Lakes Commission, 2011; USGS, 2011). It is therefore included under the grouping of species which could potentially threaten the Mississippi River Basin.

Each of the three subgroups (i.e., fish, virus, copepod) in Table 4 was evaluated based on the dispersal mechanisms and general mobility of the species within each group. Since this location is positioned on the basin divide, well upstream of any know ANS listed here, any organism that moves solely through this aquatic pathway must possess either self-propelled mobility or the ability to “hitchhike” on other organisms to travel upstream. This eliminates organisms that rely on current for dispersal such as plants and algae

Based on the evaluation by subgroups, only fish, or fish pathogens, were considered to have the requisite means of reaching Loomis Lake from either direction, independent of barriers being present. To facilitate determination of the ANS transfer potential via this site, the team of biologists then selected a smaller group of representative species for focused assessment. The species selected may be those most likely to arrive at the divide, pose the greatest possibility of ecological damage, and/or exhibit a broad range of biological characteristics that provides a more thorough and conservative evaluation of potential probability that ANS could spread between the basins at this location. Of all species considered, the Loomis Lake aquatic pathway team determined four of these possible future invaders as ANS of potentially significant threat to the Great Lakes Basin, and five of these ANS of potentially significant threat to the Mississippi River Basin (Table 4).

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 and other relevant scientific literature (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 Indiana. Additional information was obtained from the USGS Non-indigenous Aquatic Species (NAS) website (USGS, 2011).

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 / 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

Table 2: ANS of Concern Threatening the Mississippi River Basin.			
Taxa	**Species**	**Common Name**	**Interbasin Dispersal Mechanism**
fish	*Alosa aestivalis*	blueback herring	swimmer
fish	*Alosa psuedoharengus*	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.			
Taxa	**Species**	**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 and trailers
plant	*Murdannia keisak*	marsh dewflower	recreational boats and trailers
plant	*Oxycaryum cubense*	Cuban bulrush	recreational boats and trailers

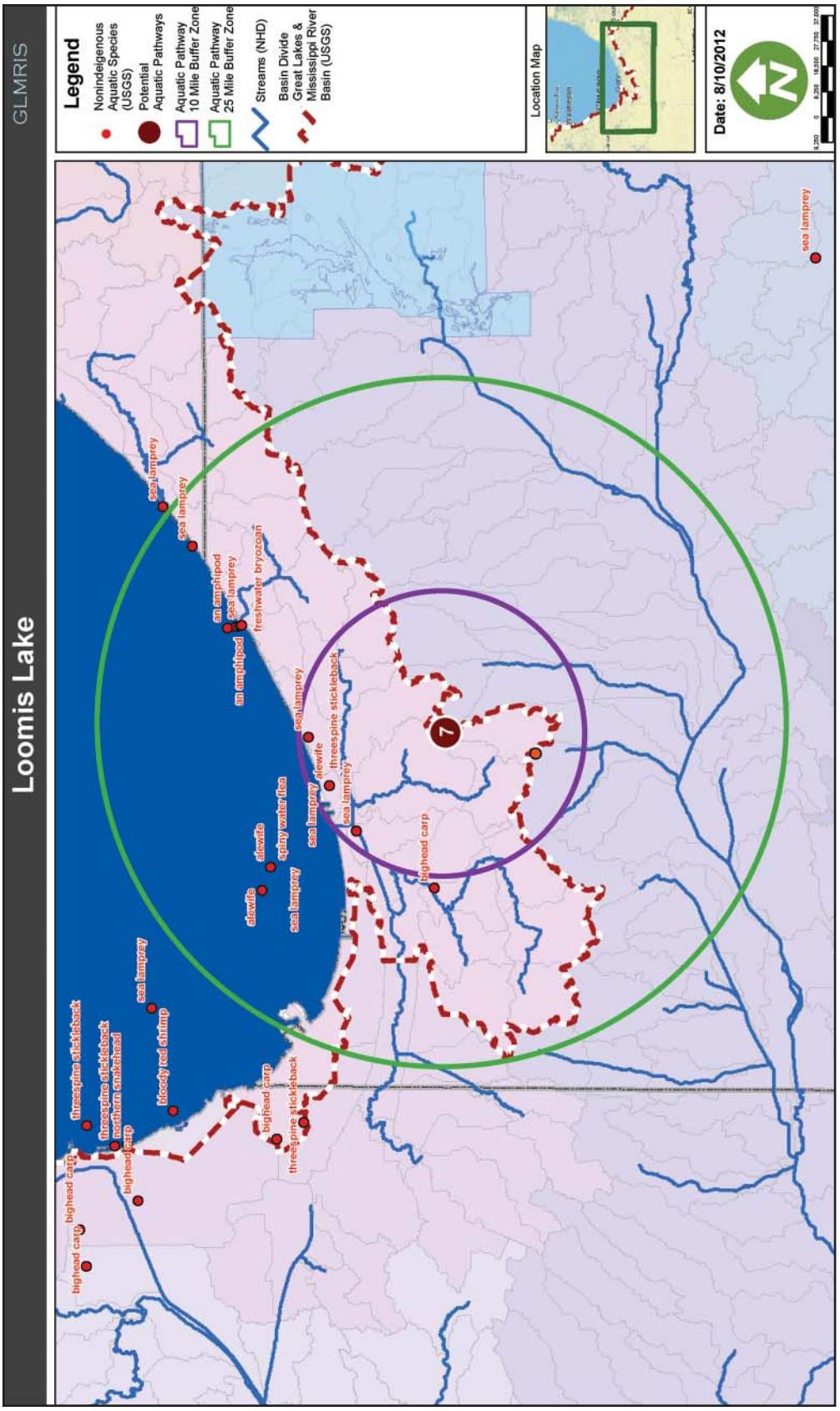


Figure 2. Map of known ANS occurrences near Loomis Lake (site number 7) (Source: USGS, 2011).

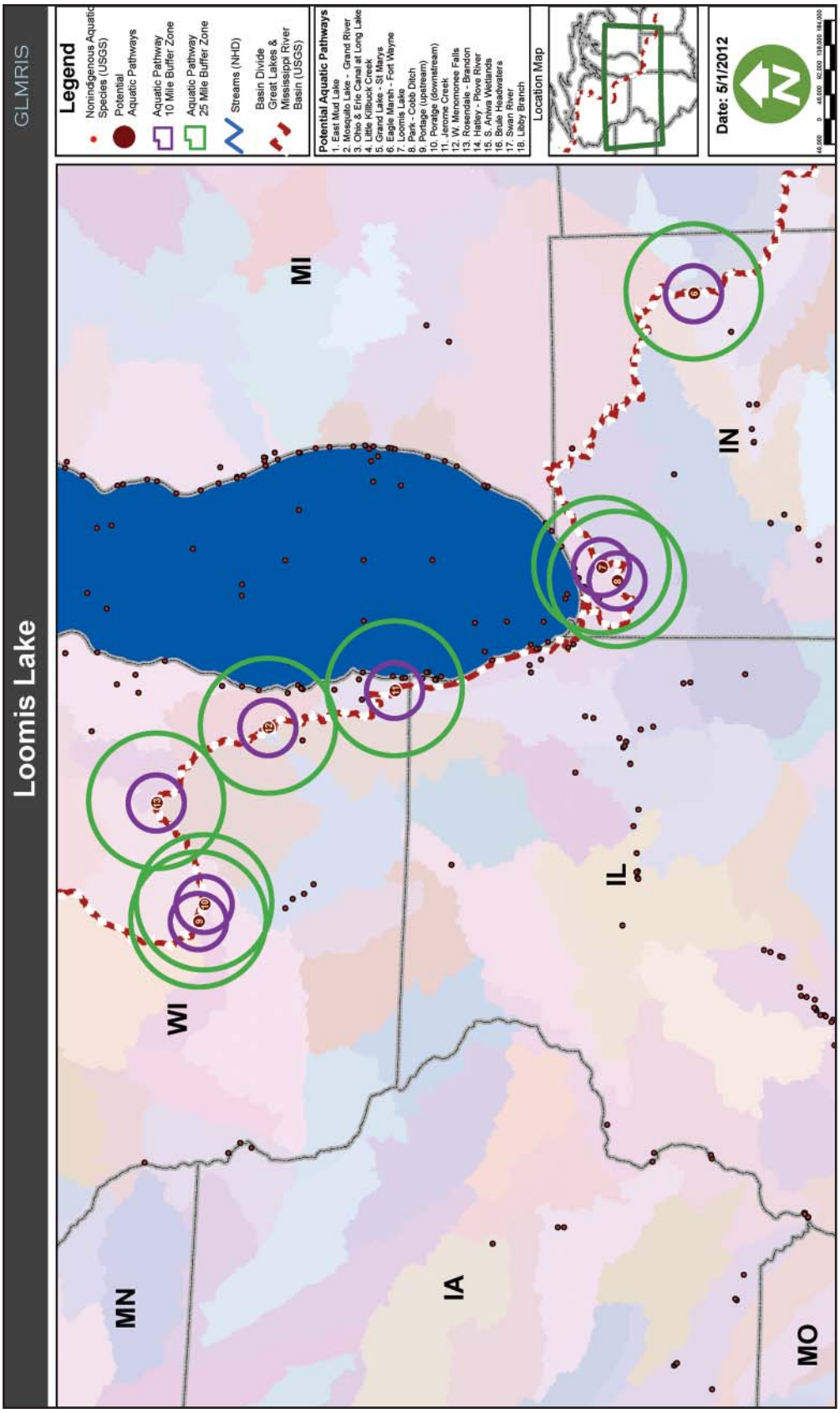


Figure 3: Map of ANS occurrences in and around Lake Michigan (Source: USGS 2011). Loomis Lake is site number 7 on the map.

Table 4: Species of Greatest Concern at Loomis Lake.				
Taxa	**Species**	**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	*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
crustacean	*Neoergasilus japonicus*	parasitic copepod	GL	parasite to fish
Virus	*Novirhabdovirus sp*	VHSv	GL	Pathogen to Fish/Water Column

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 (P_3) and spread (P_4) in the new basin. In addition, the third element of Equation 3, ANS transits pathway (P_2), 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 (P_3 and P_4) 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 at 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 at 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 Loomis Lake 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..

2.5 Example Calculation of Overall Aquatic Pathway Viability

As described in Section 2.2, a list of ANS of concern for the Loomis Lake pathway was developed with input from Federal, State, and local agencies responsible for water resources, and fish and wildlife management in the state of Indiana 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 5. 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 same way and is shown in Table 6. 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 6, 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 regarding the probability rating (H, M, or L) and the level of certainty (VC, RC, MC, RU, or VU). Final agreement was reached on team ratings for each element through collaboration and sharing of applicable information with all team members. The level of certainty in these ratings was modified during these discussions to reflect the range of opinion.

3 Aquatic Pathway Characterization

This section describes and illustrates the topography and features in the vicinity of the potential pathway at Loomis Lake, Indiana, and is intended to help inform the biological evaluations contained later in this report with a compilation of 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 hydrologic and hydraulic conditions near the drainage divide. Also, this section identifies any significant data gaps and uncertainties related to the topographic and hydrologic information in the area of interest.

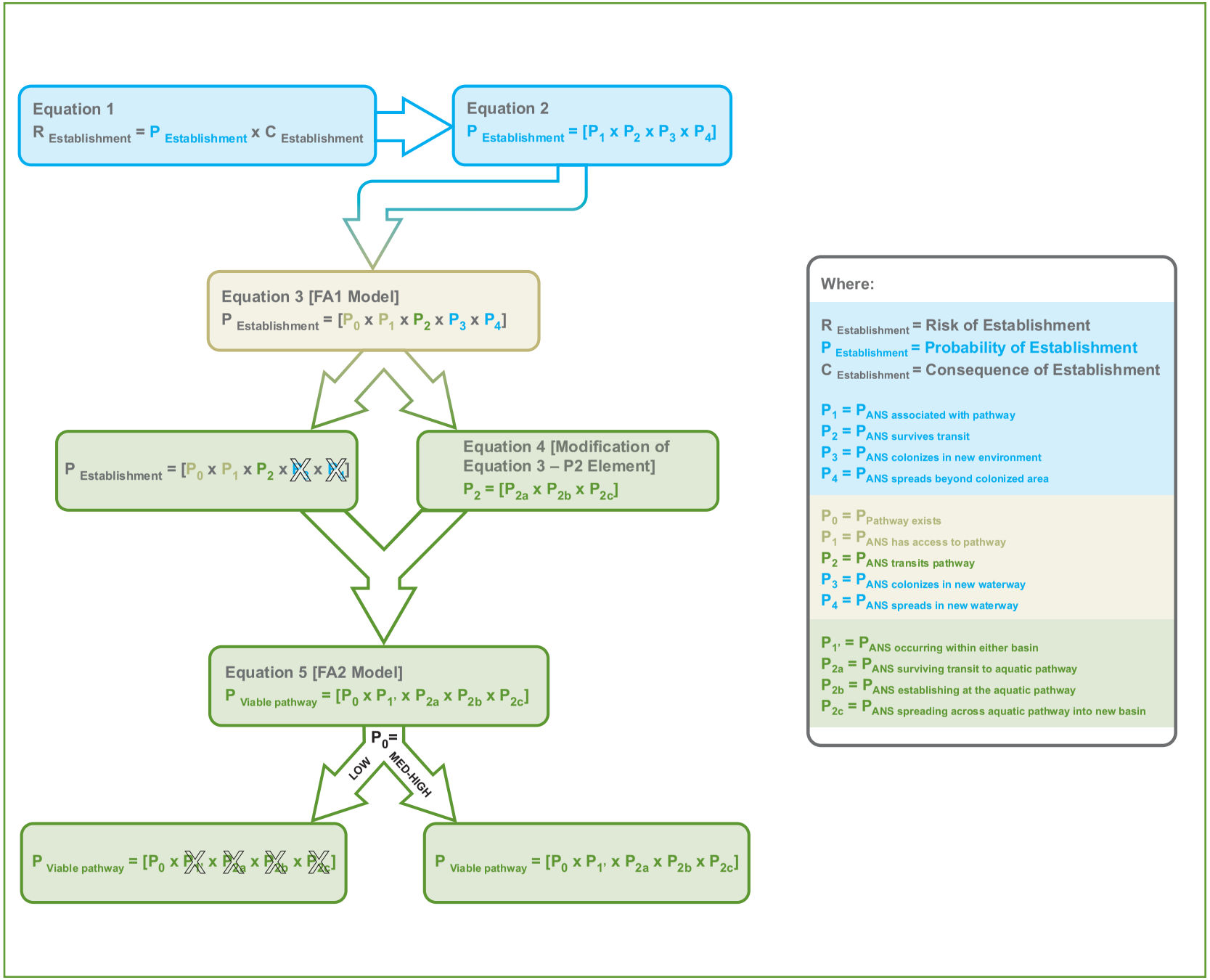


Figure 4. Diagram of the derivation of the GLMRIS Focus Area 2 aquatic pathway assessment model.

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 at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way 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 at Aquatic Pathway?**	**ANS Spread-ing Across Aquatic Pathway into New Basin?**	**ANS/Path-way 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**

3.1 Location

Loomis Lake and Flint Lake are part of what comprise the Valparaiso Lakes, which are located north of the city of Valparaiso, Indiana. The location of these lakes relative to the city of Valparaiso is illustrated in Figure 5, while Figure 6 presents a slightly larger scale aerial view of the lakes showing the Great Lakes and Mississippi River Basin divide line and general land use in the area. Also presented in this section are the streams and associated subwatersheds for each lake as well as the roadways in the area (Figure 7). The general flow path of these lakes is from Spectacle Lake into Loomis Lake, and then from Loomis Lake primarily into Flint Lake. However, Loomis Lake also has a secondary spillway allowing periodic flows to go north into Damon Run within the Great Lakes Basin. Loomis Lake has no other surface water inputs other than precipitation and inflow from Spectacle Lake, and Flint Lake has no other surface water inputs other than precipitation and inflow from Loomis Lake. The only outflow from Flint Lake is through a pair of culverts located at the southeast corner which empty into Crooked Creek.

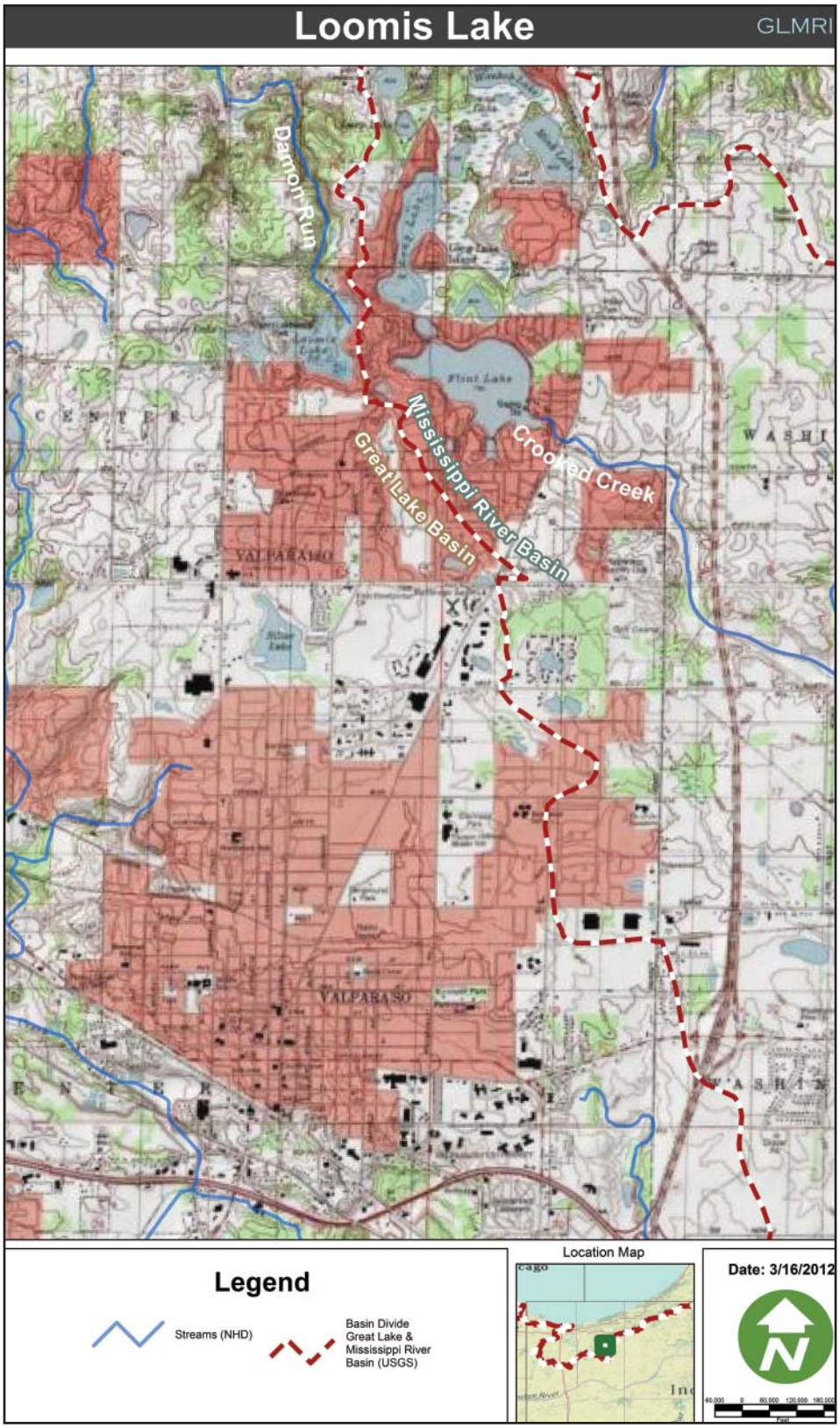


Figure 5. Loomis and Flint Lakes USGS topographic map, north of the City of Valparaiso, Indiana.

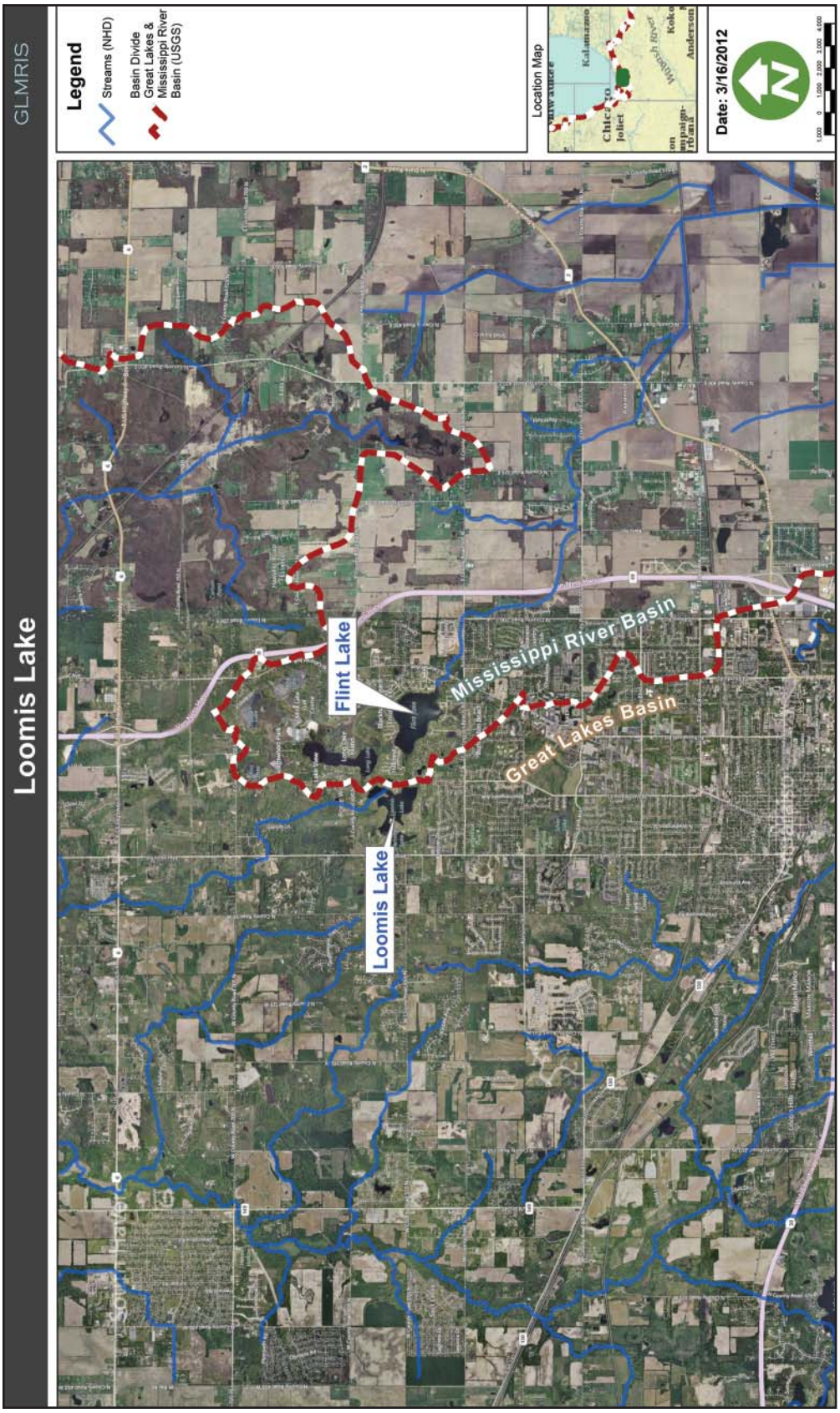


Figure 6. Location of Loomis and Flint Lakes overlaid on aerial photograph showing basin divide (red-white line) and general land use in the area. Blue lines indicate nearby streams. Base map courtesy of Bing Maps.

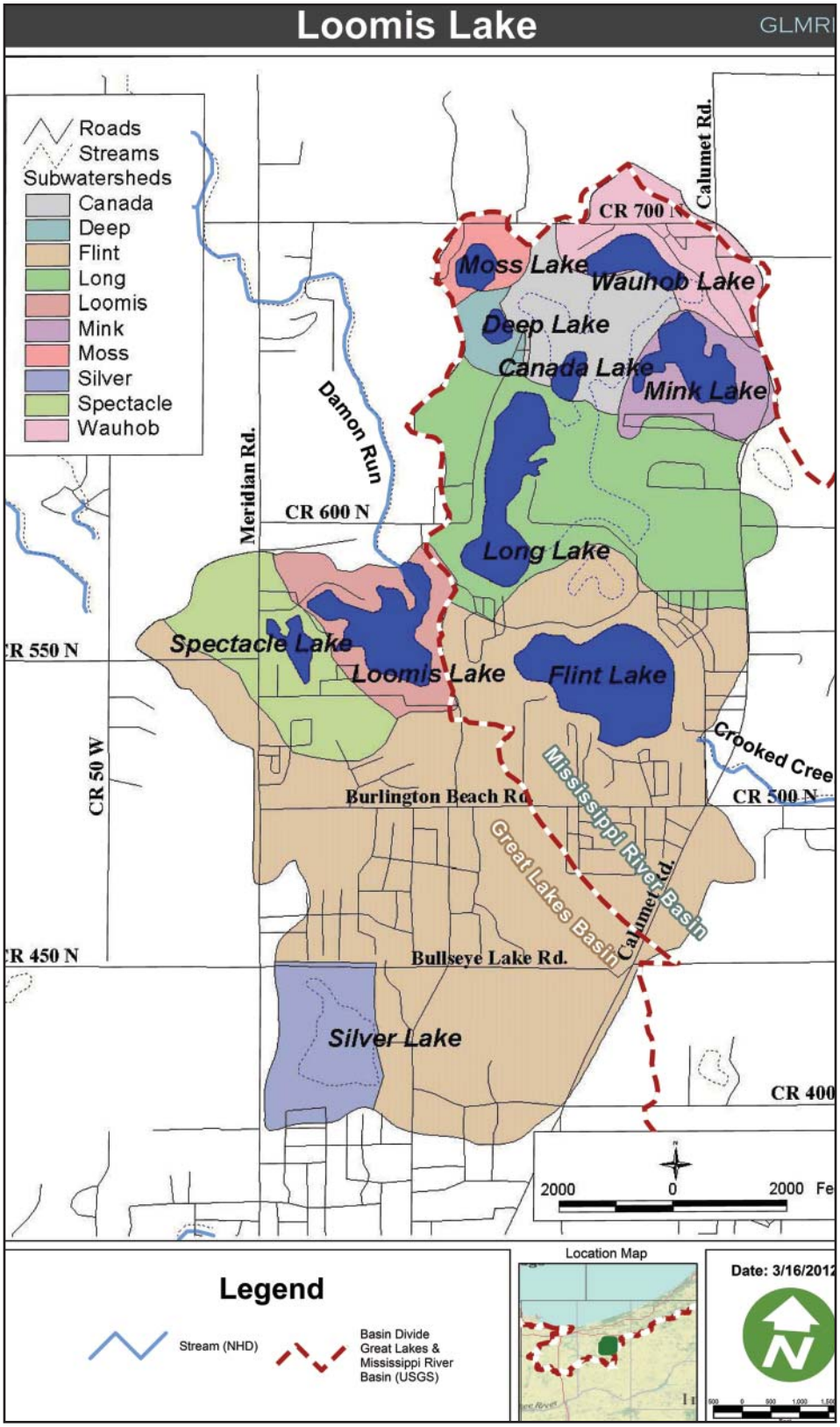


Figure 7. Surface water features and watershed boundaries in proximity of Loomis Lake, Indiana. Spectacle Lake drains to Loomis Lake, which then drains primarily to Flint Lake in the Mississippi River Basin. Base imagery courtesy of Bing Maps.

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 northern Indiana is classified as temperate continental with warm summers and cold winters that typically provide enough precipitation, in the form of snow, to supply the soil with sufficient moisture to minimize drought conditions when the hot summers begin (INDNR, 2006). Temperatures in winter average 27ºF (-2.7ºC), while summers are mild, averaging 71ºF (21.6ºC). The average temperatures in June, July, and August range from highs in the low 80's (ºF) (26-28ºC) to lows in the high 50's to low 60's (ºF) (14-17ºC). Combined with the lack of available shade, surface water temperatures could elevate substantially on hot summer days. Conversely, the average temperature in December, January, and February range from highs in the low to mid 30's (ºF) to lows in the teens to low 20's (ºF).

The average annual precipitation is approximately 40-inches (101 cm), with the driest times of the year generally occurring between October and March (JFNew, 2006). Precipitation data also indicate that the wettest times of the year occur between April and September (Frankenberger and Carroll, 2011). Area records indicate that especially intense storms are most likely to occur during the spring, and modeling indicates that a one percent annual recurrence interval storm would be expected to produce approximately eight inches (20 cm) of rainfall in a 24 hour period (Frankenberger and Carroll, 2011). The climate of Porter County could therefore limit the quality and quantity of surface water in the small streams leading away from Loomis and Flint Lakes during the hottest summer months (e.g., low levels of dissolved oxygen). Substantial drying of the Damon Creek and Crooked Creek headwaters near these lakes could also occur during summer months and freezing of certain reaches downstream may also occur in the winter.

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. There are three primary areas in the Loomis Lake vicinity that collectively form the Loomis Lake Aquatic Pathway (Figure 8).

The watershed draining Loomis Lake historically drained north to Damon Run and then to Lake Michigan roughly 12 miles (30.5 km) downstream to the north. Loomis Lake was formed in 1924 by the construction of Proffitts Dam, a small earthen dam at the headwater of Damon Run (Figure 8 - Figure 10). The legal lake level of Loomis Lake is set to 813.7 feet (NAVD88), with a surface area of 49.7 acres (20.1 ha), and a normal storage of 317 acre-feet but with a capacity of 485 acre-feet.

As a result of human modification of drainage patterns in the early 1900's, all of the Valparaiso Lakes now drain to Flint Lake as a means of augmenting the former use of Flint Lake as a primary water supply during dry months. However, Flint Lake is no longer used as a primary water supply in the area but still may be used as a back-up water source. All of these lakes are therefore within the Kankakee River Watershed, which is a tributary of the Illinois River, and of the Mississippi River. The legal lake level of Flint Lake is a stage of 17.66 feet, or an approximate elevation of 797.4 feet NAVD88. As of 2002, the maximum water surface recorded was elevation 800.9 feet NAVD88, occurring on July 2, 1983 (USGS, 2003). The topography of the area was also evaluated to see what barrier the slope of the land itself might offer to the formation of an aquatic pathway, as well as possibly the spread of ANS between the basins. Representative surface elevations of the three connection points are shown in Figure 11 - Figure 13 which also depict representative cross-sections through the flow path between Loomis and Flint Lakes (Figure 11), Loomis Lake to Damon Run (Figure 12), and Flint Lake to Crooked Creek (Figure 13), based on the best available Geographic Information System (GIS) data.

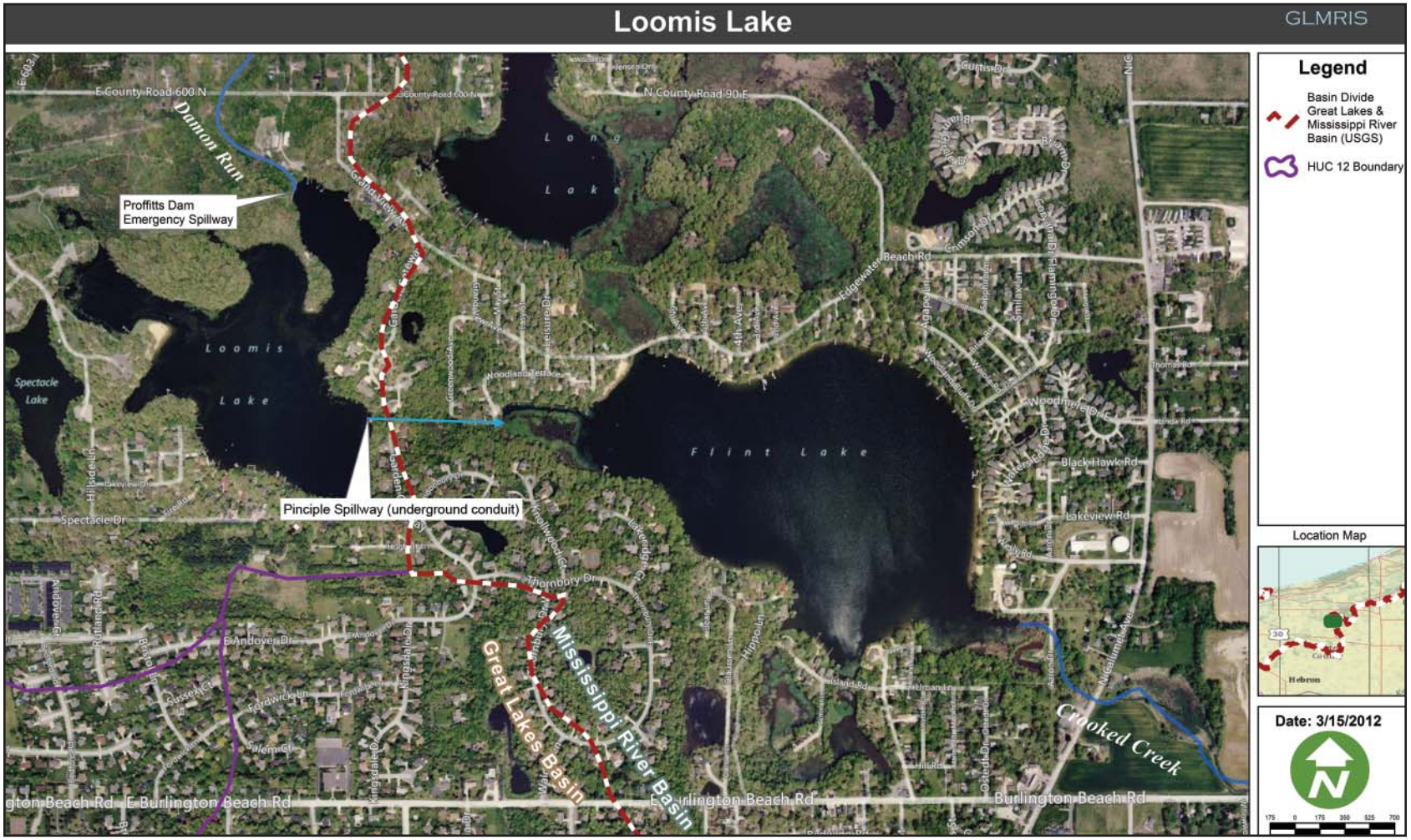


Figure 8. Enlarged plan view map of Loomis and Flint Lakes area showing network of three connection points between Flint and Loomis Lakes and their respective drainage basins: (1) Loomis Lake to Damon Run, (2) Loomis Lake to Flint Lake, and (3) Flint Lake to Crooked Creek at bottom right corner. Base imagery courtesy of Bing Maps.

Figure 9. Proffitts Dam on Loomis Lake, looking west. Photo taken June 20, 2011 by USACE.

Figure 10. Proffitts Dam on Loomis Lake, looking southwest. Photo taken June 20, 2011 by USACE.

Loomis Lake to Flint Lake:

A profile along the basin divide (hydrologic unit code (HUC)-12) depicts the 'saddle point' along the divide and is the location along the basin divide where a hydrologic connection exists between the basins (Figure 11). Also shown is a cross-section through the basin divide to depict the typical ground elevation along the flow path from Loomis Lake to Flint Lake. As can be seen in Figure 11 and Figure 13, flow from Loomis Lake would only occur from the Great Lakes Basin toward the Mississippi River Basin.

There is also a small wetland area on the west end of Flint Lake that is connected with Flint Lake, and is surrounded by a mixture of thick vegetation and residential development. This wetland does not connect with Loomis Lake. The approximate boundaries of this wetland area are shown as the shaded area on Figure 11. These boundaries are only approximate and a wetland delineation was not performed as part of the site investigation.

For this pathway, the elevations in Figure 11 through Figure 13 are based on the USGS 10m Digital Elevation Model (DEM) with a vertical accuracy of +/- five feet (1.5 m). This level of accuracy may lead one to conclude that there is a high degree of uncertainty regarding the use of this elevation data. 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 (e.g., 600 feet (183 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 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.

Loomis Lake drains through an underground culvert (called the "principal spillway") out the southeast end of the lake which runs approximately 900 feet (274 m) to the east and then empties into Flint Lake. The cross section in Figure 11 is along the surface profile at this culvert location. This culvert connects Loomis Lake, which is in the Great Lakes Basin, with Flint Lake in the Mississippi River Basin. The inlet to the principal spillway is a drop structure with an outer and secondary trash rack constructed of vertical bars with approximately three inch (7.6 cm) wide openings (Figure 14). As shown in Figure 11, Loomis Lake is approximately 17 feet (5.2 m) higher in elevation than Flint Lake. The grated opening of the culvert inlet is about three feet wide and 2 feet (61 cm) tall. Flow drops vertically several feet into the culvert. The vertical drop inside the inlet structure could not be measured accurately, but is greater than four feet (1.2 m) and is estimated to be eight feet (2.4 m) or greater based on visual inspection. The downstream invert of the pipe is approximately at elevation 796.4 NAVD88 (PTGR, Inc., 1991). The diameter of the culvert is reported in different sources as either a 24 inch (61 cm) pipe or a 48 inch (122 cm) corrugated metal pipe (INDNR, 2006; PTGR, Inc., 1991). According to drawings with the Valparaiso Lakes Area Conservancy District, it is a 24-inch (61 cm) clay tile pipe (Minarich et al., 2011). During the site investigation it was not possible to confirm which of the above diameters is accurate since it was submerged.

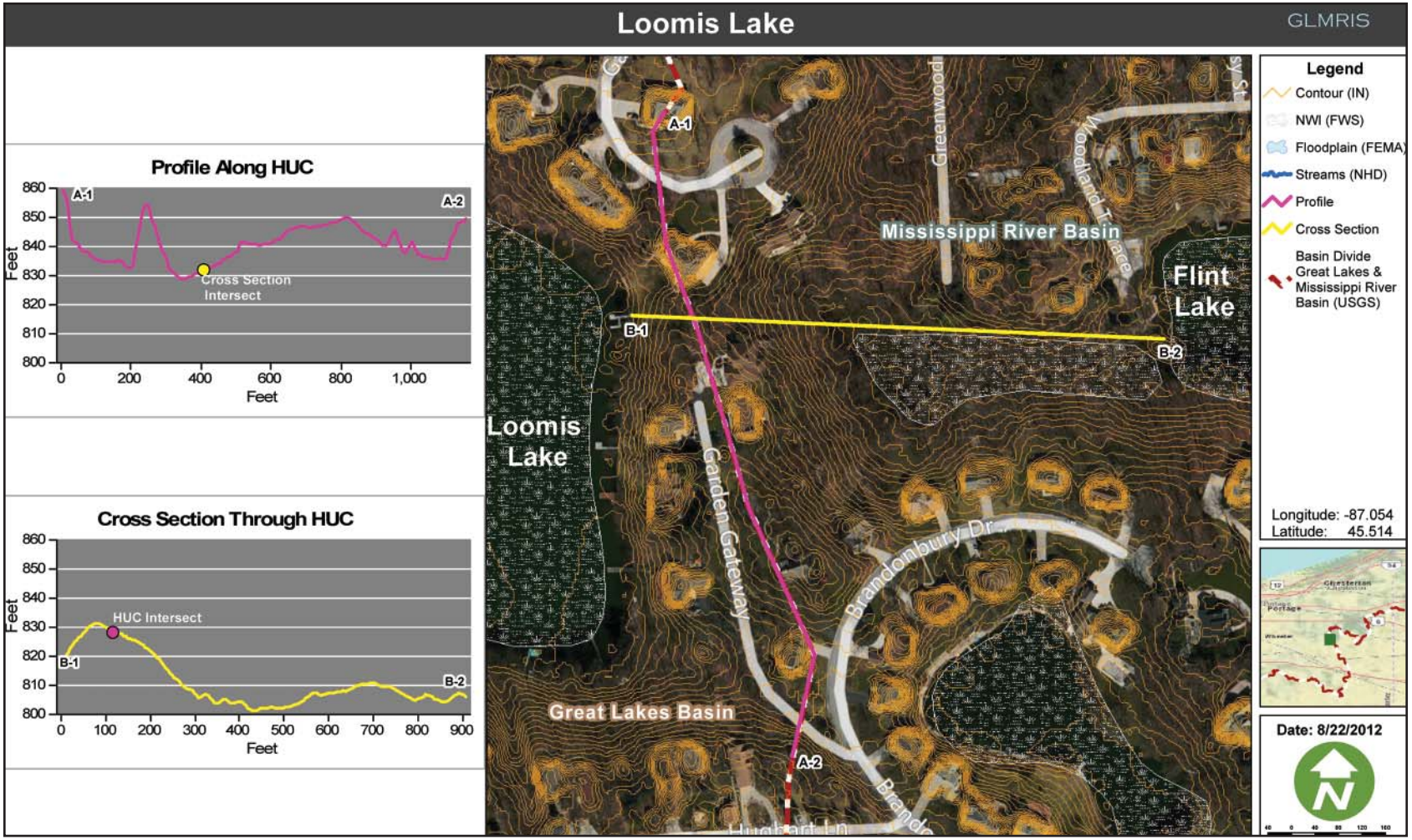


Figure 11. Location of cross-section through basin divide between Loomis Lake (left) and Flint Lake (right), based on 10m DEM, with a vertical accuracy of +/- 5 feet (1.5 m). The purple line in the aerial photograph and the graph on the top left is the profile along the basin divide. The yellow line that intersects the purple line in the photograph and graph on the bottom left is the cross sections through the basin divide along flow path between the two lakes. Shaded area represents potential wetland area connected with Flint Lake (approximate boundaries). Base imagery courtesy of Bing Maps.

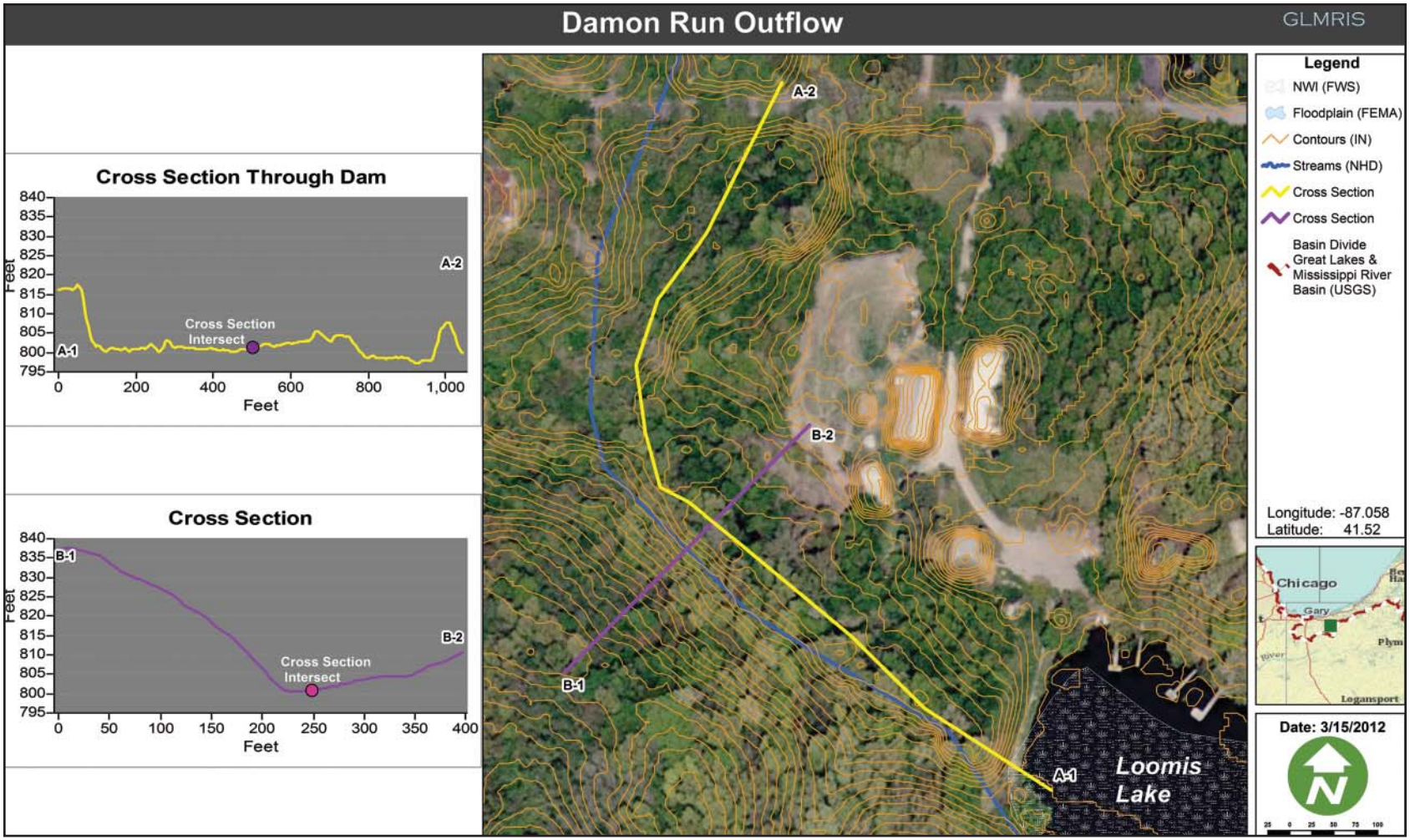


Figure 12. Location of Loomis Lake auxiliary outflow to Damon Run based on 10m DEM with a vertical accuracy of +/- 5 feet (1.5 m). The yellow line in the aerial photograph and the graph on the top left is the profile along Damon Run. The purple line that intersects the yellow line in the photograph and graph on the bottom left is the cross sections through the Damon Run profile. Base imagery courtesy of Bing Maps.

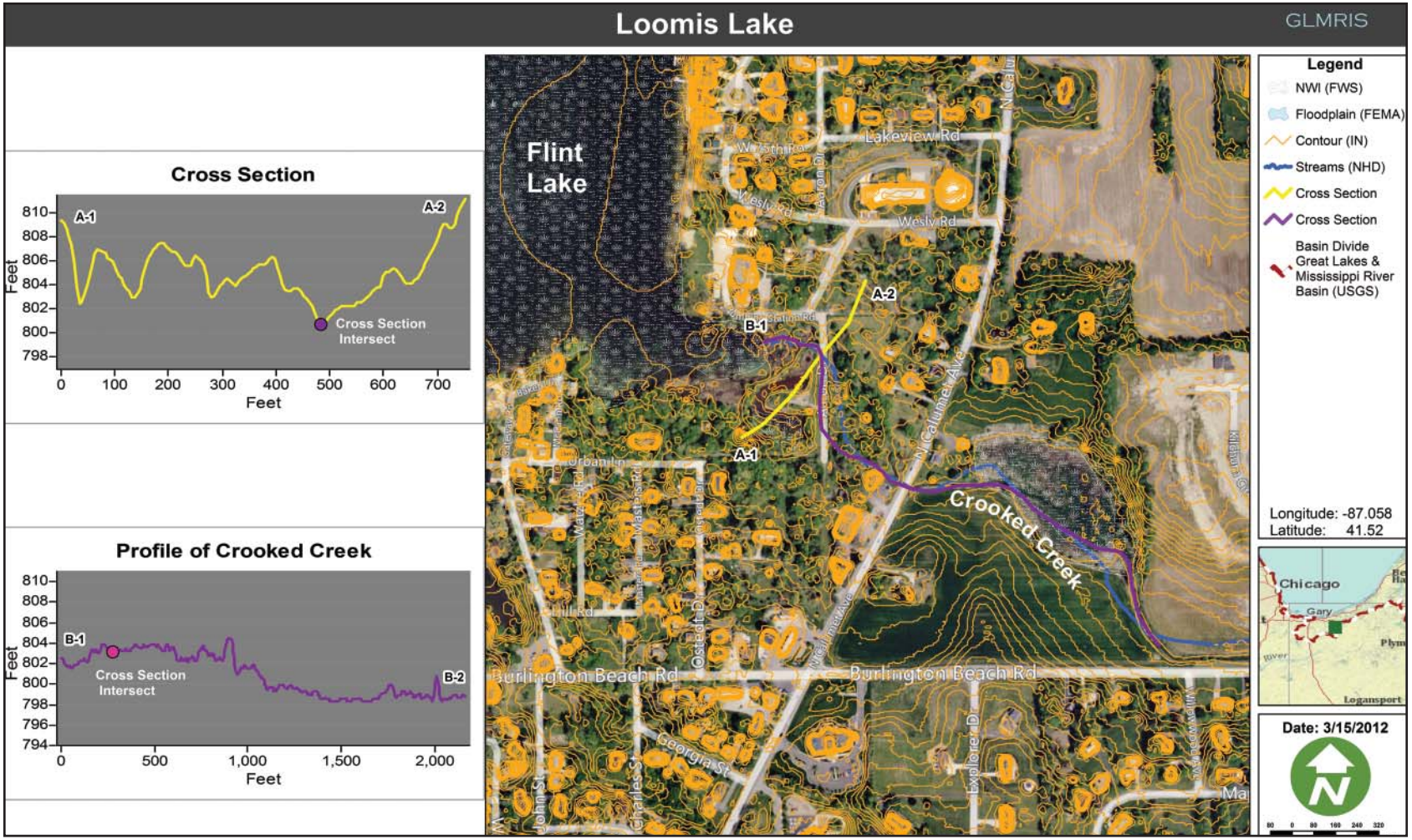


Figure 13. Location of profile along Crooked Creek downstream from Flint Lake based on 10m DEM with a vertical accuracy of +/- 5 feet (1.5 m). The purple line on the map and the graph on the bottom left is the profile along Crooked Creek. The yellow line that intersects the purple line on the map and graph on the top left is the cross section through Crooked Creek. Base imagery courtesy of Bing Maps.

Figure 14. Loomis Lake grated drop box inlet structure for culvert to Flint Lake. This is the inlet to the 900-foot (274m) long underground culvert, facing east. Photo by USACE.

Loomis Lake to Damon Run:

An approximately three foot (0.9 m) square concrete channel through Proffitts Dam serves as an auxiliary spillway for Loomis Lake, with an invert elevation of 813.6 feet, and top of spillway weir at elevation 814.5 feet (Figure 15). Water level in Loomis Lake must rise 0.8 feet (24 cm) to overtop the low weir. The frequency, depth, or duration of discharge to the Great Lakes Basin through this auxiliary spillway is not known. However, based on input from city officials during the site visit in June 2011, it is believed that overtopping of the low weir (not the dam itself) into the approximate three foot square concrete channel occurs on more than one occasion every year. Proffitts Dam itself has overtopping protection for any excessive flows leaving Loomis Lake that cannot be accommodated by both the principle and auxiliary spillways. City officials believe that overtopping does sometimes occur, but only during what they termed as “rare events.” The top of the steel grate of the Proffitts Dam emergency spillway conduit is at 816.6 feet, which is at an elevation approximately equal to top of dam. The dam is approximately 17 feet (5.2 m) high on the downstream side and 200 feet (61 m) wide, resulting in high velocity discharges through the spillway. Downstream of the dam, Damon Run is a heavily vegetated channel contained in a much wider valley (Figure 16). The profile of Damon Run downstream from the dam is shown on Figure 12 The profile line (yellow) on this figure does not match perfectly over the top of the stream line, and some downstream areas on Damon Run are actually shown as being higher in elevation than locations closer to the dam. This phenomenon is attributed to error in the data used for mapping and was not the situation as observed in the field. Accordingly, this figure should be utilized for gaining only a general understanding of the downstream profile trends away from Loomis Lake and not actual elevations.

Figure 15. Loomis Lake 3 foot (0.9 m) square (approx.) concrete channel auxiliary spillway to Damon Run, looking downstream; (Inset) Entrance to concrete channel of this auxiliary spillway at Loomis Lake. Photos by USACE

Figure 16. Damon Run downstream from Proffitts Dam. Photo by USACE.

Flint Lake to Crooked Creek:

Flint Lake drains to Crooked Creek by way of two 24-inch (61 cm) diameter corrugated metal pipes (Figure 17). The downstream end of these pipes is approximately one foot (30 cm) higher than the Crooked Creek channel bottom, thereby likely precluding most if not all aquatic species from being able to swim from Crooked Creek into Flint Lake via these two pipes. In addition, since Flint Lake is the primary source of water for Crooked Creek at this point with no other tributaries nearby, it would be highly unlikely for any backwater flow conditions to develop that could reduce or eliminate this one-foot vertical drop between the pipe and the stream.

Figure 13 presents the approximate ground elevations in the vicinity of the Flint Lake outflow as well as downstream in Crooked Creek. The profile along Crooked Creek in this figure (graph at bottom left) indicates the general downhill path for water exiting from Flint Lake as it descends approximately five feet (1.5 m) over about 2,000 feet (610 m) horizontally. Although some downstream areas appear to be at an equal or slightly higher elevation than the lake itself. This phenomenon was not observed in the field and is attributed to error in the vertical accuracy of the mapping data. What is more important than the actual elevations on this map is the overall trend in the stream profile as it descends away from Flint Lake. This helps to confirm that backflow from the creek into Flint Lake is not possible during high water events.

Figure 17. View of outflow from Flint Lake (left photo) into Crooked Creek (right photo), taken June 20, 2011by USACE during site investigation. Arrows in left photo indicate direction of flow.

3.4 Groundwater

A groundwater section is included in this report since groundwater can sometimes be a source of base flow for streams. Water levels in aquifers normally fluctuate seasonally in response to variations in groundwater 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 snowmelt and higher groundwater conditions, might result in higher volumes of water discharging from Loomis Lake to Flint Lake, from Flint Lake into Crooked Creek, and possibly from Loomis Lake to Damon Run through the auxiliary spillway.

With the exception of Loomis Lake, the Valparaiso Lakes are glacial features. The lakes are a series of kettle lakes that were formed by ice blocks trapped in the end moraine of retreating glaciers. As these ice blocks melted the resulting meltwater created kettle shaped lakes dotting the landscape. Based on this origin, the lakes are likely fed by both surface runoff and groundwater inputs (JFNew, 2006).

Water levels in Loomis Lake are the key driver in the amount of flow between Loomis Lake and Flint Lake, as well as whether or not the auxiliary spillway is used. These water levels appear to be influenced predominantly by precipitation amounts and inflow from Spectacle Lake to the west. However, groundwater may help to maintain the lake levels and flow duration through the principle spillway during periods of little to no precipitation. As the hydraulic connection between Loomis Lake and Flint Lake is an intermittent surface water connection (i.e., primary spillway to a 900-foot (274m) long culvert), groundwater conditions within the area are not likely to be a significant factor influencing Loomis Lake water levels and were therefore not further evaluated for this site

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 dispersal, reproductive patterns, and abilities to survive and establish populations in various areas. For example, given that the area is subjected to freezing temperatures on an annual basis for several months, biological activity and water flow would be somewhat restricted on a temporal basis since water (at least on the surface) would be frozen and the movement of any ANS would be restricted.

At the time of this report, detailed information such as high water marks, gage records, or similar data regarding storm events were not available that could be used to obtain the frequency for flooding events; therefore, quantifying the exact frequency and volume of the hydraulic connection between the basins is not possible at this time. It was communicated that flow is generally perennial from Loomis Lake into Flint Lake except during long periods of hot dry weather (Minarich, 2011).

Flows from Loomis Lake over the Proffitts Dam weir are likely to occur several times per year, but flows overtopping the crest of Proffitts Dam are rare. The most recent event that this occurred was during the September 2008 floods that were caused by the remnants of Hurricane Ike. Approximately 13 inches (33 cm) of rain fell on the Valparaiso area over several hours during this event and it was indicated by city officials that the dam was overtopped by three feet (0.9 m) or more at that time (Minarich et al., 2011). The precipitation for this event was reported as a 327-year event (0.3 percent annual recurrence interval) according to staff for the Valparaiso Lakes Area Conservation District (VLACD). More detailed information is not available, and there are no gages or other sources for such information. The roadways to the dam area were also reported as being impassable during this event. The likelihood of backwater flooding in the opposite direction, from Damon Run across Proffitts Dam into Loomis Lake, is also low. This is based upon findings during the site investigation

and visual inspection of the Damon Run channel which is relatively wide compared to the expected flows, and tailwater depths would be expected to be much less than the 17-foot (5.2 m) dam height under all flood frequencies. Actual elevations and probabilities cannot be calculated with the available data, but it if the dam was not inundated by backwater during the September 2008 flood event then the probability for inundation from this direction is extremely small.

Based upon available information for the primary spillway in Loomis Lake, analysis conducted by the USACE indicates that the connection from Loomis Lake to Flint Lake does appear to receive water from relatively small flows leaving the lake (Bentley Systems Incorporated, 2012). However, in order to provide a complete connection between the lakes it is estimated that the pool of Loomis Lake must increase at least 1.75 feet (53 cm) to initiate a sustained connection. During such a condition, the velocity in the culvert would be moderately high at roughly 7.5 feet per second (2.3 meters per second). Velocity of water in the culvert would increase as the height of water above the top of the pipe at the upstream end increases

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. A perennial surface water connection does exist between Loomis Lake within the Great Lakes Basin and Flint Lake in the Mississippi River Basin, based on the following

- Testimony of local area watershed managers and city officials that only small flows occur through the Proffitts Dam on an annual basis, linking Loomis Lake with the rest of the Great Lakes Basin;

- There is a permanent open spillway in Loomis Lake to allow headwater flooding in the Lake to flow toward Flint Lake through a 900-foot (274 m) long underground culvert when water levels in Loomis Lake rise at least 1.75 feet (53 cm). This flow is only from Great Lakes Basin to the Mississippi River Basin due to approximate 17-foot (5.2 m) elevation difference between the lakes over this 900-foot (274 m) culvert;

- Although small flows will periodically leave Loomis Lake through the Proffitts Dam toward the Great Lakes, flow in the opposite direction is deemed not possible due to the dam's height;

- Analysis of topographic and flow path GIS data shows there to be an obvious flow direction from Loomis Lake toward Damon Run in the Great Lakes Basin, from Loomis Lake toward Flint Lake, and from Flint Lake to Crooked Creek.

Due to the above evidence, the probability of a pathway existing from the Great Lakes to the Mississippi River Basins at Loomis Lake is rated as "medium" since it meets the criteria of an intermittent stream (in this case the 900-foot (274 m) culvert) that is capable of maintaining a surface water connection with both basins continuously for multiple days from a ten percent annual recurrence interval storm (Appendix A). This was not rated as high since there was uncertainty on the exact volume, frequency, and duration of flows going across this pathway. The rating for flow from the Mississippi River Basin toward the Great Lakes Basin was "low" as it is unlikely that water would be able to flow from Flint Lake toward Loomis Lake due to the approximate 17-foot (5.2 m) elevation difference between the two lakes, even though they are in fairly close proximity. However, if water from Flint Lake were somehow able to flow into Loomis Lake, there could at that point be an intermittent connection with the rest of the Great Lakes Basin via the outflow through the Proffitts Dam.

This rating for flow into the Mississippi River Basin is considered reasonably certain, and the rating for flow into the Great Lakes Basin is considered very certain because of the following:

- The exact volumes, frequency, and duration of flows through the 900-foot culvert are not known;

- Flint Lake is approximately 17 feet (5.2 m)

lower in elevation than Loomis Lake, with only about 900 feet (274 m) horizontally between the two lakes, making backflow from Flint Lake to Loomis Lake essentially impossible;

- There is some uncertainty related with the ground elevations as shown in the plan and profile figures for the three areas which have vertical accuracies of +/- five feet (1.5 m). This could be a contributing element to part of the Crooked Creek profile downstream of Flint Lake showing a slightly higher elevation than Flint Lake itself; and

- Proffitts Dam is about 17 feet (5.2 m) above the bed elevation of Damon Run, making any backflow from Damon Run (if it ever exists) unlikely to overtop this dam and reach Loomis Lake.

3.7 Aquatic Pathway Habitat

3.7.1 Terrestrial and Riparian Plants and Land Use

Loomis Lake provides 62 acres (25 ha) of various types of fish and wildlife habitat. The lake supports many different species of fish, birds, reptiles, amphibians, and invertebrates. The eastern and southern shores of Loomis Lake are mostly characterized as high to medium-density residential areas. The rest of the land surrounding the lake is mix of forest and open field. In some cases, there is little or no riparian habitat around the lake, especially in the residential areas on eastern shore.

3.7.2 Aquatic Resources

Loomis Lake would likely provide adequate food sources to harbor most of the invasive species of concern for this pathway. A variety of habitat types and a range of depths are also available in Loomis Lake, with most of the lake between five (1.5 m) and 20 feet (6 m) in depth, and a maximum depth of approximately 50 feet (15 m) (Figure 18). Habitat quality throughout the watershed would not likely be a deterrent for most ANS establishment requirements, as nuisance species are generally resilient, aggressive, and adaptable. Water quality in the Salt Creek Watershed within the Great Lakes Basin, of which Damon Run is a part, is considered to be impaired according to the Indiana Department of Environmental Management (IDEM) and is on the 303(d) list for E coli, biotic community impairment, and nutrient loading (e.g., nitrates, phosphorus, and sediment loading) (INDNR, 2011).

Aside from the principle spillway at the east end of Loomis Lake, Damon Run also periodically drains Loomis and Spectacle Lakes. According to the Salt Creek Water Management Plan, in 2000 the IDEM gave Damon Run a Qualitative Habitat Evaluation Index (QHEI) score of 61 (out of a possible score of 100), a ten point drop compared to its 1990 score (Salt Creek Management Plan, 2008). A decrease in substrate quality encompassed the most substantial distinction between the two sampling events. The poor substrate and lack of riffle development limits stream habitat quality in Damon Run. The Salt Creek Water Management Plan stated the following regarding habitat quality in the watershed:

> *"During the 2006 biotic community assessment/ intensive survey, QHEI scores ranged from 22 to 69, with a geometric mean of 43. Most of the sites (25 of 43 assessed) rated scores lower than the threshold (51) at which Indiana considers stream habitat to be poor. Common limitations for habitat quality included poor substrate, lack of instream cover, and lack of riffle development."*

When assessed in August 2006, physical habitat was good in Damon Run compared to other areas within the Salt Creek Watershed. The site rated a QHEI score of 55. Fish communities were also good compared to other sites, but still did not meet state standards. Eleven fish species were collected at Damon Run. However, tolerant species comprised 57.9 percent of the sample. The site rated an Index of Biological Integrity (IBI) score of 30, which placed the stream in the poor integrity class for the Central Corn Belt Region and was less than the value (36) at which IDEM considers streams to be non-supporting of its aquatic life use designation.

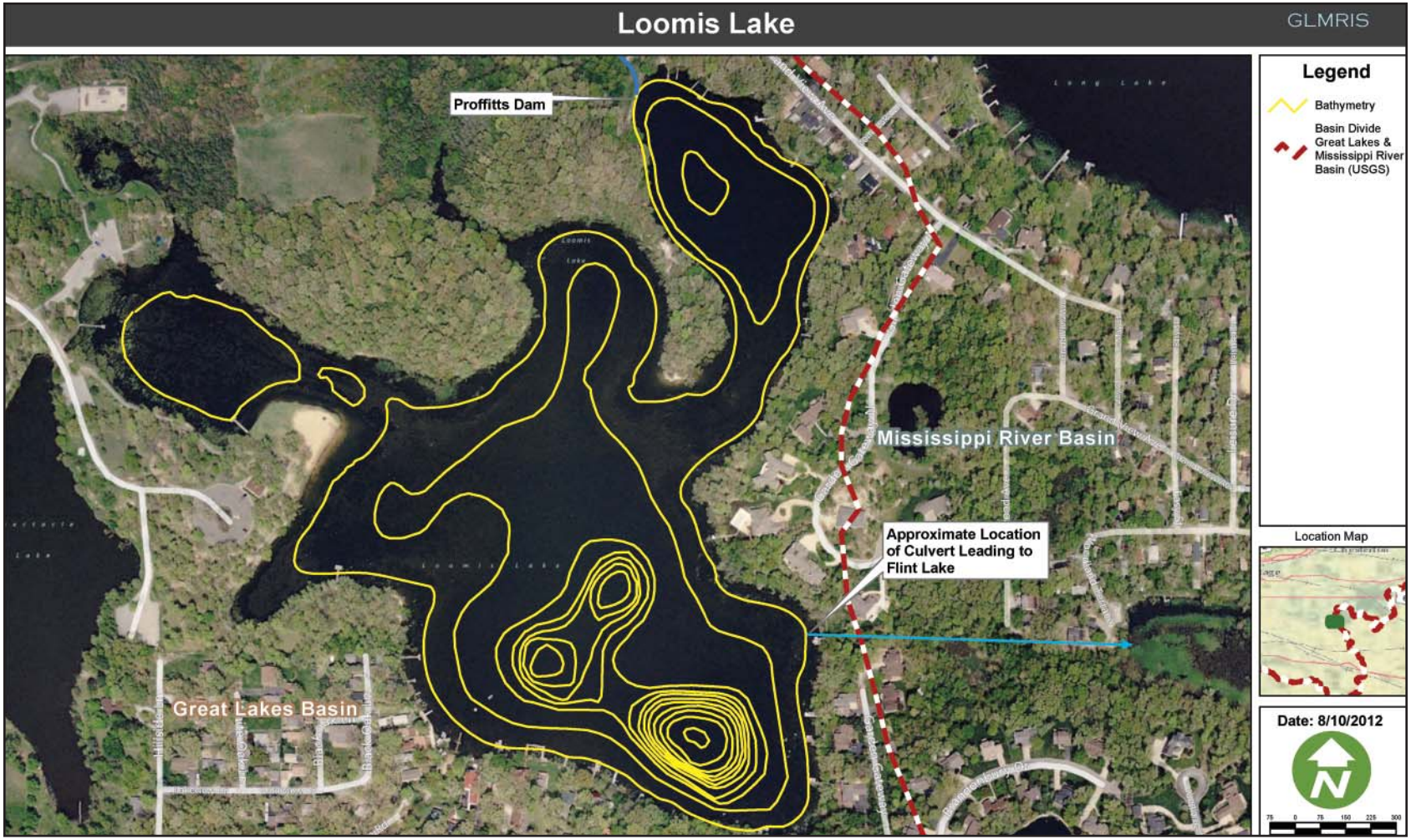


Figure 18: Bathymetry map of Loomis Lake provided by INDNR.

From Loomis Lake to the Mississippi River

Flint Lake is very similar to Loomis Lake and contains similar flora and fauna. The lake has a mean depth of 20 feet (6.1 m) and covers 86 acres (35 ha). Concentrations of mean total phosphorus in Flint Lake remain high enough to support substantial algal productivity and eutrophic conditions. Data from 2004 suggest that Flint Lake falls within the mesotrophic category according to the Indiana trophic state index (ITSI). However, using 2001 data Flint Lake falls within the hypereutrophic category of Carlson's TSI for total phosphorus (Save the Dunes Conservation Fund, 2008).

Water from Flint Lake empties into the West Branch of Crooked Creek which flows into Crooked Creek. Water then flows through Heinold Ditch before reaching the Kankakee River. These small tributaries of the Kankakee are generally shallow and exhibit poor habitat quality due to channelization and agricultural and urban run-off. The Kankakee River is an approximately 133-mile (214 km) long tributary of the Illinois River. Like many Midwestern basins, most of the Kankakee River Basin has been extensively drained. The natural flow-path of the Kankakee has been replaced by a series of canals and ditches. The main branch of the river lacks pools and riffles and is instead a continuous glide. A number of bayous are found along the river. Some remain connected to the river throughout the year while others are connected only during high water or not at all. Fish and wildlife figures indicate that of the 1,200 miles (1,931 km) of stream presently comprising the Kankakee and its minor tributaries, only 16 miles (26 km) remain in the natural state (Robertson, 1972).

The INDNR sampled the Kankakee River for habitat quality in 2001. Qualitative Habitat Evaluation Index scores for 11 stations sampled ranged from a high of 50 to a low of 30.5. Scores between 45 and 60 indicate fair aquatic habitat, and scores below 45 are poor habitat. The scores indicate that habitat is poor at five of 11 Kankakee River stations.

The Illinois River supports a diverse fishery, but is currently threatened by pollution and invasive species like Asian carp. The deposition of sediments into the basin's rivers has resulted in a loss of flow capacity, the filling of adjacent bottomland lakes and associated wetlands which are essential fish production areas, and has caused the smothering of valuable bottom-dwelling organisms and plants thus degrading quality habitat areas. The loss of depth and increased turbidity from the sedimentation threatens the present aquatic habitat and fisheries resources. In addition, the increased production of row crops and the practice of monoculture have resulted in a greater use of herbicides, insecticides and fertilizers. Many of the agricultural chemicals used are toxic to fish. Habitat quality is also diminished by numerous discharges from industrial and manufacturing operations within the basin, some of which have heavy metals, inorganic and organic chemicals, and oxygen demanding organic waste such as wood pulp fibers, canning, and dairy and food processing wastes.

From Loomis Lake to Lake Michigan

Upon exiting Loomis Lake through the Proffitts Dam outflow, an ANS would then enter Damon Run, which is a small tributary of Salt Creek. The water quality of Damon Run is moderately poor when compared to other streams in the Salt Creek Watershed. However, temperature, dissolved oxygen, pH, and conductivity measurements do not exceed Indiana water quality standards (Save the Dunes Conservation Fund, 2008).

After traversing Damon Run, an ANS would then enter Salt Creek. Land uses within the Salt Creek Watershed include agricultural, forest, grassland, residential, commercial, industrial, and recreational. The section of Salt Creek between Damon Run and the East Arm of the Calumet River has no listed impairments (Save the Dunes Conservation Fund, 2008). The section of Salt Creek upstream of the junction of Damon Run and Salt Creek is listed by the state of Indiana as having impaired biotic communities. Habitat in the reach of Salt Creek downstream of Damon Run is generally poor with low quality biological communities (IDEM, 2011). However this stretch of Salt Creek contains some of the highest quality habitat in the Salt Creek Watershed, and the Salt Creek mainstream is considered a cold water fishery (Save the Dunes Conservation Fund, 2008).

Salt Creek drains into the East Arm of the Little Calumet River. This river is largely protected as part of the Indiana Dunes National Lakeshore. Despite this designation, the East Arm of the Little Calumet River has several

advisories, including: Mercury Fish Consumption Advisory, PCB Fish Consumption Advisory, and Pathogens (USEPA, 2012). Some sections of the river contain habitat suitable for salmonids and the INDNR stocks the river with several species of salmonids (INDNR, 2012). Beaver have been detected in the river which may lead to improvements in habitat for a variety of aquatic organisms via the construction of beaver dams and the creation of ponds behind the dams (Whitaker, 1999; Pollock et al., 2003). The section of the East Arm of the Little Calumet River between Salt Creek and the Burns Ditch is approximately 1.5 miles (2.4 km) in length.

Upon exiting the East Arm of the Little Calumet River, an ANS would then need to travel through Burns Ditch which is a constructed diversion of the Little Calumet River into Lake Michigan near Portage, Indiana. Construction of the ditch drained most of the wetlands in the area leading to extensive development (Chicago Historical Society, 2005). Burns Ditch has poor water quality with unsafe levels of E. coli. The Indiana Geological Survey conducted an E. coli forecasting and modeling study at Burns Ditch and stated that "the Burns Ditch location was chosen because it is the outfall point for the largest watershed (Little Calumet drainage) contributing contaminated streamflow to Indiana's southern Lake Michigan" (Harper and Olyphant, 2010). Burns Ditch also has several impairments including Mercury Fish Consumption Advisory, PCB Fish Consumption Advisory, and Pathogens (IDEM, 2011). The distance between Burns Ditch and Lake Michigan is approximately 1.5 miles (2.4 km).

3.7.3 Water Quantity and Quality

According to the *Valparaiso Lakes Watershed Management Plan*, there has been a general increase in the lake's total phosphorus (TP) concentrations since baseline measurements were first taken in 1972 (JFNew, 2006). The data show a consistent pattern of lower TP concentrations in the surface, or epilimnetic waters, and higher concentrations in the bottom, or hypolimnetic waters. This suggests that phosphorus may be released from the sediments. Plankton density did not reflect the increases in TP concentrations, suggesting that the phosphorus entering the lake is mainly in the insoluble form rather than soluble forms which can be utilized by the phytoplankton. Though the ITSI score for 2001 places Loomis Lake in a mesotrophic category, the Carlson Trophic State Index for total phosphorus concentration in the same year places the lake in a hypereutrophic category. Hypereutrophic lakes are very nutrient-rich lakes that can be characterized by frequent and severe algal blooms and low transparency. These algal blooms can significantly reduce oxygen levels and prevent life from functioning at lower depths creating dead zones beneath the surface. Hypereutrophic lakes can be the most biologically productive lakes, and support large amounts of biodiversity (JFNew, 2006).

Lakeshore and stream bank erosion was identified as a problem in Loomis Lake by the *Valparaiso Lakes Watershed Management Plan*. Soil erosion is known to cause sediment and nutrient pollution and increase TP concentrations. Other types of non-point source pollution impacts indentified by the plan include septic systems, which can lead to toxic and bacterial pollution, in addition to nutrient loading.

The IDEM sampled Damon Run in 1990, twice in 2000, 2003, and again in 2006. Concentrations of *E. coli* were consistently high, exceeding the Indiana state standard (i.e., 235 CFU/100 ml) during each sampling event, and conductivity measurements were similarly high (IDEM, 2012). Flint Lake suffers from many of the same water quality issues like run-off and erosion that affect Loomis Lake. Both lakes suffer from anoxia in the hypolimnion (bottom layer of water), and since the lakes are connected, water quality parameters are also similar. Degraded water quality alone will likely not deter the establishment of ANS. One reason most invasive species are successful is the fact that they are able to tolerate a wider range of environmental parameters than native species occupying the same niche.

3.7.4 Aquatic Organisms

Loomis Lake supports a diverse plant community structure with thriving emergent, floating, and submerged zones. In portions of the lake, shoreline development has impaired the lake's emergent communities, limiting the emergent zone's size. While Loomis Lake does not

suffer from severe algal blooms as many ultra-fertile lakes, the abundant vegetation in the lake has been known to cause problems. Loomis Lake supports a warm water fishery that has been historically dominated by bluegill (*Lepomis macrochirus*). This skewing of the fish community structure toward bluegill (especially small bluegill) may be caused by the copious aquatic vegetation that persists in the lake. Abundant vegetation can make it difficult for predators, like the largemouth bass (*Micropterus salmoides*), to feed on the bluegill, and consequently cause overpopulation issues such as the stunted growth witnessed in Loomis Lake. It can also result in an unconsolidated lake bottom where only invertebrate and plant species that are very tolerant near anoxic conditions area able to survive.

Invasive plant species already established within and around Loomis Lake are partly to blame for the vegetation issues. Problematic exotic species found around and in the lake include purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), Eurasian water milfoil (*Myriophyllum spicatum*), and curly leaf pondweed (*Potamogeton crispus*), which is likely the most prolific exotic aquatic species in Loomis Lake. As in Loomis Lake, Flint Lake supports large beds of Eurasian water milfoil and curly leaf pondweed.

The Indiana Natural Heritage Data Center database lists five state endangered animal species as occurring in Porter County, Indiana. These include the least bittern (*Ixobrychus exilis*), black-crowned night heron (*Nycticorax nycticorax*), king rail (*Rallus elegans*), spotted turtle (*Clemmys guttata*), and Blanding's turtle (*Emydoidea blandingii*). There are also two plant species listed as state endangered: the forget-me-not (*Myosotis laxa*) and Vasey's pondweed (*Potamogeton vaseyi*). The database also lists Richardson's pondweed (*Potamogeton richardsonii*), a state threatened plant species, and pale duckweed (*Lemna valdiviana*), a state extirpated species, as occurring in the watershed.

The establishment of ANS within or around Loomis Lake may affect some listed species, even though some listed species in the area are terrestrial. Aquatic nuisance species are known to upset the balance of an ecosystem's food web dynamics, and sensitive species are usually the first to be affected. Aquatic nuisance species can ultimately negatively affect higher trophic levels in the food chain, by preying on lower level species or by outcompeting them for food or habitat.

3.8 Connecting Streams to Great Lakes and Mississippi or Ohio River

The connecting streams and/or water bodies downstream in both directions from Loomis Lake are as follows:

From Loomis Lake to Great Lakes: Damon Run ▶ Salt Creek ▶ East Arm Little Calumet River ▶ Little Calumet River ▶ Lake Michigan.

From Loomis Lake to Mississippi River: Flint Lake ▶ Crooked Creek ▶ Heinold Ditch ▶ Kankakee River ▶ Illinois River ▶ Mississippi River.

The Preliminary Risk Characterization included a compilation of the known potential obstacles to ANS movement via streams connected to the pathway at Loomis Lake (Table 7). From left to right, the table summarizes the impediments along the connecting streams from Lake Michigan up to the basin divide and down to the Mississippi River, then back up the connecting streams from the Mississippi River to the Basin Divide and back to Lake Michigan. In addition to the probable barriers listed below, the outlet structures for both Flint Lake and Loomis Lake likely serve as a barrier to the spread of ANS. Both Flint Lake and Loomis Lake drain into their receiving streams through culverts, or similar structures, through which it would be difficult for ANS to spread.

Table 7: Obstacles in connecting streams to ANS movement (NID, 2010; USACE, 2010).				
	Dispersal Difficulty from Great Lake to Location	**Dispersal Difficulty from Location to Mississippi or Ohio River**	**Dispersal Difficulty from Mississippi or Ohio River to Location**	**Dispersal Difficulty from Location to Great Lake**
Loomis Lake	Partially obstructed. NID show no dams, but completion of water column into Lake Loomis appears unlikely.	Minimally obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/max dam height of 30 feet.	Partially obstructed by 2 multi-purpose dams on Kankakee River and 7 locks and dams on the Illinois River w/max dam height of 30 feet.	Unobstructed. NID show no dams, but completion of water column out of Lake Loomis is likely very rare.

4 Aquatic Pathway Viability for ANS of Concern

The likelihood that a viable aquatic pathway exists at Loomis Lake, Indiana that would allow transfer of aquatic nuisance species (ANS) between the Great Lakes and Mississippi Rivers Basins was evaluated in accordance with the procedures outlined in the Methodology Section of this report. 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
- Probability target ANS survive transit to reach aquatic pathway
- Probability of ANS establishment at the aquatic pathway
- Probability of ANS spreading across aquatic pathway into new basin

A team probability and certainty rating is provided for each species for each category, as appropriate, and the rating represents the most conservative probability assessment for each category considered. Just as important as the subjective estimates of probability are the remarks that summarize the key data that supports the estimates, which were made by an interagency team of biologists for each ANS of concern to the Loomis Lake location. The completed forms, which include the probability and certainty ratings and the remarks from all agency professionals participating in this assessment, are included in Attachment A.

- 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

A team probability and certainty rating is provided for each species for each category, as appropriate, and the rating represents the most conservative probability assessment for each category considered. Just as important as the subjective estimates of probability are the remarks that summarize the key data that supports the estimates, which were made by an interagency team of biologists for each ANS of concern to the Loomis Lake location. The completed forms, which include the probability and certainty ratings and the remarks from all agency professionals participating in this assessment, are included in Appendix 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 Basin. Both silver carp and bighead carp have been recorded in significant numbers in the Illinois River. In the spring of 2011, an adult bighead carp was taken from the Kankakee River near Channahon, Illinois (CBS Chicago, 2011). Black carp may be established in portions of the lower Mississippi River Basin. The known distribution of black carp is not as extensive as that of the silver and bighead carp.

Team Rating: **High**
Certainty rating: Very Certain

Northern Snakehead

The northern snakehead was found in 2008 in Arkansas, and has since established a reproducing population in the area. This population is within the Mississippi River Basin and represents a population that could spread throughout the basin. Although in a different basin, this species is also established in the Potomac River in Maryland and Virginia (USGS, 2011). While this species is within the Mississippi River watershed, its population does not seem to be spreading at a high rate at this time and it is unlikely that it would reach the Loomis Lake divide location within the next 20 years without the assistance of some non-aquatic vector.

Team Rating: **Medium**
Certainty rating: Very Certain

Parasitic Copepod

The parasitic copepod has a life cycle in which the female adopts a parasitic phase on several fish species, including members of the minnow, sunfish, and catfish families, and potentially other fish species. The common carp (Cyprinus carpio) is a frequent host of this parasite (Hudson and Bowen, 2002). The females can detach and re-attach to host species. The invasive copepod has been detected in Lake Huron and Lake Erie, and is likely found throughout the Great Lakes. The common carp is established in Lake Michigan as well as the rivers and streams leading to Loomis Lake from Lake Michigan. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood it would use, and survive within, the pathway habitats. The parasitic copepod and a necessary host species are in the Great Lakes Basin. The males are free living but do not have the capability of dispersal upstream. The parasitic copepod is small and relatively easy to miss in field surveys, even by trained biologists. Therefore, the parasitic copepod may be much more prevalent than the distribution maps depict.

Team Rating: **Medium**
Certainty rating: Reasonably Certain

Viral Hemorrhagic Septicemia Virus

Viral hemorrhagic septicemia virus can infect a wide range of host fish species causing a variety of external and internal pathology, including death of the host fish. Variables such as the species of host fish 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 (USGS, 2011).

Viral hemorrhagic septicemia has been found in many species of fish including common carp. The common carp is established in Lake Michigan, as well as the rivers and streams leading to Loomis Lake from Lake Michigan. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood the common carp would use and survive in the pathway habitats. Viral hemorrhagic septicemia and a necessary host species are both within the Great Lakes Basin. It should also be noted that VHSv has 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, 2012).

Team Rating: **High**
Certainty rating: Very 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). 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 is an aggressive species that possesses the ability to feed in darkness, cold temperatures and turbid conditions. The ruffe has extended its range rapidly and modeling predicts it will find suitable habitat in all five Great Lakes (USGS, 2012). Literature reviews and actual fish survey data have not documented the collection of the ruffe in smaller upstream tributaries. The tubenose goby's introduced range includes Lake St. Clair, Erie, Huron, Superior, and Ontario and 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. 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 (USGS, 2011).

Team Rating: **High**
Certainty rating: Very Certain

Threespine Stickleback

The threespine stickleback is found in each of the Great Lakes (Lake Ontario HUC 8 records are within native range) and has been collected in some inland river systems (USGS, 2011). This species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers. The threespine stickleback was first encountered in lower Green Bay about 25 years ago, but has never been seen upstream from this area. Great Lakes populations of this species tend to be potamodromous (truly migratory but within fresh water only) and only enter the lower reaches of streams briefly during spring spawning.

Team Rating: **High**
Certainty rating: Very Certain

4.2 Probability ANS surviving transit to aquatic pathway

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

High - Target ANS are established in relatively close proximity to 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 location and have limited capability to survive passage 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.

Asian Carp

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 et al., 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).

However, the exact dispersal capability of these species 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 juveniles that have been witnessed in Midwestern rivers and their tributaries (Coulter and Goforth, 2012; D. Chapman, personal communication, September 12, 2011).

If Asian carp were able to arrive close to Flint Lake, the hydrologic connection at Loomis Lake is only from the Great Lakes Basin toward the Mississippi River Basin. Due to the obstructions of the Flint and Loomis Lake control structures, even the strongest swimmers could not spread into either lake on their own. There are also several in-stream dispersal obstructions within the Mississippi River Basin that provide a range of potential ANS dispersal obstructions. Therefore, there is a low probability that Asian carp would be able to find their way into Flint Lake or Loomis Lake solely through the aquatic pathway.

Team Rating: **Low**
Certainty rating: Very Certain

Northern Snakehead

The northern snakehead utilizes specialized structures (suprabranchial organ and a bifurcate ventral aorta) that permits aquatic and aerial respiration (Ishimatsu and Itazaw 1981, Graham 1997). This species thrives in stagnant, oxygen depleted back-waters and marshes (Courtenay, Jr. and Williams, 2004). The northern snakehead's preferred habitat is not flowing water, which may slow its spread up the Mississippi River and larger streams leading to the tributaries and eventually to Loomis Lake. Despite this information, the northern snakehead has been consistently caught by anglers in the Potomac River near Great Falls Virginia during spring high flow events (J. Newhard-USFWS, personal communication, December 22, 2011). Based on data from external tags recaptured by anglers, in rare instances northern snakehead have been found to move as far as 50 river miles (80 km) upstream at a rate of approximately one mile (1.5 km) per day. This extensive movement typically occurs in the spring with the fish returning back downstream to slower moving water in the summer (J. Newhard-USFWS, personal communication, December 22, 2011). If the Arkansas population does begin to expand into and up the Mississippi River, the locks and dams within the Mississippi River Basin and the control structures in Flint and Loomis Lakes would prevent even the strongest swimmers from reaching the pathway. Therefore, there is a low probability that northern snakehead would be able to find their way into the pathway from the Mississippi River Basin.

Team Rating: **Low**
Certainty rating: Very Certain

Parasitic Copepod

The parasitic copepod has been found on the common carp, and the common carp was therefore used as the surrogate species potential host for the parasitic copepod for the evaluation of the likelihood of the copepod to reach the Mississippi River Basin through the Loomis Lake aquatic pathway. During spring run-off events typically in April and May, common carp move into the shallow waters of bays and river systems to spawn. Within the rivers, common carp move upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as a one foot or less of water depth. Common carp are strong swimmers and though they cannot jump like members of the salmon family, they can move upstream during moderate flow events. The only obstruction for a potential host fish to reach Loomis Lake is the Proffitts Dam at the head of Damon Run. As there is an approximate 17-foot (5.2 m) elevation difference between the bed of Damon Run and the top of the dam, back flooding and subsequent overtopping of the dam into Loomis Lake would be highly unlikely. Accordingly, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Viral Hemorrhagic Septicemia Virus

In addition to the parasitic copepod, common carp is also a potential host for viral hemorrhagic septicemia (USGS, 2011). The common carp was therefore used as a surrogate potential host to estimate the probability of VHSv moving from its current location in the Great Lakes Basin to the Loomis Lake aquatic pathway. During spring run-off events in April and May, common carp move into the shallow waters of bays and river systems to spawn. Within the rivers, common carp move upstream to spawn in suitable habitat such as marshes and even drainage ditches with as little as one foot or less of water depth. Common carp are strong swimmers and though they cannot jump like members of the salmon family, they can move upstream during moderate flow events. The only obstruction for a potential host fish to reach Loomis Lake is the Proffitts Dam at the head of Damon Run. As there is an approximate 17-foot (5.2 m) elevation difference between the bed of Damon Run and the top of the dam, back flooding and subsequent overtopping of the dam into Loomis Lake would be highly unlikely. Accordingly, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Ruffe and Tubenose Goby

The ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel, 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). The ruffe has a high fecundity rate and spawns in clean water. 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). The ruffe's ability to swim upstream during high flow events and move over dams is questionable, especially since it prefers still or slow moving water (Fishbase, 2011). The tubenose is found in the open waters and estuaries of slow flowing rivers. The tubenose goby appears to be more capable of living in more diverse types of riverine habitat than the ruffe (Dopazo et al., 2008; Jude and DeBoe, 1996). Sufficient forage ranging from zooplankton to fish may be available throughout the Great Lakes side of the connection. However, suitable habitat for the ruffe and tubenose goby in Salt Creek may be limited or even nonexistent.

The only obstruction for either of these species to reach Loomis Lake is the Proffitts Dam at the head of Damon Run. As there is an approximate 17-foot (5.2 m) elevation difference between the bed of Damon Run and the top of the dam, back flooding and subsequent overtopping of the dam into Loomis Lake would be highly unlikely. Accordingly, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

Threespine Stickleback

The only obstruction for this species to reach Loomis Lake is the Proffitts Dam at the head of Damon Run. As there is an approximate 17-foot (5.2 m) elevation difference between the bed of Damon Run and the top of the dam, back flooding and subsequent overtopping of the dam into Loomis Lake would be highly unlikely. Accordingly, a rating of low was assigned.

Team Rating: **Low**
Certainty rating: Very Certain

4.2.2 Probability of ANS Surviving Transit to Aquatic Pathway through Other Means

This section does not influence the overall pathway rating outlined in this report and is only included to point out other potential pathways (e.g., anthropogenic) that may be important to different audiences. Any further analysis of 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 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 at locations in close enough proximity to the location and have limited capability to survive passage 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, Northern Snakehead, Parasitic Copepod, VHSv, Threespine Stickleback, and Ruffe/ Tubenose Goby

It is likely that most of the ANS of concern could become established in, and spread from Loomis Lake if they were introduced from sources such as aquaculture operations or exotic pet trade, bait bucket transfer, bilge releases, contaminated tackle, wading birds, and other natural and anthropogenic vectors. Loomis and Flint Lakes provide a variety of habitat types that are suitable for most of the ANS considered in this evaluation. One

reason most invasive species are successful is the fact that they are able to survive and reproduce in a wide range of environmental conditions. The motivation for anthropogenic introductions range from accidental to intentional and malicious. Public education regarding the detrimental impacts of ANS and how to prevent their spread are likely the best tools to prevent anthropogenic transfer from occurring. Because of the recreational use of the Valparaiso Lakes, including Loomis and Flint Lakes, there is some residual probability associated with the interbasin transfer of ANS due to it their location along the basin divide.

Team Rating: **Medium**
Certainty rating: Reasonably Certain

4.3 Probability of ANS Establishment at 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 the target 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.

Team Rating: Species-specific ratings for this section were not completed because the ratings for the likelihood that any of the ANS of concern for Loomis Lake would be able to survive transit from their current locations in either basin to the pathway were all low.

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.

Team Rating: Species-specific ratings for this section were not completed because the ratings for the likelihood that any of the ANS of concern for Loomis Lake would be able to survive transit from their current locations in either basin to the pathway were all low.

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 Loomis Lake 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 8 and Table 9). 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 8. At the Loomis location, all four species were rated "low"

Table 8. Summary of individual probability elements and overall pathway viability rating (Mississippi River Basin to Great Lakes Basin). Certainty ratings for each element are in parentheses.

			Form 1 (P_0)	Form 2 (P_1)	Form 3a (P_{2a})	Form 4 (P_{2b})	Form 5 (P_{2c})	$P_{Viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 3.6)**	**ANS Occurring Within Either Basin? (Sect. 4.2.1)**	**ANS Surviving Transit to Pathway? (Sect. 4.2.1)**	**ANS Establishing at Pathway? (Sect. 4.3)**	**ANS Spreading Across Aquatic Pathway into New Basin? (Sect. 4.4)**	**Aquatic Pathway Viability Rating**
fish	*Asian Carp* *silver carp, bighead carp, black carp*	swimmer	L (VC)	L (VC)	L (VC)	NN[1]	NN	L
fish	*northern snakehead*	swimmer		M (VC)	L (VC)	NN	NN	L
Overall Pathway Viability for Spread of ANS from Mississippi River Basin to Great Lakes Basin:								**L**

Note: 1: Not Necessary

Table 9. Summary of individual probability elements and overall pathway viability rating (Great Lakes Basin to Mississippi River Basin). Certainty ratings for each element are in parentheses.

			Form 1 (P_0)	Form 2 (P_1)	Form 3a (P_{2a})	Form 4 (P_{2b})	Form 5 (P_{2c})	$P_{Viable\ pathway}$
Group	**Common Name**	**Mode of Dispersal**	**Pathway Exists? (Sect. 3.6)**	**ANS Occurring Within Either Basin? (Sect. 4.1)**	**ANS Surviving Transit to Pathway? (Sect. 4.2.1)**	**ANS Establishing at Pathway? (Sect. 4.3)**	**ANS Spreading Across Aquatic Pathway into New Basin? (Sect. 4.4)**	**Aquatic Pathway Viability Rating**
fish	*threespine stickleback*	swimmer	M (RC)	H (VC)	L (VC)	NN	NN	L
fish	*Benthic fish* *ruffe and tubenose goby*	swimmer		H (VC)	L (VC)	NN	NN	L
copepod	*parasitic copepod*	parasite		M (RC)	L (VC)	NN	NN	L
virus	*VHSv*	fish pathogen/ water column		H (VC)	L (VC)	NN	NN	L
Overall Pathway Viability for Spread of ANS from Great Lakes Basin to Mississippi River Basin:								**L**

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 same way and is shown in Table 9. At the Loomis Lake location, the overall pathway viability for transferring species from the Great Lakes Basin to the Mississippi River Basin is “low”. 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 8 and 9. Thus, the overall probability that a viable aquatic pathway exists at the Loomis Lake Pathway is “low”

6 Conclusions

The overall viability of the Loomis Lake aquatic pathway to facilitate the interbasin spread of ANS was determined to be low by an interagency team because no species was found capable of being able to reach Loomis Lake solely through the aquatic pathway. However, should an ANS be introduced into Loomis Lake or Spectacle Lake, it would likely then be able to spread into the Mississippi River Basin through the primary spillway from Loomis Lake into Flint Lake. Once in Loomis Lake, it may also be possible for ANS to then spread into the Great Lakes Basin through the auxiliary spillway (Proffits Dam) to the headwaters of Damon Run, but only during more significant flooding events when the spillway might be used. One way ANS could be introduced to either Spectacle Lake or Loomis Lake is through the release of live bait, which may inadvertently contain ANS. Another is by ANS attachment to recreational boats and other portable marine equipment while in one basin, which are then transported over land and placed into either lake. Direct human release of imported aquaria fish or other exotic species into Loomis or Spectacle Lakes could also likely result in the spread of ANS into the Mississippi River Basin and perhaps the Great Lakes Basin. So while the viability of the aquatic pathway at Loomis Lake to facilitate the interbasin spread of ANS is low, it is at a unique geographic location where development and implementation of some site specific measures may be appropriate.

6.1 Loomis Lake Opportunity Statements

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 spreading between the basins at the Loomis Lake site. The opportunities listed below are not necessarily specific to the Loomis Lake location and they are also not specific to the USACE authorities, but incorporate a wide range of possible applicable authorities, capabilities, and jurisdictions at the Federal, State, and local levels and include some more regional opportunities:

- Prevent introductions of additional ANS by exploring legislative prevention measures, and for prohibiting the establishment of drainage ways that would connect the Mississippi River tributaries with Great Lakes tributaries.
- There are broad categories of technology for potential active measures to prevent ANS transfer at this locations, such as:
    - Chemical deterrents in order to reduce habitat 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
    - Physical removal of ANS at their current locations
    - Increase commercial and recreational harvest, specifically of bighead and silver carp
- Public education 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
- Take ANS transfer potential into account for proposed water resource projects (e.g., ecosystem restoration, dam removal, stream restoration, water management).
- 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 integrated ANS sampling and analysis plan utilizing eDNA and conventional biological sampling events at 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 Indiana to identify, report, collect, and deliver ANS to the appropriate agencies
- Prevent introductions of additional ANS by exploring prevention measures:
    - Improve or new regulations for bilge releases
    - Improve or new regulations on the pet industry
    - Improve or new regulations on the live bait industry
    - Improve or new 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 the Loomis Lake location would likely benefit from corresponding development and implementation of one or more of the other types of opportunities identified. The results of this assessment may also aid in the implementation of, and future updates to, the Indiana Aquatic Nuisance Species (ANS) Management Plan.

7 References:

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Loomis Lake Report

November 2012

Appendix A

Evaluation Forms for each ANS of Concern Selected for Loomis Lake

Loomis Lake Report

November 2012

Loomis Lake Report

November 2012

Parker-Cobb Ditch, Porter County, IN - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Asian Carp

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	VC		
	USACE, Louisville - Biologist	High	RC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	RC		
	Team Rating	**High**	**VC**		

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 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.

	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 and bighead carp are established throughout the Mississippi River Basin. Both silver carp and bighead carp have been recorded in significant numbers in the Illinois River. In the Spring of 2011, an adult bighead carp was taken from the Kankakee River near Channahon, Illinois (CBS Chicago, 2011). Black carp may be established in portions of the lower Mississippi River Basin. The known distribution of black carp is not as extensive as that of the silver and bighead carp.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	Low	RC	Low	RC
	USACE, Louisville - Biologist	Medium	RC	Medium	RC
	USACE, Detroit - Biologist	Medium	RC	Low	RC
	Indiana DNR - AIS Coordinator	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 passage 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.

Spawning and the subsequent migration of silver and bighead carp is initiated by rising water levels following heavy rains (Jennings, 1988; Verigin, 1978). Both species are strong swimmers and silver carp are capable of jumping considerable distances out of the water. There are no obstacles in the Kankakee that would permanently prevent upstream migration of Asian carp. In addition to some low head dams, there are two substantial dams on the Kankakee River that are inundated at very high flows (Section 2.7). Asian carp in the Mississippi River Basin might be able to bypass these dams during high flow events when they become completely inundated. The proximity of the silver and bighead carp to the Parker-Cobb Ditch pathway (lower Kankakee River), combined with their history of dispersal throughout the Mississippi River Basin, indicates that these species are likely capable of utilizing this pathway if hydrological conditions allow. Habitat present within most of Sandy Hook Ditch and Cobb Ditch is not ideal habitat for silver and bighead carp which thrive in large rivers, but there is a slight level of uncertainty regarding to what extent this poor habitat quality may prevent movement of Asian carp through the network of connecting ditches. While both species are highly opportunistic, 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). Sufficient forage is available throughout the Kankakee River for adult silver and bighead carp. Forage abundance, diversity, water quality, and water volume all decreases as one moves up Sandy Hook Ditch and into Cobb Ditch.

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 et al, 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)."

Juvenile Asian carp have been observed in the upmost reaches of small tributaries to large rivers attempting to pass over in-stream barriers (e.g., dams) to continue their upstream movement (D. Chapman, personal communication, September 12, 2011; N. Caswell, U.S. Fish and Wildlife Service, September 12, 2011). It is unknown if Asian carp would be likely to spread into Sandy Hook Ditch. Sandy Hook Ditch is a small tributary with limited habitat for adult Asian Carp. It shares several characteristics (e.g., small size, located high in the watershed) with the Graham McCulloch Ditch in Fort Wayne, Indiana which has been tested for Asian carp using an environmental DNA (eDNA) sampling technique in the fall of 2010 and during the early summer of 2011, all with negative results (D. Keller, IDNR, personal communication, August 16, 2011).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). While newly hatched fry are not known to move significant distances upstream, they may move long distances up small tributaries and side channels in the vicinities of where they hatch. It has also been noted that 12-18-inch Asian carp have been known to travel long distances, throughout river systems, for no apparent reason (D. Chapman, personal communication, September 12, 2011). Adult, sexually mature Asian carp have also been found in very small streams (D. Chapman, personal communication, September 12, 2011). While on-going research by IDNR may suggest adult Asian carp have no interest in spreading into small ditches and streams from more suitable areas, more long term studies are needed, and even these may not help explain the seemingly random movements of juveniles that have been witnessed (D. Chapman, personal communication, September 12, 2011 and D. Keller, IDNR, personal communication, August 16, 2011). The ability of Asian carp to arrive at the Parker-Cobb Ditch aquatic pathway location was given a rating of low for several reasons: (1) the presence of dams on the Kankakee River prevent the upstream movement of Asain Carp in all but the most severe flood events (Section 2.6), (2) the Kankakee River floods across a large food plain and the velocity of the Kankakee River during these events is low, which may be inadequate to trigger a spawing run by Asian carp in the upper Kankakee River, and (3) the lack of suitable spawning habitat for adult Asian carp in the Ditches leading to the pathway further inhibit the upstream movement of Asian carp to the Parker-Cobb Ditch pathway. All these elements combined make it unlikely that Asian carp will be able reach this pathway location within the next 50 years.

Parker-Cobb Ditch, Porter County, IN - Asian Carp

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	Medium	RC		
	Indiana DNR - AIS Coordinator	Medium	RC		
	Team Ratings	**Medium**	**RC**		

4. How do you rate the probability of ANS establishing at 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: Silver and bighead carp are fast growing species that are capable of surviving in a wide range of water temperatures and reproducing quickly, providing suitable habitat is available. In some stretches of the Illinois River, silver and bighead carp make up as much as 90% of the biomass. It's believed that silver and bighead carp require sufficient flow to keep fertilized eggs suspended for successful reproduction (Gorbach and Krykhtin 1980). Black carp reach sexual maturity in as little as 5 years and adult females can produce up to one million eggs per spawning event. It is unlikely that spawning, of any of the Asian Carp species, would occur within most of streams in the Park-Cobb pathway due to the small sizes of the streams (Cobb Ditch, Sandy Hook Ditch). It is not know if the Kankakee River offers suitable habitat for Asian Carp spawning. The flow of Parker and Cobb ditch, at the connection location, is often sluggish and the ditches are generally shallow. During periods of prolonged cold weather, as is common in this area, the water in the connection may freeze solid. Additionally, during the summer months the water in the connection often becomes stagnant, depleted of oxygen, and very shallow. The conditions at the area of the watershed connection would make it exceptionally difficult for an adult Asian Carp to survive in the area year-round.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	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: Asian carp have demonstrated exceptional capabilities of spreading through large river systems, and will likely continue to do so. If Asian carp are able to establish in the area ditches, then will likely then be able to spread past the Parker-Cobb Ditch connection into the Great Lakes Basin.

Parker-Cobb Ditch, Porter County, IN - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Northern Snakehead (*Channa argus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	MC		
	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 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.

	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 was found in 2008 in Arkansas, and has since established a reproducing population in the area. Although in a different basin, this species is also established in the Potomac River in Maryland and Virginia (USGS, 2011). While this species is within the Mississippi River watershed, its population does not seem to be spreading at a high rate at this time and it is unlikely that it would reach the Parker-Cobb Ditch divide location within the next 20 years without the assistance of some non-aquatic vector.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	Medium	MC	Low	RC
	USACE, Louisville - Biologist	Low	MC	Medium	RC
	USACE, Detroit - Biologist	Medium	RC	Low	RC
	Indiana DNR - AIS Coordinator	Medium	RC	Low	RC
	Team Ratings	**Medium**	**MC**	**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 passage 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.

As obligate air breathers, northern snakeheads obtain required oxygen directly from the atmosphere. This species thrives in stagnant, oxygen depleted back-waters and marshes (Courtenay, Jr. and Williams, 2004). The northern snakehead likely possesses the ability to migrate to the Parker Cobb Ditch pathway through the interconnecting network of ditches. However, its preferred habit is not flowing waters, which may slow its spread up the Mississippi River and to the tributaries connecting to Parker-Cobb Ditch.

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

Fishing and boating are unlikely to occur in the Parker-Cobb Ditch area. The ditches are too small to support sport fishing and are also too small for boating or kayaking. The small size of the ditches virtually eliminates the threat of ANS transfer via water craft, associated equipment, or fishing gear.

Parker-Cobb Ditch, Porter County, IN - Northern Snakehead (*Channa argus*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	High	MC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	High	RC		
	Team Ratings	**High**	**MC**		

4. How do you rate the probability of ANS establishing at 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 and temperature tolerance indicates a species that could establish populations throughout most of the contiguous United States (Courtenay, Jr. and Williams, 2004). Northern snakeheads are naturally aggressive predators that could easily acclimate to the conditions in and around Parker-Cobb Ditch as long as there is an ample food supply, which is likely to be the case. They can be very opportunistic in their feeding habits, preying on everything from insect larvae to fish, frogs, and crustaceans.

Parker-Cobb Ditch, Porter County, IN - Northern Snakehead (*Channa argus*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	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: It is very likely that the northern snakehead possesses the ability to spread into the Great Lakes Basin from Parker-Cobb Ditch if a population were established near that location.

Parker-Cobb Ditch, Porter County, IN - Parasitic Copepod (*Neoergasilus japonicus*)

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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Parasitic Copepod (*Neoergasilus japonicus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Louisville - Biologist	High	VC		
	USACE, Detroit - Biologist	Medium	RC		
	Indiana DNR - AIS Coordinator	Medium	MC		
	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 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.

	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 common carp (*Cyprinus carpio*) is a frequent host of the parasite. The common carp is established in Lake Michigan, as well as the rivers and streams leading to Parker-Cobb Ditch from Lake Michigan. While other host fish species are known to exist in the pathway system, the common carp was selected as the most likely host species because of the life cycle capabilities of the common carp and the likelihood the common carp would use, and survive within, the pathway habitats. The parasitic copepod species and a necessary host species are in the Great Lakes Basin.

Parker-Cobb Ditch, Porter County, IN - Parasitic Copepod (*Neoergasilus japonicus*)

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, Louisville - Biologist	Medium	MC	Low	MC
	USACE, Louisville - Biologist	Medium	MC	Medium	MC
	USACE, Detroit - Biologist	Medium	RC	Low	RC
	Indiana DNR - AIS Coordinator	Medium	MC	Medium	MC
	Team Ratings	**Medium**	**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 passage 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 parasitic copepod has been found on the common carp, and the common carp was therefore used as a surrogate potential fish host to estimate the probability of the parasitic copepod moving from its current location in the Great Lakes Basin to the Parker-Cobb Ditch pathway location. It is possible that common carp could migrate to the watershed divide since it is a very resilient species that is capable of surviving a wide range of water quality parameters.

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

Fishing and boating are unlikely to occur in the Parker-Cobb Ditch area. The ditches are too small to support sport fishing and are also too small for boating or kayaking. The small size of the ditches virtually eliminates the threat of ANS transfer via water craft, associated equipment, or fishing gear.

Parker-Cobb Ditch, Porter County, IN - Parasitic Copepod (*Neoergasilus japonicus*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Detroit - Biologist	Medium	RC		
	Indiana DNR - AIS Coordinator	High	RC		
	Team Ratings	**High**	**MC**		

4. How do you rate the probability of ANS establishing at 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 parasitic copepod is very capable of persisting in eutrophic and polluted waters (USGS, 2011). The copepod demonstrates a rapid reproductive cycle and is capable of utilizing many different host species. It is likely that the copepod would be successful in establishing in Parker-Cobb Ditch and connecting tributaries since numerous potential host fish species such as common carp can be present in the area.

Parker-Cobb Ditch, Porter County, IN - Parasitic Copepod (*Neoergasilus japonicus*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	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: The copepod could easily spread beyond the pathway location into the Mississippi River Basin. The female copepod can detach and re-attach to another host fish. Potential host fish for this species are present throughout the connecting streams between Cobb Ditch and the Mississippi River.

Parker-Cobb Ditch, Porter County, IN - Viral Hemorrhagic 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Viral Hemorrhagic Septicemia virus (VHSv)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	VC		
	USACE, Louisville - Biologist	High	VC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	MC		
	Team Rating	**High**	**VC**		

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 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.

	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: This virus has been reported from throughout the Great Lakes Basin (USGS, 2011). VHSv has been found in many species of fish including common carp. The common carp is established in Lake Michigan, as well as the rivers and streams leading to Parker Cobb Ditch from Lake Michigan.

Parker-Cobb Ditch, Porter County, IN - Viral Hemorrhagic 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, Louisville - Biologist	Medium	RC	Low	RC
	USACE, Louisville - Biologist	Medium	RC	Medium	MC
	USACE, Detroit - Biologist	High	RC	Low	RC
	Indiana DNR - AIS Coordinator	Medium	MC	Medium	MC
	Team Ratings	**Medium**	**MC**	**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 passage 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 common carp is also a potential host for VHSv. The common carp was therefore used as a surrogate potential fish host to estimate the probability of VHSv moving from its current location in the Great Lakes Basin to the Parker-Cobb Ditch pathway location. During spring run-off events in April and May, common carp migrate into the shallow waters of bays and river systems to spawn. Common carp are strong swimmers and though they cannot jump like members of the salmon family, they can migrate upstream during moderate flow events. The surface water connection from Lake Michigan to Parker-Cobb Ditch provides suitable habitat for carp during run-off events. It is possible that the common carp could migrate to the watershed divide since it is a very resilient species capable of surviving a wide range of water quality parameters.

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

Fishing and boating are unlikely to occur in the Parker-Cobb Ditch area. The ditches are too small to support sport fishing and are also too small for boating or kayaking. The small size of the ditches virtually eliminates the threat of ANS transfer via water craft, associated equipment, or fishing gear.

Parker-Cobb Ditch, Porter County, IN - Viral Hemorrhagic Septicemia virus (VHSv)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	High	MC		
	Indiana DNR - AIS Coordinator	High	RC		
	Team Ratings	**High**	**MC**		

4. How do you rate the probability of ANS establishing at 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: VHSv is capable of persisting outside of a host for several days when water temperatures are cool. The virus demonstrates a rapid reproductive cycle and is capable of utilizing many different host species . It is likely that VHSv would be successful in establishing in Parker -Cobb ditch and/or the receiving streams of Parker-Cobb Ditch.

Parker-Cobb Ditch, Porter County, IN - Viral Hemorrhagic 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, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	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: Since VHSv can survive for periods of time outside of a host fish, this pathogen could spread beyond the pathway to the Mississippi River Basin on or off a host fish via the Parker-Cobb Ditch pathway. However, as VHSv is active at water temperatures less than 60ºF, the higher water temperatures that likely occur in the summer months at Parker-Cobb Ditch might prevent the establishment and passage of VHSv during that time (USGS, 2011).

Parker-Cobb Ditch, Porter County, IN - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	High	RC		
	USACE, Louisville - Biologist	High	VC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	RC		
	Team Rating	**High**	**VC**		

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 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.

	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 goby are located within the Great Lakes and are associated with river mouths and estuaries of large river systems entering the Great Lakes, and the ruffe has been identified in Lake Michigan. The tubenose goby has been collected in the lower reaches of larger Great Lakes rivers and estuaries.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	Low	MC	Low	RC
	USACE, Louisville - Biologist	Low	MC	Medium	MC
	USACE, Detroit - Biologist	Low	RC	Low	RC
	Indiana DNR - AIS Coordinator	Low	MC	Medium	MC
	Team Ratings	**Low**	**MC**	**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 passage 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 ruffe prefers deep waters of lakes and pools of rivers, usually over sand and gravel, but has a tolerance for different habitats and environmental conditions. The ruffe's ability to swim upstream during high flow events and migrate over dams is questionable. The tubenose goby is found in the open waters and estuaries of slow flowing rivers. The tubenose goby appears to be more capable of living in more diverse types of riverine habitat than the ruffe. Sufficient forage ranging from zooplankton to fish may be available throughout the Great Lakes side of the connection. However, suitable habitat for the ruffe and tubenose goby in Salt Creek and Parker Ditch may be limited or even nonexistent.

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

Fishing and boating are unlikely to occur in the Parker-Cobb Ditch area. The ditches are too small to support sport fishing and are also too small for boating or kayaking. The small size of the ditches virtually eliminates the threat of ANS transfer via water craft, associated equipment, or fishing gear.

Parker-Cobb Ditch, Porter County, IN - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Low	MC		
	USACE, Louisville - Biologist	Medium	RC		
	USACE, Detroit - Biologist	Low	RC		
	Indiana DNR - AIS Coordinator	Low	MC		
	Team Ratings	**Low**	**MC**		

4. How do you rate the probability of ANS establishing at 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 is an aggressive species that possesses the ability to feed in darkness, cold temperatures and turbid conditions. Tubenose gobies are benthic species that consume a wide variety of invertebrates. They are often quite abundant in backwaters and lakes and seem to prefer dense vegetation. However, survival of a viable, reproducing population of ruffe and tubenose goby within Parker-Cobb Ditch may be unlikely due to low water quality and high temperatures in summer months. The receiving stream (Sandy Hook Ditch) of Cobb Ditch also offers only limited habitat due to the same reasons listed for Cobb Ditch. Limited suitable habitat may be present in the most downstream reaches of Sandy Hook Ditch.

Parker-Cobb Ditch, Porter County, IN - Ruffe (*Gymnochephalus cernuus*) / Tubenose Goby (*Proterorhinus semilunaris*)

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

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Detroit - Biologist	Medium	RC		
	Indiana DNR - AIS Coordinator	Medium	RC		
	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: Ruffe and the tubenose goby have not been found in rivers or streams similar to Sandy Hook Ditch or its tributaries.

Parker-Cobb Ditch, Porter County, IN - 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	High	VC	High	VC
	USACE, Louisville - Hydraulic Engineer	High	VC	High	VC
	USGS, Indiana WSC - Hydrologist	High	VC	High	VC
	Indiana DNR - Engineering Geologist	Medium	RC	Medium	RC
	Team Ratings	**Medium**	**VC**	**High**	**VC**

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: A hydraulic connection is likely to be maintained through the field access culvert for multiple days multiple times per year, based upon professional judgement and cursory runoff calculations and calculated depths of flow. A hydraulic connection is likely to be maintained through the field access culvert through late winter to early summer, then episodically as sufficient rain falls, and again more continuously after transpiration declines and precipitation falls in late fall to winter. This is based on my understanding of drainage of similar areas and soils and flow patterns in the region. The ditch system leading to the culvert under the farm road at the basing boundary appears to be very low gradient for a distance of over one mile. It likely behaves more like a wetland scenario than a flowing stream. The upland nature of the site, lacking significant watershed to provide for a larger water volume, would serve to decrease any long term flow volume.

Parker-Cobb Ditch, Porter County, IN - Threespine Stickleback (*Gasterosteus aculeatus*)

2. Probability of ANS occurring within either basin

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Louisville - Biologist	High	VC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	Medium	MC		
	Team Rating	**High**	**VC**		

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 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.

	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 is found in each of the Great Lakes except Lake Ontario and has been collected in some inland river systems. Literature indicates this species prefers to live in smaller streams but may occur in a variety of habitat including lakes and large rivers.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	Medium	RC	Low	RC
	USACE, Louisville - Biologist	Medium	RC	Medium	RC
	USACE, Detroit - Biologist	Medium	RC	Low	RC
	Indiana DNR - AIS Coordinator	High	MC	Medium	RC
	Team Ratings	**Medium**	**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 passage 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.

There are no known obstacles to prevent the spread of the threespine stickleback on the Great Lakes side of the Parker- Cobb Ditch pathway. It is likely that sufficient forage and habitat is available throughout the pathway for the threespine stickleback.

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

Fishing and boating are unlikely to occur in the Parker-Cobb Ditch area. The ditches are too small to support sport fishing and are also too small for boating or kayaking. The small size of the ditches virtually eliminates the threat of ANS transfer via water craft, associated equipment, or fishing gear.

Parker-Cobb Ditch, Porter County, IN - Threespine Stickleback (*Gasterosteus aculeatus*)

4. Probability of ANS establishing at the aquatic pathway

Aquatic Pathway Team	Expertise Position title or team role	Rating	Certainty		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Detroit - Biologist	Medium	RC		
	Indiana DNR - AIS Coordinator	Medium	RC		
	Team Ratings	**Medium**	**MC**		

4. How do you rate the probability of ANS establishing at 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: Establishment of a sustained population of threespine stickleback within Parker-Cobb ditch is possible, but the intermittent nature of flows and poor water quality in Parker-Cobb Ditch and connecting ditches may limit the numbers and health of any such population. Portions of connecting streams between Parker-Cobb Ditch and Lake Michigan may provide sufficient habitat for this species and it may be able to establish in fairly close proximity to the pathway location to at some point take advantage of a suitable flood event and cross the basin divide.

Parker-Cobb Ditch, Porter County, IN - 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, Louisville - Biologist	High	MC		
	USACE, Louisville - Biologist	Medium	MC		
	USACE, Detroit - Biologist	High	RC		
	Indiana DNR - AIS Coordinator	High	RC		
	Team Ratings	**High**	**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: The threespine stickleback has been found in small river systems and therefore downstream migration from Parker-Cobb Ditch into the Mississippi River Basin would be possible.