GLMRIS – Brandon Road

Appendix B - Planning

FINAL

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U.S. ARMY

US Army Corps of Engineers ®
Rock Island & Chicago Districts

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1.1. Studies, Reports, and Existing Water Projects within Study Area

1.1.1. Great Lakes and Connected Tributaries

Listed below are some specific selected projects that USACE has undertaken recently with non-federal partners to restore areas within the GLB. The projects discussed below were implemented under the Great Lakes Fishery and Ecosystem Restoration Program (GLFER) authorized by Section 506 of the Water Resources Development Act of 2000, P.L. 106-541, as amended (42 U.S.C. § 1962d-22).

Keweenaw Stamp Sands, MI Section 506, Great Lakes Fishery and Ecosystem Restoration (GLFER) Project. The project area is in Lake Superior in Michigan's Upper Peninsula on the eastern side of the Keweenaw Peninsula. The project area is close to the Torch Lake Area of Concern but is not included within the Area of Concern. Two stamping mills in the Town of Gay dumped more than 25 million tons of waste stamp sands containing elevated amounts of copper into Lake Superior. Material from the deposit has migrated more than five miles along the shoreline of the Keweenaw Peninsula. The deposit's movement along the shoreline is threatening the nearby Buffalo Reef, a productive Lake Trout and Whitefish spawning area. Modeling studies predict that 60% of the reef will be covered by 2019 unless the erosion is stopped. Protection of the Reef has been identified as a high priority in the Lake Superior Lakewide Area Management Plan. The USACE has proposed construction of a 1.2 mi (1.9 km) long stone revetment to prevent the further loss of stamp sands and allow restoration efforts to occur.

St. Marys River Habitat Restoration, MI Section 506, GLFER Project. Past modifications to incorporate commercial shipping in the St. Marys River have greatly altered its aquatic habitat. This area was once a valuable rapids habitat used as a spawning area for fish and invertebrate species in the river system. The study has proposed measures to protect this valuable habitat. The Tentatively Selected Plan includes two sites, east and west project areas. The west project site would consist of removal of old building foundations, excavation of a channel, and the installation of a culvert to allow water to flow behind the existing rock piles over the natural rock-rubble/cobble substrate. The east project site would require the modification of the eastern remnants of the upper dam. A portion of the upper dam would be removed and culverts placed under the existing roadway. A channel would then be excavated to allow water to flow behind the existing rock piles over the natural rock-rubble/cobble substrate. The goal of this project is to restore water flow over the rock-rubble/cobble substrate to provide critical habitat for a number of fish and invertebrate species.

White Rapids/Chalk Hill Dams, Menominee River, MI Section 506, GLFER Project. The project is located on the Menominee River, which forms the border between Michigan's Upper Peninsula and northeastern Wisconsin. The proposed project involves construction of fish passage facilities around both the White Rapids and Chalk Hill Dams, which are the fourth and fifth dams, respectively, upstream from Lake Michigan on the Menominee River in Menominee County, Michigan, and Marinette County, Wisconsin. Upon construction of fish passage facilities at these dams, sturgeon in Lake Michigan would have access to nearly 80 additional miles of high quality spawning and rearing habitat within the Menominee River.

Grand Rapids Dam, Menominee River, MI Section 506, GLFER Project. The project is located on the Menominee River, which forms the border between Michigan's Upper Peninsula and northeastern Wisconsin. The proposed project involves construction of fish passage facilities around Grand Rapids Dams, which is the third dam upstream from Lake Michigan on the Menominee River in Menominee County, Michigan, and Marinette County, Wisconsin. Upon construction of fish passage facilities at this dam, in conjunction with another project, sturgeon in Lake Michigan would have access to nearly 80 additional miles (128.7 km) of high-quality spawning and rearing habitat within the Menominee River.

Menominee & Park Mill Dams, Menominee River, MI Section 506, GLFER Project. Three separable sturgeon passage projects are being studied on the Menominee River which separates Michigan and Wisconsin as it drains into Green Bay on the northwest shore of Lake Michigan. Under natural conditions the Menominee River allowed Lake Sturgeon living in Lake Michigan access to over 80 mi (128.7 km) of stream before they encountered an impassable barrier (Sturgeon Falls). The development of five hydropower facilities has broken the river into four segments below Sturgeon Falls. Only the first three miles (4.8 km) from Green Bay are now accessible to Lake Michigan sturgeon. At that point they encounter the Menominee Dam and within about a mile the Park Mill Dam. The next segment upstream extends for about 19 mi (30.6 km) to the Grand Rapids Dam.

Fort Sheridan Ravine & Coastal Restoration, Section 506 Great Lakes Fishery & Ecosystem Restoration, Detailed Project Report and Integrated Environmental Assessment, U.S. Army Corps of Engineers, 2015. This project is part of the northeastern Illinois coastline of Lake Michigan and is located within Lake County and within Lake Forest, Fort Sheridan, and Highland Park, Illinois. The project includes restoring four main ravines (McCormick, Hutchinson, Schenk, and Scott), 40 acres (16 ha) of bluff along the coastline and about 1.5 miles (2.4 km) of coastal lake and dune habitat. The goal is to stabilize coastal communities and restore historic native plant communities along Lake Michigan. The project is currently under construction. A contract was awarded in 2015.

Saganashkee Slough-McMahon Woods Ecosystem Restoration, Section 506 Great Lakes Fishery & Ecosystem Restoration, Feasibility Study and Integrated Environmental Assessment, U.S. Army Corps of Engineers, 2015. The project borders the Cal-Sag Channel to the north and is located in Cook County, near Palos, Illinois. The report has evaluated the feasibility and environmental effects of restoring geomorphic features, hydrology, marsh and wooded riparian plant communities within McMahon Woods. The scope of this study addressed the issues of altered geomorphology, absence of native plant communities, invasive species, fire suppression, rare wetland/fen communities, degradation of critical habitat for a federally listed species and poor water quality.

Little Calumet River Riparian, Section 506, Great Lakes Fishery and Ecosystem Restoration, Detailed Project Report and Environmental Assessment, U.S. Army Corps of Engineers, 2012. The project is located on the East Branch Little Calumet River in Porter County near Chesterton, Indiana. Restoration actions that are being undertaken include restoration of natural habitat variability to support riverine specialist species, restoration of canopy structure and increase in native diversity of the floodplain forest, and elimination of invasive plant species that threaten high quality wetland plants. Expected benefits of the project include increased biological integrity of the Little Calumet River, restoration of the natural floodplain morphology and hydro-periods, and increased floristic quality scores throughout the riparian ecosystem. Construction of the project was completed in fall 2015.

Elkhart River, IN Section 506, GLFER Project. The Elkhart River and Christiana Creek are two tributaries to the St. Joseph River, which extends a total of 210 mi (338.0 km) through portions of northern Indiana and southern Michigan before flowing into Lake Michigan. Both have dams located in Elkhart that substantially alter the character of the riverine water system; they have also played a central role in the decline of migratory aquatic species by severing their historic migration routes and preventing healthy recruitment. The dams effectively obstruct some 20-30 native fish species, including the state endangered Greater Redhorse and the highly prized Walleye. The restoration project would enable the passage of aquatic species to far reaching areas above the dams, improve the riverine habitat for endangered and threatened fish and mussel species, and stabilize the stream bank and naturalize sediment transport.

Boardman River Dam Removal, MI Section 506, GLFER Project. The proposed project consists of modification/removal of three dams along the Boardman River: (1) Union Street Dam at river mile 1.5; (2) Sabin Dam at river mile 5.3, and (3) Boardman Dam at river mile 6.1. The purpose of the project is to increase upstream migration of aquatic organisms and reduce thermal impacts of the existing dams on the Boardman River.

Frankenmuth Dam Fish Passage, MI Section 506, GLFER Project. The Frankenmuth Dam, originally constructed in 1850's, prevented the upstream passage of fish and separated Saginaw Bay fish from valuable spawning habitat. Species of particular interest to the Michigan Department of Natural Resources include Walleye and Lake Sturgeon. In lieu of dam removal, the project included construction of a rock ramp structure to provide an approximate 3% grade through this stretch of the Cass River, allowing passage of the target species upstream.

Ford Estate Dam Fish Passage, MI Section 506, GLFER Project. The dam at the Henry Ford Estate is located on the middle branch of the Rouge River just upstream from its confluence with the lower branch of the Rouge River in the City of Dearborn. The dam, a National Historic Landmark, is the first dam upstream of the mouth of the Rouge River and blocks fish movement from the watershed into the lower reaches of the Rouge River as well as movement of Great Lakes fish from the Detroit River upstream into potential spawning and foraging habitat in the Rouge. Fish passage around the dam would be a major step in reconnecting segments (18-36 mi (29.0-57.9 km)) of the Rouge for the benefit of fish and other wildlife.

Harpersfield Dam, OH Section 506, GLFER Project. The presence of Harpersfield Dam, immediately upstream of the historic Harpersfield covered bridge, has promoted habitat degradation, altered sediment transport dynamics, and degraded water supply. It has also played a central role in the decline of migratory aquatic species by severing their migration routes and preventing healthy recruitment. At this particular dam it has been determined that the benefits of sea lamprey prevention outweigh the negative impact the dam has on fish passage. Likely project alternatives that will be evaluated include repairing or modifying the existing dam to maintain its current structure, which effectively prevents sea lamprey passage; construction of a sea lamprey trap at the existing dam; or construction of a new barrier and trap at a location farther downstream of Harpersfield Dam. Improvement to prevent sea lamprey passage and reproduction upstream will prevent the need for lampricide treatments above the dam, which currently cost $335,000 per treatment. These improvements will contribute to an overall lower sea lamprey population in Lake Erie, which in turn improves the sustainability of valuable fisheries resources.

Conneaut Creek, PA Section 506, GLFER Project. Each of the three dam sites in Conneaut Creek will be considered for modification or removal. Modification may include installation of a fish ladder or rock ramp, or notching. The selected activity must accomplish the following goals: reconnect the creek, provide fish passage, and prevent the further spread of invasive sea lamprey. Increased biodiversity, access to high quality habitat and spawning areas, enhanced water quality, and restoration of normal sediment movement will result from modification and/or removal of the dams. Removing the impediments to fish passage will decrease the likelihood that fish populations will decline or become dependent on annual stocking programs.

Elk Creek, PA Section 506, GLFER Project. The project proposes restoration of a section of the Elk Creek riparian corridor that is in close proximity to Highway 79 in the Town of McKean. Elk Creek is a coolwater system that supports a wide range of native, naturalized, and stocked fish species. Since resident and migratory fish species can be found within the creek, benefits of the project extend well beyond the immediate project area. Primary reasons for habitat degradation at the site are streambank failure; insufficient riffle, run, pool sequences, or similar fluvial geomorphic impairments; and lack of native riparian cover. In recent years the project area has experienced rapid and significant erosion and loss of in-stream habitat. Preliminary field observations revealed that a headcut has developed within the project area and is likely to continue upstream and cause additional valuable habitat to be lost.

Springville Dam, NY Section 506, GLFER Project. The Springville Dam is located in the Village of Springville, approximately 30 mi (48.2 km) south of the City of Buffalo, on the Cattaraugus Creek. Cattaraugus Creek is the natural boundary for Erie and Cattaraugus Counties. The feasibility study will evaluate an array of measures which will allow steelhead and other fisheries access to the upstream reaches of Cattaraugus Creek and associated tributaries. In addition, the dam blocks access to the upper 34 mi (54.7 km) of Cattaraugus Creek. The implementation of a fish passage project will provide increased fishery resources of prime spawning habitat for the fisheries which exist in Cattaraugus Creek. The expected outputs of the proposed project include the availability of an additional 34 miles (54.7 km) of free-flowing creek containing suitable spawning habitat to fish and benthic species and restoration of sediment transport processes.

1.1.2. CAWS

Bubbly Creek, South Branch of the Chicago River, Illinois, Draft Integrated Feasibility Report and Environmental Assessment, U.S. Army Corps of Engineers, April 2015. This study was conducted in accordance with the study resolution adopted by the Committee on Environment and Public Works, United States Senate, July 20, 2005. The study evaluated opportunities for ecosystem restoration within the 1.25 mile (2.0 km) Bubbly Creek. The draft feasibility report was released for public comment in April 2015, during which a comment was received that alerted USACE to remediation efforts at former manufactured gas plants adjacent to Bubbly Creek and the South Branch Chicago River waterways. The study has been suspended pending the completion of remediation by Peoples Gas and USEPA Region V; however, USACE could reexamine the feasibility of ecosystem restoration at Bubbly Creek following the completion of remediation activities by Peoples Gas. USACE is currently continuing consultation with USEPA Region V.

Eugene Field Park Section 206 Ecosystem Restoration, Integrated Feasibility Report and Environmental Assessment, U.S. Army Corps of Engineers, 2007. Eugene Park is bisected by the North Branch of the Chicago River and is located in Cook County, Chicago, Illinois. The project included restoring the landscape of Eugene Field Park to as close to presettlement conditions as possible. Expected benefits of the project included greater species richness in the stream corridor and riparian zone, improvement in local water quality, lessening of unnatural erosion along the stream banks, and an increase in habitat for migratory and resident bird species. Construction of the project was completed in 2015.

Horner Park, Section 206, Aquatic Ecosystem Restoration, Integrated Feasibility Report and Environmental Assessment, U.S. Army Corps of Engineers, 2013. Horner Park is located along the North Branch of the Chicago River in Cook County, Chicago, Illinois. The goal of the project was to restore natural features of the North Branch Chicago River at Horner Park and its riparian zone within the constraints of the current system. The objectives of the project included restoration of stream hydraulics and morphology, restoration of riparian zone habitat and vegetation, restoration of oak savanna habitat, and prevention and/or removal of invasive species. Construction is currently underway with activities expected to be completed by 2019.

Indian Ridge Marsh, Section 1135, Integrated Feasibility Report and Environmental Assessment, U.S. Army Corps of Engineers, 2011. The project covers approximately 145 acres (58.7 ha) between Lake Calumet and the Calumet River in Cook County, Chicago, Illinois. Goals of the project included preservation of existing Black-crowned Night Heron rookery, enhancement and naturalization of existing aquatic, wetland, and woodland areas; creation of marsh, wet prairie, mesic prairie, savanna, and wet woodland habitats; and protection of restored areas while encouraging public access. Construction of the project was completed in 2015.

Little Calumet River Riparian, Section 506, Great Lakes Fishery and Ecosystem Restoration, Detailed Project Report and Environmental Assessment, U.S. Army Corps of Engineers, 2012. The project is located on the East Branch Little Calumet River in Porter County near Chesterton, Indiana. Restoration actions that are being undertaken include restoration of natural habitat variability to support riverine specialist species, restoration of canopy structure and increase in native diversity of the floodplain forest, and elimination of invasive plant species that threaten high quality wetland plants. Expected benefits of the project include increased biological integrity of the Little Calumet River, restoration of the natural floodplain morphology and hydro-periods, and increased floristic quality scores throughout the riparian ecosystem. Construction of the project was completed in fall 2015.

Lockport Prairie Ecosystem Restoration, Section 206 Aquatic Ecosystem Restoration, Feasibility Study and Integrated Environmental Assessment, U.S. Army Corps of Engineers, 2015. The project is located on the CSSC in Will County near Lockport, Illinois. Lockport Prairie supports numerous rare and uncommon plant and animal species. Nearly 400 native plant species have been identified at Lockport Prairie, and at least nine of those are identified as threatened or endangered species. The proposed project will restore approximately 300 acres (121.4 ha) of wetlands at the nature preserve. Alternative measures onsite and offsite that will be considered to restore the surface and groundwater hydrology include but are not limited to: additional culverts under Division Street; additional culverts under the railroad line; installation of subsurface drainage structures; modification of nearby wells; modification of existing culverts; and implementation of invasive species control measures. This project is currently under construction.

North Branch of the Chicago River Dams – Forest Preserve District of Cook County, Section 22 Planning Assitance to States, Integrated Planning Report and Environmental Assessment, U.S. Army Corps of Engineers, 2013. This investigation was conducted under the Planning Assistance to States Program as authorized in Public Law 93-251 and amended in subsequent legislation. The purpose of the study was to provide planning assistance to the Forest Preserve District of Cook County on the potential feasibility of dam removal to further defragment the North Branch of the Chicago River. The report provided planning and design recommendations for the removal of the three dams on the North Branch of the Chicago River, which included the Winnetka, Chick Evans, and Tam O'Shanter Dams. The Winnetka Dam was removed in 2015, while the removal of the Chicak Evans and Tam O'Shanter Dams is yet to be determined.

1.1.3. Des Plaines River

Upper Des Plaines River, Illinois, Interim Feasibility Report and Environmental Impact Statement, U.S. Army Corps of Engineers, 1999. This is a flood damage reduction project that consists of six structural elements: two levees, two expansions of existing reservoirs, one lateral storage area and one dam modification. The levee projects also include a flood warning system. Work involves construction of the Mount Prospect/Prospect Heights Levee, also known as Levee 37; the Rand Park Levee, also known as Levee 50; the Buffalo Creek Reservoir expansion; the Big Bend Lake expansion; the Van Patten Woods lateral storage area; and the North Fork Mill Creek Dam modification. Levee 50 and levee 37 have been constructed. The North Fork Mill Creek Dam modification has been recommended for deauthorization.

Upper Des Plaines River and Tributaries, Illinois and Wisconsin, Integrated Feasibility Report and Environmental Assessment, U.S. Army Corps of Engineers, 2013. This study expands the area of concern from the mainstem in Illinois to include the entire Upper Des Plaines watershed, comprised of 15 tributaries in Illinois and Wisconsin. In addition to flood risk management, the purpose of this study also includes ecosystem restoration, water quality and recreation features. Primary objectives of the study included further reduction of main stem flooding, reduction of tributary flooding, and environmental restoration of degraded ecosystems within the basin. The study considered sites located within tributary watersheds and along the main stem for both Flood Risk Management and Ecosystem Restoration potential. The effects of flood risk management sites within tributary watersheds on main stem flooding were also evaluated. The project is currently awaiting authorization from Congress to move ahead with design and construction.

Hofmann Dam Section 206 Ecosystem Restoration, Detailed Project Report, U.S. Army Corps of Engineers, 2016. This study was conducted with the Illinois Department of Natural Resources (ILDNR) and was part of a larger effort to consider dam removal to address safety concerns as well as ecosystem restoration. The recommended plan called for the removal of 3 dams, Hofmann, Armitage, and Fairbank that no longer serve their original purposes. These dams created obstacles for fish migration, negatively impacted water quality, and created stagnant reservoir habitat where riverine habitat used to flourish. Removal of all three dams was completed in 2012.

Des Plaines River Dams – Forest Preserve District of Cook County, Section 22 Planning Assistance to States, Integrated Planning Report and Environmental Assessment, U.S. Army Corps of Engineers, 2013. This investigation was conducted under the Planning Assistance to States Program as authorized in Public Law 93-251 and amended in subsequent legislation. The purpose of this study was to provide planning assistance to the Forest Preserve District of Cook County on the potential feasibility of dam removal to completely defragment the upper Des Plaines River mainstem. The report provided planning and design recommendations for the removal of 5 dams on the Des Plaines River, which included Dam #1, Dam #2, Dempster Street Dam, Touhy Avenue Dam, and Dam #4. Dam #1 and Dam #2 were removed in 2014, while the Dempster Street Dam was removed in 2016. The removal of the remaining two dams (i.e., Touhy Avenue Dam and Dam #4) is yet to be determined.

1.1.4. Illinois River

Illinois River from Henry to Naples, Illinois, Peoria Lake and La Grange Pool, Illinois River Basin, U.S. Army Corps of Engineers Reconnaissance Study, 1987. This study, authorized in Section 109 of Section 1304 of the Supplemental Appropriations Act, investigates the advisability of the preservation, enhancement, and rehabilitation of Peoria Lake near Peoria, Illinois.

Upper Mississippi River System Environmental Management Program, Definite Project Report with Integrated Environmental Assessment, Peoria Lake Habitat Enhancement, U.S. Army Corps of Engineers, 1990. This technical publication, complete with NEPA documentation and engineering plans, was the authorizing document by which a 16 acre (6.4 ha) barrier island was created in Upper Peoria Lake. This project enhanced migratory waterfowl, fish, and aquatic habitat. Project monitoring indicates an increase in absolute numbers and diversity of water bird and fish species at the project site.

Section 216 Initial Appraisal, Illinois Waterway System Ecosystem Restoration and Sedimentation, Illinois, U.S. Army Corps of Engineers, Rock Island District, 1996. This document recommends further study of the IWW ecosystem in light of changed physical and economic conditions since the 9-foot navigation channel was constructed.

General Investigation Reconnaissance Study, Illinois River, Ecosystem Restoration, Section 905(b) Reconnaissance Analysis, U.S. Army Corps of Engineers, Rock Island District, 1999. This report concluded that ecosystem restoration in the Illinois River Basin is within the Federal interest and that Corps of Engineers involvement is appropriate. Further, measures to address the loss of backwaters, changed hydrologic regimes and water fluctuations, and other impacts upon the system were identified and found to have no anticipated negative environmental impacts. The resulting Project Study Plan and

Cost Sharing Agreements with the Illinois DNR have resulted in the initiation of the Illinois River Ecosystem Restoration Feasibility Study.

Initial Assessment, Illinois River Basin Restoration, Section 519 of the Water Resources Development Act (WRDA) of 2000, U.S. Army Corps of Engineers, Rock Island District, 2002. The initial assessment served as a reconnaissance-level report outlining the Federal interest, work for future phases, relationship to the Illinois River Ecosystem Restoration Study, and summary of proposed Critical Restoration Projects and Long-Term Resource Monitoring.

1.1.5. Kankakee River

Illinois River Basin Restoration, Section 519, Kankakee River Mainstem, Critical Restoration Project, U.S. Army Corps of Engineers, Rock Island District, 2014. A reconnaissance study outlining the potential for federal interest in removing sand from the mainstem of the Kankakee River in order to reduce sedimentation in downstream high quality habitat areas. The report recommended that there were no viable projects in the Kankakee mainstem at the time because of the continued in flow of uncontrolled sediment from portions of the drainage area.

Draft Detailed Project Report with Integrated Environmental Assessment, Section 206 Kankakee State Line, Aquatic Ecosystem Restoration Project, U.S. Army Corps of Engineers, 2006. This study investigated continuous and periodic sediment removal options at the Illinois-Indiana stateline. Results showed that both sediment removal methods had minimal effects on reducing downstream aggradation. Additionally, the study also proposed a potential wetland restoration project near the state line.

1.2. Affected Environment

Information regarding the subsections under Physical Resources and Biological Resources is summarized in the main report under the same subsection headings. If additional information, beyond that presented in the main report, was available it is presented here in this section. Subsections of Physical Resources and Biological Resources where additional information was unavailable are not presented below, only the summary information is available in the main report.

1.2.1. Physical Resources

Hydrology and Hydraulics

Great Lakes. Lake Superior has been regulated since 1921 by means of a series of control structures including a gated dam across the St. Marys River at Sault Ste. Marie, Michigan and Ontario. Construction of the gated dam was authorized by the International Joint Commission (IJC) as a condition to approval of the water diversion for hydropower. By operation of the gates, locks, and changes in power diversions, flows specified by the adopted plan of regulation can be achieved. The present plan of regulation is known as Plan 1977-A. In general, the plan balances the levels of Lake Superior and Lakes Michigan-Huron to maintain their levels at the same positions to each other according to their long-term monthly means, while protecting the maximum levels on Lake Superior. The plan of regulation is designed to meet criteria specified by the IJC which requires, among other things, that the control works be operated so that the mean level of Lake Superior would be retained within its normal range of stage such that the level shall not exceed elevation 603.2 ft. (183.9 m) International Great Lakes Datum (IGLD) (1985) or fall below elevation 599.6 ft. (182.8 m) IGLD (1985), and will be done in such a manner so as not to interfere with navigation. This regulation plan affects water levels on Lakes Superior, Michigan, Huron, and to a lesser degree, downstream through Lake Erie.

Connecting Channels. The connecting channels of the Great Lakes are unregulated (i.e., free flow) except for the St. Marys River and St. Lawrence River, which is controlled by a series of improvements. Although compensating dikes were constructed on the Lower Detroit River to partially offset (hydraulically) the lowering of the water levels (due to past authorized navigational improvements in 1912, 1936, and 1962), the Detroit River is not considered regulated.

St. Marys River. St. Marys River is the outlet of Lake Superior and leaves the lake at Point Iroquois, flowing in a generally southeasterly direction through several channels to Lake Huron, a distance of 63 to 75 mi (101.4 – 120.7 km) according to the route traversed. The river drops approximately 22 ft (6.7 m) with most of the drop (20 ft, 6.1 m) occurring at the St. Marys Falls Canal, where four U.S. navigation locks and one Canadian lock allow for the transit of vessels (Table B-1). The natural control of the outflow from Lake Superior was a rock ledge at the head of the St. Marys River. This natural control has been replaced by the locks, compensating works, and powerhouses. As a result, the outflow from Lake Superior is regulated.

St. Clair River-Lake St. Clair-Detroit River System. The St. Clair River-Lake St. Clair-Detroit River System connects Lake Huron and Lake Erie. The system on Lake Erie is approximately 89 mi (143.2 km) long and has a relatively uniform water surface profile with a fall of 8 ft. (2.4 m) from Lake Huron to Lake Erie. The St. Clair River has a length of about 39 mi (62.7 km). Lake St. Clair, extending between the mouth of the St. Clair River and the head of the Detroit River (a distance of about 18 mi (29.0 km)) occupies a shallow basin having an average depth of about 10 ft (3 m), with low, marshy shores. The shallow depth requires a dredged commercial navigation channel 27.5 ft (8.4 m) deep and 800 ft (243.8 m) wide throughout its length. The Detroit River extends about 32 mi (51.5 km) to Lake Erie (Table B-1).

Welland Canal. The Welland Canal connects Lake Erie and Lake Ontario. The system is approximately 27 mi (43.5 km) long and is somewhat restricted by structures, but has no level and flow problems because it can be completely controlled by locking operations (Table B-1).

St. Lawrence River. The St. Lawrence River connects Lake Ontario and the Atlantic Ocean. The system is approximately 189 mi (304.2 km) long and is somewhat restricted by water level flow problems. Tidal variations from Quebec seaward are quite large, up to 8 ft. (2.4 m); however, at Montreal and upstream the variation is only 6 in (15 cm) (Table B-1).

Table B-1: Characteristics of the Great Lakes-St. Lawrence Seaway Connecting Channels

Connecting Channel	Length	Width	Depth	Fall
St. Marys River	63 mi (101 km)	300-1500 ft (91-457 m)	27-30 ft (8-9 m)	23 ft (7 m)
Straits of Mackinac	0.80 mi (1.3 km)	1250 ft (381 m)	30 ft (9 m)	0 ft (0 m)
St. Clair River	40 mi (64 km)	700-1400 ft (213-427 m)	27-30 ft (8-9 m)	5 ft (1.5 m)
Lake St. Clair	18 mi (29 km)	700-800 ft (213-244 m)	27.5 ft (8.4 m)	0 ft (0 m)
Detroit River	31 mi (50 km)	300-1200 ft (91-366 m)	27.5-29.5 ft (8.4-9 m)	3 ft (0.9 m)
Welland Canal	27 mi (43 km)	192-350 ft (59-107 m)	26 ft (8 m)	326 ft (99 m)
St. Lawrence River	189 mi (304 km)	225-600 ft (69-183 m)	26 ft (8 m)	226 ft (69 m)

Locks

St. Marys Falls. Locks in the Great Lakes-St. Lawrence Seaway system are located in the St. Marys River, Welland Canal, and St. Lawrence River. In the St. Marys River at Sault Ste. Marie, Michigan, and Ontario, four parallel locks on the U.S. side, and one on the Canadian side are operational. The principal features of the locks in the St. Marys River are shown in Table B-2 as follows.

Table B-2: Principal Features of the St. Marys Falls Canal Locks

Principal Features	Lock				
	MacArthur	**Poe**	**Davis**	**Sabin**	**Canadian**
Opened to Commerce	1943	1969	1914	1919	1895
Width	80 ft (24 m)	110 ft (34 m)	80 ft (24 m)	80 ft (24 m)	59 ft (18 m)
Length Between Mitre Sill	800 ft (244 m)	1200 ft (366 m)	1350 ft (411 m)	1350 ft (411 m)	900 ft (274 m)
Depth on Upper Mitre Sill	31 ft (9 m)	32 ft (10 m)	24.3 ft (7 m)	24.3 ft (7 m)	16.8 ft (5 m)
Depth on Lower Mitre Sill	31 ft (9 m)	32 ft (10 m)	23.1 ft (7 m)	23.1 ft (7 m)	16.8 ft (5 m)
Lift	22 ft (6.7 m)	22 ft (6.7 m)	22 ft (6.7 m)	22 ft (6.7 m)	22 ft (6.7 m)

Welland Canal. The Welland Canal is located in Canada about 20 mi (32 km) west of the Niagara River, and connects Lake Erie to Lake Ontario. It is 27 mi (43 km) long and contains eight locks. The principal features of the locks in the Welland Canal are shown in **Error! Reference source not found.** B-3.

Table B-3 Principal Features of the Welland Canal Locks

Principal Features	All Eight Locks
	Canadian
Opened to Commerce	1932
Width	80 ft. (24 m)
Length Between Mitre Sill	766 ft. (233 m)
Depth Over Mitre Sill	30 ft. (9 m)
Lift	46.5[1] ft. (14 m)

[1]Lift for locks 1 through 7; variable list Lock 8, normally less than 3 ft. (0.9 m)

St. Lawrence River Locks. There are seven locks in the portion of the St. Lawrence River between Lake Ontario and Montreal Quebec. The two U.S. locks, Snell and Eisenhower, are located near Massena, New York; and the remaining five locks are Canadian, the St. Lambert and Cote Ste. Catherine Locks near Montreal Quebec; the Upper and Lower Beauharnois Locks in the Beauharnois Power Canal and the Iroquois Lock near Iroquois, Ontario. The principal features of the locks in the St. Lawrence River are shown in
B-4.

Table B-4: Principal Features of the St. Lawrence River Locks

Principal Features	Lock						
	Canadian				U.S.		Canadian
	St. Lambert	Cote Ste. Catherine	Lower Beauharnois	Upper Beauharnois	Snell	Eisenhower	Iroquois
Opened to Commerce	1959	1959	1959	1959	1959	1959	1959
Width	80 ft (24 m)	80 ft (24 m)	80 ft (24 m)	80 ft (24 m)	80 ft (24 m)	80 ft (24 m)	80 ft (24 m)
Length Between Mitre Sill	766 ft (233 m)	766 ft (233 m)	766 ft (233 m)	766 ft (233 m)	766 ft (233 m)	766 ft (233 m)	766 ft (233 m)
Depth Over Mitre Sill	30 ft (9 m)	30 ft (9 m)	30 ft (9 m)	30 ft (9 m)	30 ft (9 m)	30 ft (9 m)	30 ft (9 m)
Lift	22 ft (7 m)	37 ft (11 m)	42 ft (13 m)	40 ft (12 m)	49 ft (15 m)	42 ft (13 m)	6 ft (2 m)

Land Use

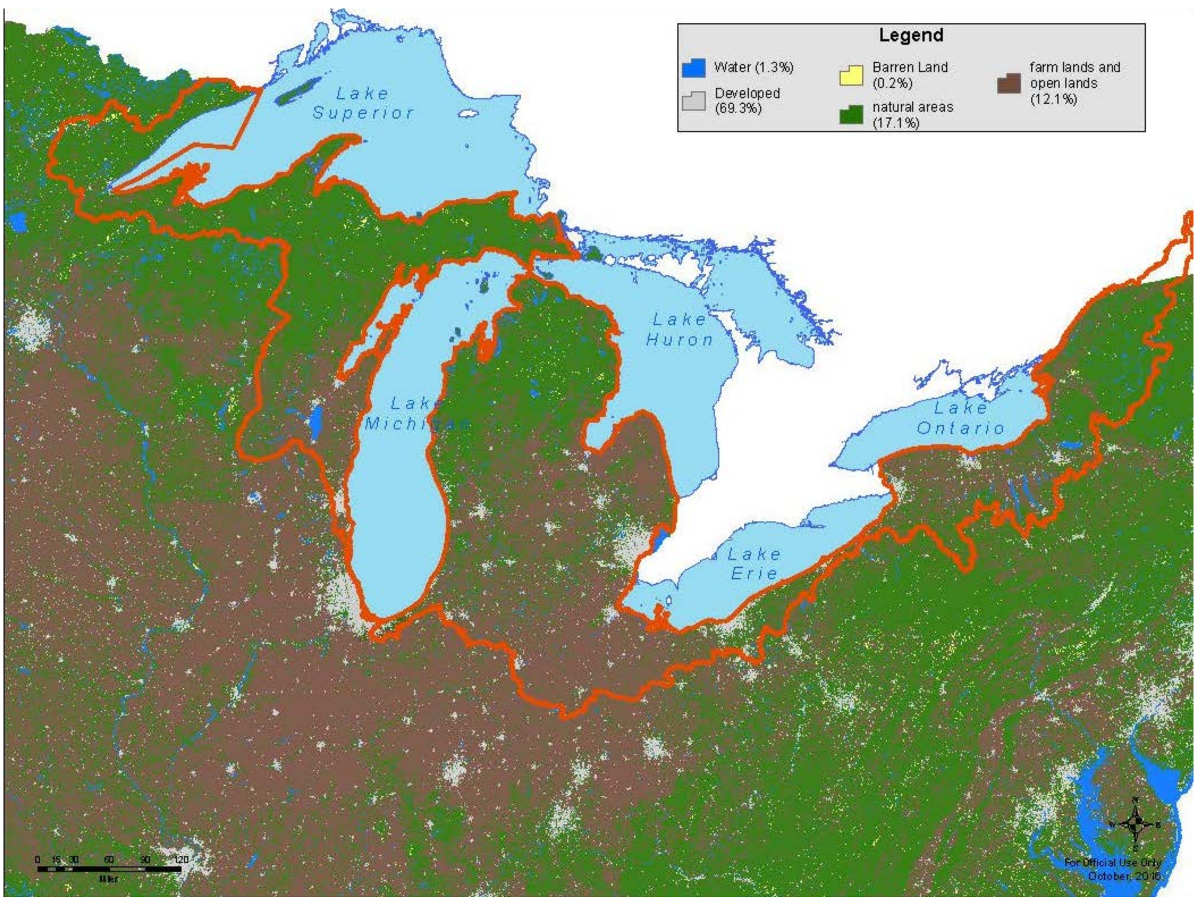

Figure B-1: Land Use Surrounding the Great Lakes

Lake Superior. According to the International Joint Commission's Levels Reference Study Board (1993), land use in the coastal counties varies significantly around the lakes. The northern shore of the 2,724 mi (4,383.9 km) Lake Superior shoreline remains virtually undisturbed and many reaches are heavily forested (Figure B-1). Only about 22% of the Canadian shoreline and 20% of the U.S. shoreline are in residential or commercial classes.

Lake Michigan. The 1,638 mi (2,636.1 km) long Lake Michigan shoreline is mostly smooth and unbroken, backed by gently rolling terrain. Dunes border the eastern and southern shores. Forested lands interspersed with wetlands are primarily found in the northern portion, while the central portion is largely agricultural. Dense urbanization occurs along the southern shore from approximately Menominee, WI to Muskegon, MI, with about 33% of the shoreline designated urban residential and commercial (Figure B-1).

Lake Huron. The Lake Huron shoreline is 3,827 mi (6,159.0 km) long, including Georgian Bay, North Channel, and Saginaw Bay. The northern half where Georgian Bay is located, is largely forested with wetlands and some developed areas interspersed. Major urban development is centered around the Saginaw River drainage area. About 17% of the Canadian and 32% of the U.S. shoreline are in residential, commercial/industrial use (Figure B-1).

The Lake St. Clair shoreline is about 164 mi (263.9 km) long. Considered one of the Great Lakes' most ecologically productive connecting waterways, around 10% of the shoreline is key wetland area. A major portion of the shoreline is development with about 40% of the Canadian side and 53% of the U.S. side in residential use (Figure B-1).

Lake Erie. Lake Erie has about 871 mi (1,401.7 km) of shoreline, with extensive agricultural development over much of the watershed. About 25% of the Canadian and 44% of the U.S. shoreline is in residential or commercial development, with heavy urban concentration at the western end. The eastern end of the lake, especially from Cleveland, OH west to Buffalo, NY is primarily forest with wetlands and agriculture interspersed (Figure B-1).

Lake Ontario. Lake Ontario has a shoreline of about 712 mi (1,145.9 km). Approximately 26% of the Canadian side and 45% of the U.S. side is residential or commercial and this is found primarily along the western half of the lake. The 42% residential development rate on the U.S. is the highest for any of the five Great Lakes. Residential use is also high on the connecting channels and St. Lawrence River. Along the eastern half of the lake, there is primarily forested land with urban area, agriculture, and wetlands interspersed (Figure B-1).

Natural Areas

Within the GLB there is one National Park, one National Historic Park, four National Lakeshores, six National Forests, three National Wilderness Preserves, and 20 National Wildlife Refuges (NWR) (Figure B-2). Isle Royale National Park located in Lake Superior, is a remote island cluster near Michigan's border with Canada that encompasses 571,790 ac (231,400 ha). Isle Royale was also designated as a National Wilderness Area is 1976 and an International Biosphere Reserve in 1980. It is the largest island in Lake Superior. Keweenaw National Historical Park was established in 1992 and celebrates the life and history of the Keweenaw Peninsula, part of the Upper Peninsula of Michigan, and located on Lake Superior. National Lakeshores within the GLB include Apostle Islands, Pictured Rocks, Indiana Dunes, and Sleeping Bear Dunes. The Apostle Islands National Lakeshore consists of 21 islands and 12 mi (19 km) of mainland encompassing a total of 69,372 ac (28,703 ha) on the northern tip of Wisconsin in Lake Superior. Pictured Rocks National Lakeshore hugs the south shore of Lake Superior in Michigan's Upper Peninsula and encompasses 73,236 ac (29,637 ha). Indiana Dunes National Lakeshore, located on the southern shore of Lake Michigan in Indiana, encompasses 15 mi of lakeshore and a total acreage of 15,067 ac (6,097 ha). Natural features include dunes, wetlands, prairies, rivers, and forests. Lastly is Sleeping Bear Dunes National Lakeshore located along the northwest coast of Michigan's Lower

Peninsula and encompassing 71,198 ac (28,812 ha). The area provides miles of sand beach, bluffs that tower 450 ft. (137 m) above Lake Michigan, lush forests, clear inland lakes, and unique flora and fauna.

The six National Forests located within the GLB are Chippewa National Forest; Superior National Forest; Chequamegon-Nicolet National Forest; Ottawa National Forest; Huron-Manistee National Forest; and Finger Lakes National Forest. Located in Minnesota are Chippewa and Superior National Forests which were established in 1908 and 1909, respectively. Chippewa National Forest covers approximately 666,623 ac (269,772 ha) of which approximately 75% is within the Leech Lake Indian Reservation. The Superior National Forest encompasses approximately 3,900,000 ac (1,578,274 ha) which includes some 2,000 lakes and rivers, more than 1,300 mi (2,100 km) of cold water stream, and 950 mi (1,530 km) of water streams. In addition, there is a small true boreal forest and mixed conifer-hardwood forest located here. Chequamegon-Nicolet National Forest was established in 1933 and is located along the southern shoreline of Lake Superior in Wisconsin. Chequamegon-Nicolet encompasses approximately 1,530,647 ac (619,430 ha) and includes remove areas of uplands, bogs, wetlands, muskegs, rivers, streams, pine savannas, meadows and numerous glacial lakes. The Ottawa National Forest covers approximately 993,010 ac (401,860 ha) of Michigan's Upper Peninsula and was established in 1931. The Huron-Manistee National Forest were combined in 1945, with the Huron Forest having been established in 1909 and the Manistee Forest having been established in 1938. They encompass a total of 978,906 ac (396,149 ha) which includes 5,786 ac (2,341 ha) of wetlands extending across the northern portion of Michigan's Lower Peninsula. Lastly is the Finger Lakes National Forest in located near Lake Ontario in New York. It was established in 1985 and encompasses 16,259 ac (6,579 ha).

There are three NWRs within the GLB—Michigan Islands, Seney, and West Sister Island. Michigan Islands NWR was established in 1943 and encompasses 744 ac (301 ha). There are eight islands within this refuge that are scattered between Lake Michigan and Lake Huron. They were originally set aside as resting habitat for migratory birds traversing the Great Lakes Flyway. The Seney NWR was established in 1935 and encompasses 95,265 ac (38,552 ha). Similar to Michigan Islands NWR, Seney was set aside for migratory bird habitat, but also provides habitat for North American river otters, beavers, moose, black bears, and gray wolves. Lastly is the West Sister Island NWR established in 1937 and encompassing 77 ac (31 ha) in the western basin of Lake Erie.

The 20 National Wilderness Preserves within the GLB: Boundary Waters Canoe Area (MN), Blackjack Springs (WI), Gaylord Nelson (WI), Headwaters (WI), Porcupine Lake (WI), Rainbow Lake (WI), Whisker Lake (WI), Beaver Basin (MI), Big Island Lake (MI), Delirium (MI), Horseshoe Bay (MI), Huron Islands (MI), Mackinac (MI), Magic Mountain (MI), McCormick (MI), Nordhouse Dunes (MI), Rock River Canyon (MI), Round Island (MI), Sturgeon River Gorge (MI), and Sylvania (MI). Combined acreage for all 20 National Wilderness Preserves is 1,283,590 ac (519,450 ha).

In addition to National Parks/Historic Parks/Lakeshores/Forests/Wildlife Refuges/Wilderness Areas, there are numerous state parks, wayside areas, nature preserves, fish and wildlife management areas, and forests within the GLB (**Error! Reference source not found.** B-2 and Table B-5).

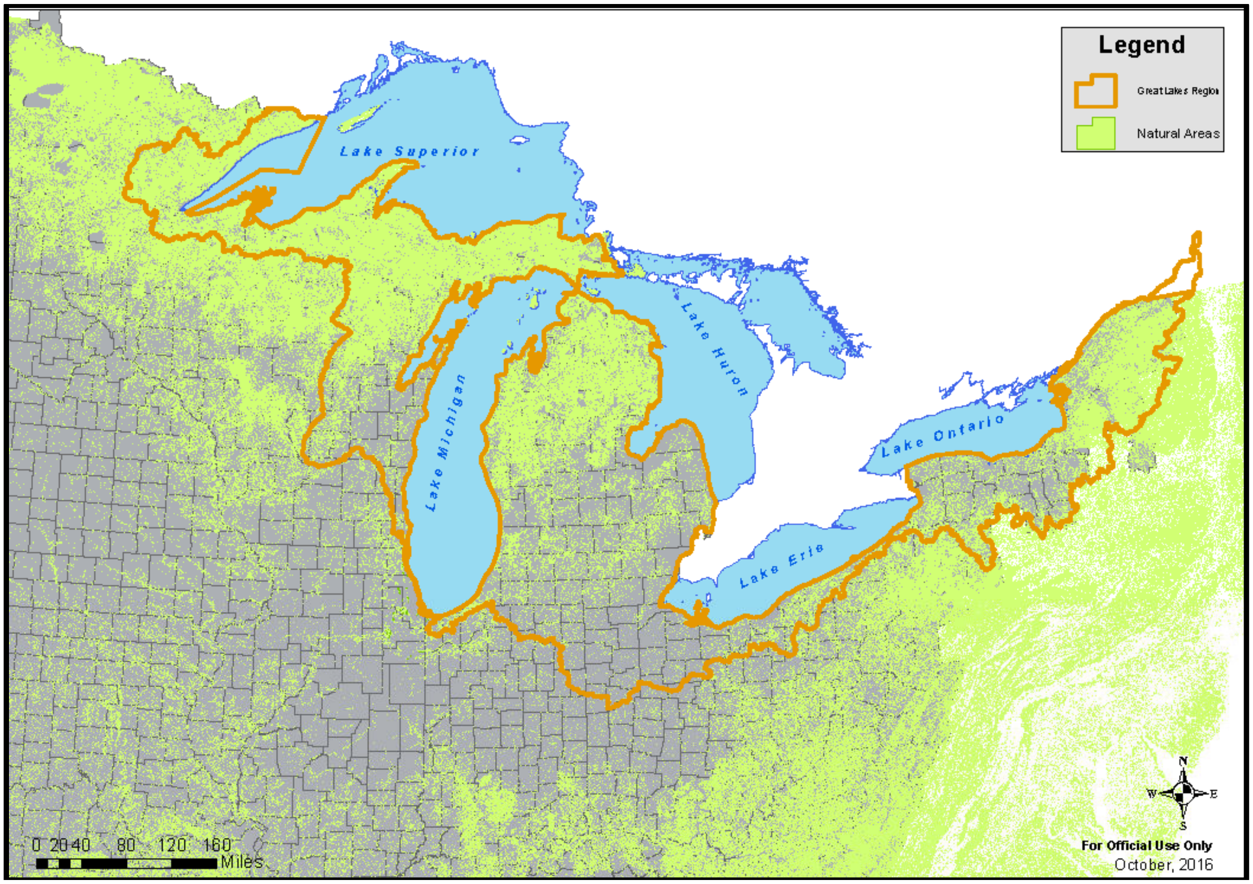

Figure B-2: Location of Natural Areas within the GLB

Table B-5: State Parks, Wilderness Areas, and Wildlife Management Areas (WMA) Within the GLB

Minnesota			
Grand Portage State Park	Judge C.R. Mageny State Park	Jay Cooke State Park	Cascade River State Park
Temperance River State Park	George Crosby Manitou State Park	Tettegouche State Park	Gooseberry Falls State Park
Split Rock Lighthouse State Park	Caribou Falls State Wayside Park	Cross River State Wayside Park	Devil Track State Wayside Park
Flood Bay State Wayside Park	Kadunce State Wayside Park	Ray Berglund State Wayside Park	
Wisconsin			
Big Bay State Park	Copper Culture State Park	Potawatomi State Park	Peninsula State Park
Rock Island State Park	Newport State Park	Whitefish Dunes State Park	Point Beach State Park
Fischer Creek State Park	Kohler-Andrae State Park	Harrington Beach State Park	Lakeshore State Park
Illinois			
Illinois Beach			
Indiana			
Indiana Dunes State Park			
Michigan			
Porcupine Mountains State Park	McLain State Park	Fort Wilkins Historic State Park	Baraga State Park
Muskallonge Lake State Park	Brimley State Park	Wells State Park	Fayette Historic State Park
Palms Book State Park	Fr. Marquette Memorial Scenic Site	Strait’s State Park	Colonial Michilimackinac Historic State Park
Wilderness State Park	Petoskey State Park	Fisherman’s Island State Park	Keith J. Charters Traverse City State Park
Petoskey State Park	Fisherman’s Island State Park	Keith J. Charters Traverse City State Park	Leelanau State Park
Orchard Beach State Park	Ludington State Park	Mears State Park	Silver Lake State Park
Duck Lake State Park	Muskegon State Park	Hoffmaster State Park	Grand Haven State Park
Holland State Park	Saugatuck Dunes State Park	Van Buren State Park	Grand Mere State Park
Warren Dunes State Park	Warren Woods State Park	Lime Island State Recreation Area	Mackinac Island State Park
Fort Mackinac Historic Park	Historic Mill Creek Discovery Park	Cheboygan State Park	Hoeft State Park
Thompson’s Harbor State Park	Rockport Recreation Area	Negwegon State Park	Sturgeon Point State Park
Harrisville State Park	Tawa Point State Park	Bay City State Recreation Area	Sleeper State Park
Port Crescent State Park	Lakeport State Park	Sterling State Park	
Ohio			
Maumee Bay State Park	Catawba Island State Park	South Bass Island State Park	Oak Point State Park
Middle Bass Island State Park	North Bass Island State Park	Kelleys Island State Park	East Harbor State Park
Marblehead Lighthouse State Park	Headlands Beach State Park	Geneva State Park	
Pennsylvania			
Erie Bluffs State Park	Presque Isle State Park		
New York			
Lake Erie State Park	Evangola State Park	Woodlawn Beach State Park	Buffalo Harbor State Park
Buckhorn Island State Park	Beaver Island State Park	Niagara Falls State Park	Joseph Davis State Park
Four Mile Creek State Park	Wilson Tuscarora State Park	Olcott Beach Carousel State Park	Golden Hill State Park
Lakeshire State Park	Hamlin Beach State Park	Braddock Bay Park State Park	Braddock Bay Fish and WMA
Island Cottage Woods Preserve	Irondequoit Bay Marine Park	Webster Park	Lake Shore Marshes
Chimney Bluffs State Park	Lake Shore Marshes WMA	Fair Haven Beach State Park	Fort Ontario Park
Mexico Point	Selkirk Shores	Deer Creek Marsh WMA	Sandy Island Beach State Park
Lakeview WMA	Black Pond WMA	El Dorado Beach Preserve	Robert Wehle State Park
Westcott Beach	Long Point		

1.2.2. Biological Resources

Summary of Area Habitat

Lake Superior. The Lake Superior basin is one of the most pristine and unique ecosystems in North America. Sparsely populated even today, Lake Superior has not experienced the same level of development, urbanization, or pollution as the other Great Lakes. More than any of the other Great Lakes, Lake Superior's aquatic communities most closely resemble the original community of the Lake prior to European settlement. However, even Lake Superior's aquatic communities are affected by significant human-caused stresses that threaten to reduce its diversity and proper functioning. Nearshore open water habitat consists of areas where the water depth is less than 262 ft (80 m). Embayments (or bays) are partially enclosed by land and therefore less exposed to wind and wave energy. Together, nearshore areas and bays make up about 20% of Lake Superior's surface area. The most extensive areas of nearshore habitat are at the east and west ends of the lake. Nearshore habitat is also found around Isle Royale and other islands and includes offshore shallow waters, such as the Superior Shoal and the Caribou Island Reef Complex. Major embayments include Black Bay, Nipigon Bay, Thunder Bay, Batchawana Bay, Whitefish Bay, Keweenaw Bay, and Chequamegon Bay. These areas are important because they are more diverse and productive than offshore areas. Most of Lake Superior's fish species use nearshore waters at some stage of their life cycle. Many commercially important fish use nearshore waters exclusively. Aquatic vegetation, needed for food and cover, is found only in nearshore habitats. The native fish community of Lake Superior was and is still dominated by salmon, trout, cisco, and whitefish. Historically, the fish community of the main lake was comprised of lake trout, whitefishes and ciscoes, burbot, sticklebacks, sculpins, and suckers. Lake trout, and to a lesser extent burbot, were the dominant predators. Today, the predator mix has been expanded by the introduction of non-native salmonines like the Chinook Salmon (*Oncorhynchus tshawytscha*), but Lake Trout (*Salvelinus namaycush*) remains the dominant predator.

Lake Michigan. Lake Michigan habitat and littoral process within the study area have been altered from the natural state by the installation of engineered structures for recreational and storm damage protection purposes. Over time, the shoreline was sculpted and armored into its present form of headlands, promontories, small harbors, lagoons, piers, and pocket beaches. Natural lacustrine habitat primarily consists of sand flats, beach surf, and open water, with small isolated pockets of aquatic vegetation, limestone shoals, and clay mounds. There are a few natural features of importance, such as Oakland Shoal and Morgan Shoal in Illinois and the clay mounds off the coast of Mt. Baldy in the Indiana Dunes National Lakeshore. It is believed that the limestone outcrops that form Oakland and Morgan Shoals were historic spawning reefs for Lake Michigan whitefish (*Coregonus* spp.) species. It is known that the clay mounds off of Mt. Baldy provide critical spawning habitat for Yellow Perch (*Perca flavescens*), among other nearshore fish and invertebrate species.

Lake Huron. Lake Huron is a unique system within the GLB. It is made up of four bodies of water: the North Channel, Georgian Bay, Saginaw Bay and Lake Huron proper (MDEQ 2002). This Great Lake is considered the "lake in the middle" because it receives water from two of the Great Lakes, Lakes Superior and Michigan, and it sends its water to Lakes Erie and Ontario. Lake Huron has the longest shoreline of all the Great Lakes and has more islands than any other lake in the world. It has over 30,000 islands, including Manitoulin Island, the largest island in any freshwater lake. The large number of islands, along with the low level of human impact on both sides of Lake Huron, create ideal habitat for many unique plants and animals, some even globally rare. All of these qualities contribute to the significance and importance of the Lake Huron and its basin. 6-Fathom Bank and Drummon Island Reef were the important mainstays of Lake Huron's Lake Trout reproduction and still are the source of lake whitefish reproduction. Reefs suitable for lake trout reproduction are bedrock or glacial formations of clean stone and bedrock that offer aerated crevices and pockets for eggs to incubate. They are critical habitat for lake trout, which were historically the keystone predator of Lake Huron (MDEQ 2002).

Lake Erie. Habitat within Lake Erie has been lost and degraded over the years due primarily to human activities. Because of the shallowness of the lake and low water volume, it tends to be more susceptible to environmental changes. In recent years, reduced nutrient and contaminant loadings, and the establishment of zebra mussels have resulted in a shift towards a low eutrophic (i.e., highly productive) system. The habitat surrounding the lake is characterized by sand beaches, dunes, wetlands, and oak savannas. In general, species composition in the lake differs from that of the other lakes due to higher water temperatures and its more southern geographic location. Over 140 species of fish have been documented from the Lake Erie Basin (USACE 2002). Additionally, the Lake Erie Watersnake occurs exclusively within the Lake Erie basin and was once listed by the USFWS as federally threatened, but was delisted in 2011.

Lake Ontario. Similar to the other Great Lakes, habitat within Lake Ontario has been impacted over time from human activities occurring within the lake and surrounding watershed. Changes in species composition, productivity, and energy flow dynamics have occurred as a result of human intervention in the basin (USACE 2002). Water quality initiatives and the spread of Zebra mussels appear to be resulting in a shift towards a more oligotrophic (i.e., unproductive) lake. The shoreline of Lake Ontario supports numerous habitat types such as bays, sand dunes, beaches, spits, wetlands, and unconsolidated bluffs. Additionally, the Lake once supported approximately 140 fish species.

Plant Communities

Lake Superior. The southeastern portion of Lake Superior lies within the Northern Lacustrine-Influenced Upper Michigan and Wisconsin Ecoregion which is generally characterized by peatland and swamp forest (Reid and Holland 1996). Ancient beach ridges and swales can be found here, sometimes a distance from the shore. Sand dunes, sand spits, and beach ridges are also common. Red and jack pine dominated the ridge and swale topography prior to European settlement. Stressors have included logging and draining of the swamps for agriculture. The southwestern portion of Lake Superior lies within the Northern Continental Michigan, Wisconsin, and Minnesota ecoregion. Historically occurring plant communities included northern hardwood forests. Red and white pine, red oak, and paper birch were also common. Additionally within the area prior to European settlement was boreal forest, but logging, mining, and development have altered the historic plant communities. The northwestern portion of Lake Superior is in the Northern Minnesota ecoregion. Prior to European settlement, conifers dominated the vegetation, with some hardwoods. Heavy logging in the early 20th century changed the composition of the forest, replacing original red and white pines with jack and red pine plantations (Reid and Holland 1996).

Lake Michigan. The northeastern portion of Lake Michigan lies within the Northern Lacustrine-Influenced Lower Michigan Ecoregion (Reid and Holland 1996). Significant features within this area are primarily islands with perched sand dunes, other high dune areas, and dune and swale ridges. Prior to European settlement, northern hardwood forest dominated the dunes (Reid and Holland 1996).

The southeastern portion of Lake Michigan extending from Muskegon, Michigan, through the Calumet Region of northwest Indiana and into the southeast side of Chicago is the South Central Great Lakes ecoregion (Reid and Holland 1996). This region is a combination of gently rolling lowlands and flat lacustrine plains. Lakeshore erosion and deposition have contributed to a dune system. Oak-hickory covered dunes, sand beaches, tallgrass prairies, and wetlands characterize plant communities within the area. Industrial and urban development are the primary factors for degradation of plant communities within this region (Reid and Holland 1996).

The southwestern portion of Lake Michigan lies within the Southwestern Great Lakes Morainal and Southeastern Wisconsin Savanna ecoregions (Reid and Holland 1996). The area is primarily flat, with gently sloping moraines and end moraine ridges that were characterized by dune and swale, oak savanna, and tallgrass prairie communities. Remnants of these communities have been preserved primarily within two natural areas: Chiwaukee Prairie in Wisconsin and Illinois Beach State Park (Reid and Holland 1996). Of particular note within the Lake Michigan shoreline, are the presence of native plants that are considered endemic (occurring only within the Great Lakes). Examples include dwarf lake iris (*Iris lacustris*), pitcher's thistle (*Cersium pitcheri*), and Houghton's goldenrod (*Solidago houghtonii*) which are all associated with Lake Michigan terrestrial habitats, including dunes, beaches, and lakeplain prairies. Federally threatened Dwarf Lake Iris (*Iris lacustris*) grows around the Great Lakes, near the northern shores of Lakes Huron and Michigan in Michigan, Wisconsin, and Ontario, Canada. Further up, between the Illinois-Wisconsin state line and Port Washington, Wisconsin, along Lake Michigan's southeast shore is a gently sloping region where rare plant communities include tallgrass prairie, oak savannah, and fens. Predominant forest of the area is sugar maple-basswood forest. Prior to European settlement, white and black oaks were likely present. Additionally, marshes and sedge meadows were common. Inland, there are still remnants of bog and marsh habitat, although these sites have experienced fragmentation due to urban expansion (Reid and Holland 1996).

The northwestern portion of Lake Michigan is located in the Northern Lacustrine-Influenced Upper Michigan and Wisconsin ecoregion which is characterized by peatland and swamp forest (Reid and Holland 1996). Common landforms along the shoreline include transverse dunes, sand spits, beach ridges, and deltas. Rare alvar plant community is also found here. Prior to European settlement, the region was covered by northern hardwood forest, jack pine barren, white and red pine forest, conifer swamp, and hardwood-conifer swamp. Extensive marshes were also found along the shoreline. Further north along the Lake Michigan shoreline which includes the Door Peninsula, Wisconsin, the shoreline was historically characterized by dune and swale topography with ridges of white or red pine, white spruce, balsam fir, and hardwoods. Jack pine barrens were also prevalent in limited areas. Logging and agriculture altered that landscape originally, with urban development being the primary stressor to high quality plant communities (e.g., alvar, interdunal wetlands, etc.) currently (Reid and Holland 1996).

Lake Huron. The southeastern portion of Lake Huron lies within the Southern Lower Michigan ecoregion (Reid and Holland 1996). Prior to European settlement, this region was predominately marshes with low beach ridges and sand pits with white and black oak. In addition, wet prairies, prairies, oak savannas, white pine, and hemlock were also characteristic of the area. This area supported rare plant, animal, and waterfowl species associated with coastal marshes, wet prairies, and savanna plant communities. Extensive diking and draining of marsh and wet prairies has significantly altered this region.

The southwestern portion of Lake Huron lies within the Northern Lacustrine-Influenced Lower Michigan Ecoregion. Prior to European settlement, Jack pine barrens dominated the area north of Saginaw Bay, with white pine, red pine, and black and white oak also occurring. Embayments along the Saginaw Bay shoreline were bog or shrub swamps with jack pine barrens. Swamp forests, marshes, and wet prairies dominated low-lying swales, whereas white pine and red oaks dominated the beach ridges. These areas have been altered through draining for agricultural use (e.g., pasture and row crops), timber, and recreation (Reid and Holland 1996). As mentioned, Saginaw Bay is located within this area, which is the largest freshwater coastal wetland in the United States spanning 1,143 mi^2 (2,961 km^2). Tobico Marsh, within Saginaw Bay, is one of the best quality, freshwater marshes in the north central U.S. because of its large size, relatively undisturbed condition, and the variety of aquatic plants. Many coastal wetlands can also still be found in areas along the St. Mary's River, the North Channel, Les Cheneaux Islands, Saginaw Bay, eastern shore of Georgian Bay, Northern Michigan, and Northern Ontario.

Lake Erie. The shoreline of Lake Erie falls within the Erie and Ontario Lake Plain ecoregion, which extends along the southern end of Lake Ontario and the St. Lawrence Seaway as well (Reid and Holland

1996). The southern shoreline of Lake Erie may be characterized by the presence of sand beaches and dunes as well as wetlands and oak openings that are a part of the Maumee Basin. Predominant forest types within the southern Lake Erie region include oak-hickory-ash dry forest, northern hardwood forest, black oak-white oak woodland, red-maple-black ash swamps, northern hardwood forests, northern white cedar forests, and pine-heath woods. Beechgrass dunes are also prevalent within the area along with numerous sand beaches. Along the Michigan portion of Lake Erie or the western side of the lake, this area was historically forested with wetlands. Supported plant communities included oak barrens, wet prairies, and marshes. The greatest impact to the plant communities within the ecoregion has been the draining and conversion of the land to agriculture which has left few high-quality remnants (Reid and Holland 1996).

Lake Ontario. As mentioned above, the Lake Ontario shoreline falls within the Erie and Ontario Lake Plain ecoregion (Reid and Holland 1996). From the St. Lawrence Seaway along the eastern portion of Lake Ontario, is an irregular lowland with bays, sand dunes, beaches, and spits, wetlands, and unconsolidated bluffs. Forests of oak, hickory, and ash, white cedar forests, and alvar wetlands are predominate plant communities. Numerous sand beaches also dot the southeastern shoreline. Extending from the southeastern shoreline to the western shoreline of Lake Ontario are sand beaches, bays, forests of oak-hickory-ash, chinquapin oak, and white cedar limestone woodlands. Areas within this region were drained for orchards (Reid and Holland 1996).

Aquatic Resources

Macroinvertebrate Communities

Lake Superior. Scharold et al. (2009) investigated macroinvertebrate assemblages in southern nearshore Lake Superior in 1994, 2000, and 2003. During the study, 97 species were collected from 11 families. Families collected included: Sphaeriidae, Pontoporeiidae, Lumbriculidae, Enchytraeidae, Naididae, Aeolosomatidae, Chironomidae, Ceratopogonidae, Ephemeridae, and Apataniidae. The dominant species of the macroinvertebrate community was Diporeia (i.e., Family Pontoporeiidae), an amphipod that serves as an important food item for many species of fish. The following families were ranked 2nd through 4th in dominance of the macroinvertebrate assemblage, respectively: Oligochaete, Sphaeriidae, and Chironomiidae.

In relation to the other lakes, the biomass of phytoplankton and zooplankton within Lake Superior is very low due to it being an ultra-oligotrophic lake. Highest densities of phytoplankton and zooplankton communities are typically found along nearshore areas, especially embayments where higher nutrient concentrations may be found. In deep water areas of Lake Superior, benthic macroinvertebrate communities, such as mollusks and aquatic insects, are extremely scarce (University of Wisconsin Extension 2007).

Lake Michigan. Garza and Whitman of the United States Geological Survey investigated macroinvertebrate assemblages of southern Lake Michigan and observed macroinvertebrates from 40 taxa (Garza and Whitman). Approximately 81% of the observed taxa consisted of *Chaetogaster diastrophus* and Nematoda. Nalepa et al. (1998) also conducted surveys throughout southern Lake Michigan that encompasses areas adjacent to the City of Chicago. Their study identified three main groups of macroinvertebrates including Diporeia (Amphipoda), Oligochaeta (worms), and Sphaeriidae (bivalves).

Both phytoplankton and zooplankton communities of Lake Michigan have seen notable decreases in size and extent during the spring season (Environment Canada and USEPA 2014). Larger-sized zooplankton species, typically located in water of low biotic productivity, are making up an increasing proportion of the community during the summer, while smaller zooplankton decline. *Diporeia*, a small, native, shrimp-like species, was once the main food source for small fish but is now almost completely extirpated. Small fish have been forced to change their diets due to the *Diporeia* decline, which has resulted in reductions in small fish weight and energy.

The overall decline of zooplankton has strong implications for the food web because these organisms are an important link between phytoplankton and healthy fish populations. Preyfish population numbers are near historic lows in Lake Michigan for several species, such as Alewife, Rainbow Smelt, and Deepwater Sculpin (Environment Canada and USEPA 2014).

Lake Huron. Nalepa et al. (2003) investigated the trends in benthic macroinvertebrate populations in inner and outer Saginaw Bay, Lake Huron, from 1987 to 1996. Major taxa included Oligochaeta, Chironomidae, Amphipoda, and Sphaeriidae. Surveys conducted in 2002 and 2003 of Lake Huron's main basin, Georgian Bay, and North Channel showed similar results to the surveys conducted between 1987 and 1996 (Nalepa et al. 2007). Major taxa for the main basin included Diporiea spp., Oligochaeta, Sphaeriidae, and Chironomidae; while dominant taxa for Georgian Bay and North Channel included Diporiea, Oligochaeta, Sphaeriidae, and Dreissena spp. In general, results from both studies suggest that the total density of the four major benthic taxa (e.g., *Diporiea* spp., Oligochaeta, Sphaeriidae, and Chironomidae) declined between the early 1970s and 2000.

Nalepa et al. (2007) surveyed the benthic macroinvertebrate community of Lake Huron's main basin in 2000 and 2003, and Georgian Bay and North Channel in 2002. In general, results suggested that the total density of the four major benthic taxa (e.g., Diporiea spp., Oligochaeta, Sphaeriidae, and Chironomidae) in the main basin declined between early 1970s and 2000. Major taxa collected in Georgian Bay and North Channel included Diporeia, Oligochaeta, Sphaeriidae, *Dreissena* spp.

Lake Erie. A survey of the benthic macroinvertebrate assemblage in the nearshore zone of Lake Erie was conducted during fall 2009 (Scharold et al. 2015). During the survey, 82 taxa were collected encompassing 23 families. The macroinvertebrate assemblage was dominated by *Dreissena* spp. which accounted for 63% of total organisms collected. Other dominant taxa included Oligochaete, Chironomidae, Hexagenia, Amphipods, Gastropods, and Sphaeriidae.

Lake Ontario. Lozano et al. (2001) investigated macroinvertebrate assemblages within Lake Ontario and how they have changed since the 1970s when the majority of data for Lake Ontario was collected and published. Surveys of the macroinvertebrate community were conducted in Lake Ontario during 1994 and 1997. Dominant taxa included *Diporeia* spp., Oligochaeta, and Sphaeriidae which comprised 91-99% of all macroinvertebrates collected. Other taxa collected included *Dreissena* spp., Naididae, Tubificidae, and Chironomidae. In general, the study found that densities of macroinvertebrates within Lake Ontario, especially Diporeia spp., Oligochaeta, and Sphaeriidae were significantly lower when compared to studies conducted in 1964 and 1972. The primary culprit for the decrease is believed to be the invasion of *Dreissena* spp. into the Great Lakes ecosystem. The negative impact of *Dreissena* spp. on Diporeia and other benthic macroinvertebrate species is attributed to its high filtering capacity and large population densities.

Freshwater mussels found within the GLB as listed by the USFWS in their draft CAR are presented in Table B-6.

Table B-6: Freshwater Mussel Species Recorded from the Great Lakes Basin

Common Name	Scientific Name
Black Sandshell	*Ligumia recta*
Bluff Vertigo	*Vertigo meramecensis*
Butterfly	*Ellipsaria lineolata*
Clubshell	*Pleurobema clava*
Eastern Pondshell	*Ligumia nasuta*
Ebonyshell	*Fusconaia ebena*
Elephant-ear	*Elliptio crassidens crassidens*
Elktoe	*Alasmidonta marginata*
Ellipse	*Venustaconcha ellipsiformis*
Fawnsfoot	*Truncilla donaciformis*
Fluted-shell	*Lasmigona costata*
Green Floater	*Lasmigona subviridis*
Hickorynut	*Obovaria olivaria*
Higgins Eye	*Lampsilis higginsii*
Lilliput	*Toxolasma parvum*
Monkeyface	*Quadrula metanevra*
Mucket	*Actinonaias ligamentina*
Northern Riffleshell	*Epioblasma torulosa rangiana*
Pink Papershell	*Potamilus ohiensis*
Pistolgrip	*Tritogonia verrucosa*
Pondhorn	*Uniomerus tetralasmus*
Pondmussel	*Ligumia subrostrata*
Purple Lilliput	*Toxolasma lividus*
Purple Wartyback	*Cyclonaias tuberculata*
Rabbitsfoot	*Quadrula cylindrical cylindrical*
Rainbow	*Villosa iris*
Rayed Bean	*Villosa fabalis*
Rock Pocketbook	*Arcidens confragosus*
Round Hickorynut	*Obovaria subrotunda*
Round Lake Floater	*Pyganodon subgibbosa*
Salamander Mussel	*Simpsonaias ambigua*
Sheepnose	*Plethobasus cyphyus*
Slippershell Mussel	*Alasmidonta viridis*
Snuffbox	*Epioblasma triquetra*
Spectaclecase	*Cumberlandia monodonta*
Spike	*Elliptio dilatata*
Threehorn Wartyback	*Obliquaria reflexa*
Wartyback	*Quadrula nodulata*
Washboard	*Megalonaias nervosa*
Wavyrayed Lampmussel	*Lampsilis fasciola*
White Catspaw	*Epioblasma obliquata perobliqua*
Winged Mapleleaf	*Quadrula fragosa*
Yellow Sandshell	*Lampsilis teres*

CAWS. The MWRDGC used to sample the macroinvertebrate community within the Calumet River System and Chicago River System as part of the Ambient Water Quality Monitoring program. The last time data was collected by MWRDGC was 2010. Data from 2010 was published by MWRDGC (MWRDGC 2012, Table B-7) and are presented below in an effort to describe the macroinvertebrate communities in the two systems.

Table B-7: Macroinvertebrates Collected from the Calumet and Chicago River Systems in 2005.

Taxa	Calumet River System	Chicago River System	
		NSC	CSSC
Ablabesymia annulata		X	
Ablabesymia mallochi	X	X	
Ablabesymia janta	X		X
Argia	X		
Baetis intercalaris		X	
Bithynia tentaculata	X		
Caecidotea	X	X	
Cercaclea maculata		X	
Chironomus	X	X	
Cladopelma		X	
Cladotanytarsus mancus grp.			X
Coelotanypus	X		
Collembola	X		
Corbicula fluminea	X		X
Cricotopus bicinctus grp.	X	X	X
Cricotopus sylvestric grp.		X	X
Cricotopus tremulus grp.		X	
Cryptochironomus	X	X	X
Crypto tendipes		X	
Cyrnellus fraternus	X		X
Dicrotendipes fumidus		X	
Dicrotendipes modestus	X	X	
Dicrotendipes simpsoni	X	X	X
Dicrotendipes neomodestus	X		X
Dreissena polymorpha	X	X	
Dubiraphia			X
Enallagma	X	X	
Ferrissia	X		X
Gammarus	X	X	X
Glyptotendipes	X	X	X
Gyraulus		X	
Helisoma	X	X	X
Helobdella stagnalis		X	
Helobdella triserialis		X	X
Hyalella azteca	X	X	X
Hydra	X	X	X
Hydropsyche			X
Hydroptila	X		X
Menetus dilatatus		X	
Mooreobdella microstoma	X	X	
Musculium			X
Nanocladius distinctus	X	X	X
Oligochaeta	X	X	X
Parachironomus	X	X	X
Parakiefferiella	X	X	
Paratanytarsus	X	X	
Phaenopsectra obediens grp.		X	
Phaenopsectra punctipes grp.		X	

Taxa	Calumet River System	Chicago River System	
		NSC	CSSC
Physa	X	X	X
Pisidium	X	X	
Plumatella	X		X
Polypedilum flavum		X	X
Polypedilum halterale grp.	X	X	X
Polypedilum illinoense		X	
Polypedilum scalaenum grp.			X
Porifera	X		
Procladius	X	X	X
Psectrocladius	X		
Psectrotanypus		X	
Pseudochironomus			X
Sisyridae	X		
Sphaerium		X	
Stenacron			X
Stenochironomus	X		X
Tanypus		X	
Tanytarsus		X	
Thienemannimyia grp.		X	X
Thienemannimyia similis			X
Turbellaria	X	X	X
Urnatella gracilis			X
Xenochironomus xenolabis	X		X

Des Plaines River. Table B-8 shows a detailed list of the macroinvertebrate community found within the Des Plaines River system. It is important to note that the last year MWRDGC collected benthic invertebrate samples was 2010, and samples are no longer collected by MWRDGC (St. Pierre 2017). Additionally, the samples collected by MWRDGC between 2001 and 2004 and presented in Table B-8, were entirely from the Upper Des Plaines River as it is defined by the Illinois Environmental Protection Agency (IEPA) and Illinois Department of Natural Resources (Illinois DNR) (St. Pierre 2017). However, this report defines the Upper Des Plaines River as the portion of the watershed upstream of the confluence with Salt Creek. This definition of the Des Plaines River is in agreement with the USACE Upper Des Plaines River and Tributaries, IL and WI Integrated Feasibility Report and Environmental Assessment (USACE 2015). Therefore, the 2010 MWRDGC sample data was divided based on location sampled into either the Upper Des Plaines River or Lower Des Plaines River based on this reports definition of the Upper Des Plaines River.

For a detailed list of the mussel assemblage within the Des Plaines River system refer to Table B-9 and Table B-10.

Table B-8 Macroinvertebrates Collected from the Lower and Upper Des Plaines River Between 2001 and 2004 by the MWRDGC[1].

Taxa	Reach	
	UpperDes Plaines	Lower Des Plaines
Hydra	X	X
Nematoda		X
Turbellaria	X	X
Urnatella gracilis	X	
Plumatella	X	X
Oligochaeta	X	X
Helobdella stagnalis	X	X
Helobdella triserialis	X	X
Placobdella pediculata	X	
Mooreobdella microstoma	X	X
Ostracoda	X	X
Caecidotea	X	X
Gammarus		X
Gammarus fasciatus	X	X
Orconectes		X
Orconectes virilis		X
Hydracarina	X	X
Isonychia	X	
Baetis flavistriga		X
Baetis intercalaris	X	X
Pseudocloeon ephippiatum	X	
Heptagenia	X	
Leucrocuta	X	X
Stenacron	X	X
Stenonema	X	X
Stenonema exiguum	X	
Stenonema integrum	X	X
Stenonema terminatum	X	X
Caenis	X	X
Tricorythodes	X	X
Anthopotamus myops grp.	X	X
Hexagenia	X	
Hexagenia bilineata	X	
Perlesta	X	
Argia	X	X
Enallagma	X	
Stylurus	X	
Sialis	X	
Somatachlora	X	
Trepobates		X
Corixidae		X
Palmacorixa		X
Cyrnellus fraternus	X	X
Ceratopsyche morosa	X	X
Cheumatopsyche	X	X

[1] MWRDGC. Benthic Invertebrate Data Chicago Area Waterways 2001-2004. Accessed at: https://www.mwrd.org/irj/portal/anonymous/WQM

Taxa	Reach	
	UpperDes Plaines	**Lower Des Plaines**
Hydropsyche	X	X
Hydropsyche betteni	X	X
Hydropsyche bidens	X	X
Hydropsyche orris		X
Hydropsyche simulans	X	X
Hydropsychidae	X	
Cheumatopsyche	X	
Potamyia flava	X	X
Culicoides		X
Hydroptila	X	X
Petrophila		X
Laccophilus maculosus	X	
Ancyronyx variegata	X	
Dubiraphia	X	
Macronychus glabratus	X	X
Stenelmis	X	X
Stenelmis crenata grp.	X	X
Ceratopogon	X	
Ceratopogonidae	X	
Hemerodromia		X
Simulium	X	X
Chironomidae	X	X
Ablabesmyia janta	X	X
Ablabesmyia mallochi		X
Natarsia sp. A		X
Nilotanypus fimbriatus	X	X
Procladius (Holotanypus)	X	X
Tanypus	X	
Thienemannimyia grp.	X	X
Corynoneura		X
Corynoneura lobata	X	X
Cricotopus bicinctus grp.	X	X
Cricotopus sylvestris grp.	X	
Cricotopus tremulus grp.	X	X
Cricotopus trifascia grp.		X
Cricotopus/Orthocladius		X
Nanocladius		X
Nanocladius	X	X
Nancladius distinctus	X	X
Orthocladius		X
Parakiefferiella	X	
Rheocricotopus robacki	X	X
Thienemanniella similis	X	X
Thienemanniella xena	X	X
Tvetenia discoloripes grp.		X
Chironomus	X	X
Cladopelma	X	
Cryptochironomus	X	X
Dicrotendipes	X	X
Dicrotendipes neomodestus	X	X

Taxa	Reach	
	UpperDes Plaines	**Lower Des Plaines**
Dicrotendipes simpsoni	X	X
Dicrotendipes nigricans	X	
Glyptotendipes	X	X
Harnischia	X	X
Microtendipes	X	
Parachironomus		X
Paracladopelma	X	X
Polypedilum fallax grp.		X
Polypedilum flavum	X	X
Polypedilum halterale grp.	X	X
Polypedilum illinoense	X	X
Polypedilum scalaenum grp.	X	X
Saetheria	X	
Stenochironomus	X	X
Stictochironomus	X	
Tribelos fuscicorne	X	X
Cladotanytarsus mancus grp.	X	X
Cladotanytarsus vanderwulpi grp.	X	X
Paratanytarsus	X	
Rheotanytarsus	X	X
Tanytarsus	X	X
Tanytarsus guerlus grp.	X	X
Amnicola	X	X
Campeloma decisum	X	
Ferrisssia	X	X
Physa	X	X
Pleuroceridae		X
Pleurocera	X	X
Menetus dilatatus	X	X
Corbicula fluminea	X	X
Dreissena polymorpha		X
Musculium	X	X
Musculium transversum	X	X
Pisidium	X	X
Sphaerium	X	X

Table B-9: Freshwater Mussel Species Observed in the Mainstem Des Plaines River by INHS During 2009-2011 Surveys[2]

Common Name	Scientific Name	Location					
		Upstream Mainstem			Downstream Mainstem		
		Live	Dead[1]	Relict[2]	Live	Dead[a]	Relict[b]
White Heelsplitter	*Lasmigona complanata*	X					
Fluted-shell	*Lasmigona costata*						X
Giant Floater	*Pyganodon grandis*	X	X			X	
Paper Pondshell	*Utterbackia imbecillis*		X				X
Fatmucket	*Lampsilis siliquoidea*		X				X

[1] Dead refers to shells from mussels that are recently deceased (e.g., shell interior shiny, fleshy material may be present)
[2] Relict refers to shells from mussels that have been deceased for an extended period of time (e.g., exterior of shell appears weathered, faded shell interior, absence of fleshy material)

Table B-10: Freshwater Mussel Species Observed in Tributaries to the Des Plaines River by INHS During 2009-2011 surveys[3].

Common Name	Scientific Name	Location								
		Upstream Tributaries			Downstream Tributaries (Above BRLD)			Downstream Tributaries (Below BRLD)		
		Live	Dead[a]	Relict[b]	Live	Dead[a]	Relict[b]	Live	Dead[a]	Relict[b]
Elktoe	*Alasmidonta marginata*									X
Slippershell	*Alasmidonta viridis*			X						
Cylindrical Papershell	*Anodontoides ferussacianus*	X		X						X
White Heelsplitter	*Lasmigona complanata*	X						X	X	
Creek Heelsplitter	*Lasmigona compressa*						X			
Giant Floater	*Pyganodon grandis*	X	X		X			X	X	
Creeper	*Strophitus undulates*								X	X
Paper Pondshell	*Utterbackia imbecilis*		X					X	X	
Threeridge	*Amblema plicata*		X	X			X			
Wabash Pigtoe	*Fusconaia flava*			X			X			X
Plain Pocketbook	*Lampsilis cardium*							X	X	
Fatmucket	*Lampsilis siliquoidea*	X				X		X	X	X
Liliput Shell	*Toxolasma parvum*		X	X					X	X
Ellipse	*Venustaconcha ellipsiformis*		X	X			X			X
Rainbow Mussel	*Villosa iris*									X

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[2] Price, A.L, D.K. Shasteen, and S.A. Bales. 2012. Freshwater Mussels of the Des Plaines River and Lake Michigan Tributaries in Illinois. Illinois Natural History Survey Technical Report 2012(10), Prepared for Illinois Department of Natural Resources: Office of Resource Conservation. 20 pp. Accessed at: https://www.ideals.illinois.edu/bitstream/handle/2142/46026/INHS2012_10.pdf?sequence=2

[3] Price, A.L, D.K. Shasteen, and S.A. Bales. 2012. Freshwater Mussels of the Des Plaines River and Lake Michigan Tributaries in Illinois. Illinois Natural History Survey Technical Report 2012(10), Prepared for Illinois Department of Natural Resources: Office of Resource Conservation. 20 pp. Accessed at: https://www.ideals.illinois.edu/bitstream/handle/2142/46026/INHS2012_10.pdf?sequence=2

Illinois River. In 2004, the USGS collected macroinvertebrates from the Illinois River at Ottawa, Illinois (USGS 2004). Approximately 40 taxa were collected during the survey (Table B-11).

From 2009 to 2012, INHS surveyed freshwater mussel species within tributaries of the Upper, Middle, and Lower Illinois River. For a list of the freshwater mussel species collected during the INHS survey, refer to **Error! Reference source not found.** B-12 (Stodola et al. 2013).

Table B-11: Macroinvertebrates Collected from the Illinois River at Ottawa, Illinois by the USGS in 2004[4].

Taxon	Taxon
Naididae	Tvetenia sp.
Tubificidae	Thienemannimyis grp.
Acari	Ablabesmyia sp.
Dineautus assimilis	Tricorythodes sp.
Hemerodromia sp.	*Centroptilum/Procloeon* sp.
Chironomidae	*Pseudocloeon* sp.
Chironominae	*Stenonema mexicanum*
Chironomini	Gerridae
Chironomus sp.	*Petrophila* sp.
Cryptochironomus sp.	Gomphidae
Dicrotendipes sp.	*Hydropsyche bidens*
Glyptotendipes sp.	*Hydropsyche orris*
Parachironomus sp.	*Cyrnellus fraternus*
Polypedilum sp.	*Nectopsyche candida*
Stenochironomus sp.	Hydroptilidae
Rheotanytarsus sp.	*Hydroptila* sp.
Cricotopus bicinctus grp.	*Gammarus* sp.
Cricotopus sp.	*Corbicula* sp.
Cricotopus/Orthocladius sp.	*Physa* sp.
Nanocladius sp.	Nematoda
Orthocladiinae	

[4] USGS. 2004. Benthic Macroinvertebrate Data: Illinois River at Ottawa, IL. Accessed at: http://pubs.usgs.gov/wdr/2005/wdr-il-05/data/bents_96/indices0/05553500.htm.

Table B-12: Freshwater Mussel Species Observed in Tributaries to the Upper, Middle, and Lower Illinois River by INHS During 2009-2012 surveys[5].

Common Name	Scientific Name	Location								
		Upper Illinois River Tributaries			Middle Illinois River Tributaries			Lower Illinois River Tributaries		
		Live	Dead[a]	Relict[b]	Live	Dead[a]	Relict[b]	Live	Dead[a]	Relict[b]
Elktoe	*Alasmidonta*			X						
Slippershell	*Alasmidonta viridis*	X	X	X			X			
Cylindrical Papershell	*Anodontoides ferussacianus*	X	X	X	X	X	X			X
Rock Pocketbook	*Arcidens confragosus*							X		X
White Heelsplitter	*Lasmigona complanata*	X	X	X	X	X	X	X	X	X
Creek Heelsplitter	*Lasmigona compressa*	X	X	X	X	X	X			
Fluted-shell	*Lasmigona costata*			X						X
Giant Floater	*Pyganodon grandis*		X	X	X	X		X	X	X
Creeper	*Strophitus undulatus*	X	X	X	X		X	X	X	
Paper Pondshell	*Utterbackia imbecillis*				X	X		X		
Threeridge	*Amblema plicata*			X	X	X	X	X		X
Spike	*Elliptio dilatata*						X			
Wabash Pigtoe	*Fusconaia flava*						X			X
Washboard	*Megalonaias nervosa*							X		
Round Pigtoe	*Pleurobema sintoxia*						X			X
Wartyback	*Amphinaias nodulata*								X	
Mapleleaf	*Quadrula quadrula*				X		X	X		X
Pistolgrip	*Tritogonia verrucosa*							X	X	X
Pondhorn	*Uniomerus tetralasmus*				X	X	X		X	X
Plain Pocketbook	*Lampsilis cardium*	X	X	X	X	X				X
Fatmucket	*Lampsilis teres*							X	X	X
Yellow Sandshell	*Lampsilis teres*							X	X	X
Fragile Papershell	*Leptodea fragilis*		X	X	X	X		X	X	X
Pondmussel	*Ligumia subrostrata*						X	X		X
Threehorn Wartyback	*Obliquaria reflexa*							X	X	
Pink Heelsplitter	*Potamilus alatus*				X	X		X		
Pink Papershell	*Potamilus ohiensis*			X	X	X		X	X	X
Liliput Shell	*Toxolasma parvum*	X		X	X	X	X	X		X
Fawnsfoot	*Truncilla donaciformis*					X	X	X		X
Deertoe	*Truncilla truncata*					X		X		
Ellipse	*Venustaconcha ellipsiformis*	X	X	X	X		X			

[a] Dead refers to shells from mussels that are recently deceased (e.g., shell interior shiny, fleshy material may be present)
[b] Relict refers to shells from mussels that have been deceased for an extended period of time (e.g., exterior of shell appears weathered, faded shell interior, absence of fleshy material)

[5] Stodola, A.P., D.K. Shasteen, and S.A. Bales. 2013. Freshwater Mussels of the Illinois River Tributaries: Upper, Middle and Lower Drainages. Illinois Natural History Survey Technical Report 2013 (07). Champaign, Illinois. 21 pp + appendix.

Kankakee River. In 1999, the USGS collected macroinvertebrates from the Kankakee River at Momence, Illinois (USGS 1999). Over 70 taxa were collected during the survey (Table B-13).

A total of 30 species of freshwater mussels (Table B-14), 40 species were known historically from the basin, were observed in the Kankakee River Basin during a survey by the INHS in 2009 (Price et al. 2012).

Table B-13: Macroinvertebrates Collected from the Kankakee River at Momence, Illinois by the USGS in 1999[6].

Taxon	Taxon	Taxon
Turbellaria	*Enallagma* sp.	*Hydrocanthus* sp.
Pleuroceridae	*Perlesta* sp.	Dubiraphia sp.
Pseudosuccinea columella	*Pteronarcys* sp.	*Macronychus glabratus*
Physella sp.	*Trichocorixa* sp.	*Psephenus herricki*
Corbicula sp.	Gerridae	Chironomini
Cambarinae	*Rhagovelia* sp.	*Chironomus* sp.
Caecidotea sp.	*Corydalus cornutus*	*Microtendipes* sp.
Gammarus sp.	*Hydroptila* sp.	*Paracladopelma* sp.
Hyalella azteca	*Cheumatopsyche* sp.	*Polypedilum* sp.
Ephemeroptera	*Hydropsyche bidens*	*Stenochironomus* sp.
Hexagenia limbata	*Hydropsyche rossi*	*Tribelos* sp.
Anthopotamus myops	*Hydropsyche* sp.	*Rheotanytarsus* sp.
Caenis sp.	*Hydropsyche bidens*	*Cricotopus/Orthocladius* sp.
Tricorythodes sp.	*Hydropsyche orris*	*Cricotopus bicinctus*
Baetis sp.	*Potamyia flava*	*Cricotopus* sp.
Callibaetis sp.	*Macrostemum* sp.	*Rheocricotopus* sp.
Heptagenia sp.	*Macrostemum carolina*	*Tvetenia* sp.
Heptagenia flavescens	*Neureclipsis* sp.	Tanypodinae
Stenacron interpunctatum	*Brachycentrus numerosus*	Pentaneurini
Stenonema sp.	*Ceraclea* sp.	*Ablabesmyia* sp.
Stenonema exiguum	*Nectopsyche candida*	*Pentaneura* sp.
Stenonema mexicanum	*Nectopsyche* sp.	*Procladius* sp.
Isonychia sp.	*Nectopsyche diarina*	*Simulium* sp.
Hetaerina sp.	*Petrophila* sp.	*Hemerodromia* sp.
Hetaerina titia	*Peltodytes* sp.	Hydrochnidia

[6] USGS. 1999. Benthic Macroinvertebrate Data: Kankakee River at Momence, IL. Accessed at: http://pubs.usgs.gov/wdr/2005/wdr-il-05/data/bent1999/05520500.htm.

Table B-14 Freshwater Mussel Species Observed in the Mainstem Kankakee River and Tributaries to the Kankakee River by INHS during 2010 surveys[7].

Common Name	Scientific Name	Location					
		Kankakee Mainstem			Kankakee River		
		Live	Dead[a]	Relict[b]	Live	Dead[a]	Relict[b]
Elktoe	*Alasmidonta marginata*	X	X				X
Slippershell	*Alasmidonta viridis*						X
Cylindrical Papershell	*Anodontoides*				X	X	X
White Heelsplitter	*Lasmigona complanata*	X	X		X	X	X
Creek Heelsplitter	*Lasmigona compressa*				X	X	X
Fluted-shell	*Lasmigona costata*	X			X	X	
Giant Floater	*Pyganodon grandis*	X	X	X	X	X	X
Creeper	*Strophitus undulatus*	X		X	X	X	X
Paper Pondshell	*Utterbackia imbecillis*			X			
Threeridge	*Amblema plicata*	X		X	X	X	X
Purple Wartyback	*Cyclonaias tuberculata*	X	X	X			
Spike	*Elliptio dilatata*	X		X			
Wabash Pigtoe	*Fusconaia flava*	X	X	X	X		
Washboard	*Megalonaias nervosa*	X					
Sheepnose	*Plethobasus cyphyus*	X		X			
Round Pigtoe	*Pleurobema sintoxia*	X	X	X	X		
Monkeyface	*Quadrula metanevra*	X	X				
Pimpleback	*Quadrula pustulosa*	X	X				
Mapleleaf	*Quadrula quadrula*	X		X			
Mucket	*Actinonaias ligamentina*	X			X		
Plain Pocketbook	*Lampsilis cardium*	X		X	X		X
Fatmucket	*Lampsilis siliquoidea*	X	X	X	X	X	X
Fragile Papershell	*Leptodea fragilis*	X		X			
Black Sandshell	*Ligumia recta*	X		X			
Threehorn Wartyback	*Obliquaria reflexa*			X			
Pink Heelsplitter	*Potamilus alatus*	X					
Liliput Shell	*Toxolasma parvum*		X		X	X	X
Fawnsfoot	*Truncilla donaciformis*	X					
Deertoe	*Truncilla truncata*	X					
Ellipse	*Venustaconcha*	X	X		X		X

[a] Dead refers to shells from mussels that are recently deceased (e.g., shell interior shiny, fleshy material may be present)
[b] Relict refers to shells from mussels that have been deceased for an extended period of time (e.g., exterior of shell appears weathered, faded shell interior, absence of fleshy material)

Fish Communities

Lake Superior. The fishery of Lake Superior is the least altered of the Great Lakes and is dominated by coldwater species such as whitefish, herring, Lake Trout, and chubs (USACE 2002). Lake trout stocks crashed in the 1950's following a sea lamprey buildup, but with a successful lamprey control program there is evidence that trout are returning. The invasion of Rainbow Smelt and an intensive selective fishery also contributed to changes in the fish community of the lake, particularly the decline of the Lake Herring. As smelt have become the preferred food of salmonid predators, Lake Herring populations have rebounded since the early 1980's. Introductions of Coho, Chinook, and Steelhead have been successful,

[7] Price, A.L., D.K. Shasteen, and S.A. Bales. 2012. Freshwater mussels of the Kankakee River in Illinois. Illinois Natural History Survey Technical Report 2012 (12). Champaign, Illinois. 16 pp. + appendix.

but the long-term stability of this complex fish community is likely to depend on the lower trophic levels which provide a forage base for the higher trophic levels (USACE 2002).
The Minnesota Sea Grant (2016) notes that Lake Superior has 51 native and non-native fish species that reproduce within the lake. The number of species increases to 88 if the lake, its estuaries, and associated wetlands are included. The following 34 native fish species are found in Lake Superior: Bloater, Brook Trout, Burbot, Cisco, Common Shiner, Creek Chub, Deepwater Sculpin, Emerald Shiner, Johnny Darter, Kiyi, Lake Chub, Lake Sturgeon, Lake Trout, Lake Whitefish, Longnose Dace, Longnose Sucker, Mimic Shiner, Ninspine Stickleback, Northern Pike, Pygmy Whitefish, Rock Bass, Round Whitefish, Sand Shiner, Shorthead Redhorse, Shortjaw Cisco, Silver Redhorse, Slimy Sculpin, Smallmouth Bass, Spoonhead Sculpin, Spottail Shiner, Trout-perch, Walleye, White Sucker, and Yellow Perch. Non-native, introduced game fish include Atlantic Salmon, Brown Trout, Chinook Salmon, Coho Salmon, Pink Salmon, Rainbow Trout. Non-native species include Alewife, Brook Silverside, Common Carp, Eurasian Ruffe, Fourspine Stickleback, Freshwater Drum, Rainbow Smelt, Round Goby, Sea Lamprey, Threespine Stickleback, Tubenose Goby, White Perch, and American Eel.

Lake Michigan. The Lake Michigan fishery has undergone drastic changes due to the invasions of Sea Lamprey and Alewife, over-fishing, and environmental degradation (USACE 2002). Lake Herring and deepwater Coregonids were the most abundant fish in the pelagic community, while Lake Trout were the top piscivore. Ecological changes are pronounced in the southern basin and Green Bay, areas that formerly produced major portions of the lake’s premium catches. Over-fishing and Sea Lamprey predation essentially wiped out the Lake Trout population by 1956, but by 1966 control efforts dropped spawning Sea Lamprey numbers by 80-90%. Trout and Salmon stocking programs by Michigan, Indiana, Illinois, and Wisconsin have resulted in successful harvests of these salmonids, but continuous restocking programs are necessary to maintain fish populations. The Bloater population rebounded significantly during the 1980’s to the extent they are once again the most abundant forage fish species. Coho and Chinook Salmon, Rainbow, Lake, and Brown Trout, Yellow Perch, and Whitefish comprise the majority of the current catch (USACE 2002).

Fish surveys have been conducted within the southern basin of Lake Michigan for several decades. Twenty-four native species and 10 non-native species have been identified from the surrounding area. Important rare and sensitive species include the Trout Perch (*Percopsis omiscomaycus*), Lake Chub (*Coueseuis plumbeus*), Burbot (*Lota lota*), and Mottled Sculpin (*Cottus baridii*). Important native game fishes include Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*), Rock Bass (*Ambloplites rupestris*), and Yellow Perch. Non-native, introduced game fish include the Pacific Salmonids (*Oncorhynchus* spp.), Brown Trout (*Salmo trutta*), and Rainbow Smelt. Non-native species include Common Carp, Goldfish (*Carassius auratus*), Alewife, Sea Lamprey (*Petromyzon marinus*), and Round Goby.

Lake Huron. The Lake Huron fish community was historically dominated by Lake Trout, Lake Whitefish, deepwater coregonids, Burbot, Longnose Sucker, and Deepwater Sculpin in offshore areas (USACE 2002). Cool water areas were dominated by Walleye, Northern Pike, Lake Sturgeon, Muskellunge, and Yellow Perch, while warm water areas supported populations of catfish, Smallmouth Bass, Largemouth Bass, bullheads, Rock Bass, White Sucker, and Freshwater Drum. As in Lake Michigan, a combination of over-fishing, Sea Lamprey predation, competition from non-indigenous species, and habitat loss has resulted in major shifts in population abundance over the years. Over the last decade, Lake Whitefish populations have regained stability and abundance lake-wide. Chinook Salmon have also become an important component of the fish community. Lake Trout are being actively managed but populations remain at depressed levels, likely due to increasing lamprey numbers in the northern part of the lake. Sea Lamprey reproduction in the St. Marys River has become a major problem in the last 20 years, resulting in more parasitic Sea Lamprey in Lake Huron than in the other lakes combined. Yellow Perch and Walleye remain important components of the near-shore fish community (USACE 2002).

Lake Erie. Over 140 species of fish have been documented from the Lake Erie Basin (USACE 2002). Lake Erie is more susceptible to environmental change than the other Great Lakes due to its shallowness and low water volume. Fish species composition in Lake Erie differs from the other Great Lakes due to a higher water temperature and more southern geographic location. Many of the valuable commercial and recreational species were greatly reduced due to accelerated nutrient input, phytoplankton growth, overfishing, and degradation in the chemical environment of the lake. Important habitats have been lost over the years to human activities and other areas remain in danger. In recent years reduced nutrient and contaminant loadings, and the establishment of the zebra mussel have resulted in a shift towards a less eutrophic (i.e., highly productive) system. Major fish species found in Lake Erie include Walleye, Yellow Perch, Freshwater Drum, Gizzard Shad, Smelt, Channel Catfish, Smallmouth Bass, White Bass, Common Carp, and White Sucker. Populations of warm water species such as Common Carp, Goldfish, and Gizzard Shad play prominent roles in the lake's fish community. Lake Erie has recently been stocked with Rainbow Trout, Lake Trout, and Chinook Salmon in an effort to improve the sport fishery in areas where population pressures on recreational areas is high. Stocking efforts are being re-evaluated in light of the changing abundance of various prey species. Species composition and abundance can be expected to continue to shift as the full effect of changes in nutrient loadings, nonindigenous species, and management efforts are realized (USACE 2002).

Lake Ontario. Lake Ontario at one time supported as many as 140 species of fish. Marked changes in the species composition, productivity, and energy flow dynamics have occurred and continue to occur as a result of human intervention in the basin (USACE 2002). The system experienced significant declines in productivity in the 1980s as a result of reduced nutrient loadings. This resulted in lower forage fish production and biomass. The offshore fish community is currently dominated by nonindigenous Alewife, Rainbow Smelt, Coho Salmon, Chinook Salmon, Brown Trout, Rainbow Trout, and reintroduced Lake Trout. The nearshore area currently supports bullheads, catfishes, Common Carp, Goldfish, Spottail Shiner, Golden Shiner, Emerald Shiner, Gizzard Shad, White Crappie, Black Crappie, Yellow Perch, White Perch, Walleye, Northern Pike, American Eel, and Smallmouth Bass. Reduced nutrient loading resulting from water quality initiatives and the spread of Zebra Mussels appears to be resulting in a shift towards a more oligotrophic (i.e., unproductive) lake in which the majority of energy flows through the benthic community. Fish species composition and abundance appear to be responding to this change in the food web. The return to more oligotrophic system may make the reestablishment of some native species more feasible (USACE 2002).

CAWS. In 2015, a total of 57 species and 2 hybrid groups were recorded from the CAWS[8] (Table B-15).

In 2015, a combined total of 47 species and 1 hybrid groups were recorded from Lockport and Brandon Road Pools (MRWG 2015) (Table B-16).

[8] Monitoring and Response Workgroup. 2015. 2014 Asian Carp Monitoring and Response Plan Interim Summary Reports. Asian Carp Regional Coordinating Committee. 258pp.

Table B-7: Fish Species Captured by Reach During Intensive Sampling Events in 2015 (MRWG 2016)

Species[1]	LCAL/CalR	LCR/CSC	SBCR/CSSC	CR	NBCR/NSC
Gizzard Shad (*Dorosoma cepedianum*)	X	X	X	X	X
Common Carp I (*Cyprinus Carpio*)	X	X	X	X	X
Freshwater Drum (*Aplodinotus grunniens*)	X	X	X		X
White Sucker (*Catostomus commersoni*)	X	X	X		X
Largemouth Bass (*Micropterus salmoides*)	X	X	X	X	X
Pumpkinseed (*Lepomis gibbosus*)	X	X	X		X
Yellow Perch (*Percina flavescens*)	X	X			X
Channel Catfish (*Ictalurus punctatus*)	X	X	X		X
Bluntnose Minnow (*Pimephales notatus*)	X	X	X		X
Golden Shiner (*Notemigonus crysoleucas*)	X	X	X		X
Bluegill (*Lepomis macrochirus*)	X	X	X	X	X
Smallmouth Bass (*Micropterus dolomieu*)	X	X			
Alewife I (*Alosa pseudoharengus*)	X	X			X
Emerald Shiner (*Notropis atherinoides*)	X	X	X	X	X
Rock Bass (*Ambloplites rupestris*)	X	X			
Black Bullhead (*Ameiurus melas*)	X	X	X		X
Green Sunfish (*Lepomis cyanellus*)	X	X	X		X
Banded Killifish T-IL (*Fundulus diaphanus*)	X	X	X		X
Smallmouth Buffalo (*Ictiobus bubalus*)	X	X			
Round Goby I (*Neogobius melanostomus*)	X	X	X	X	X
Fathead Minnow (*Pimephales promelas*)	X	X	X		X
Goldfish I (*Carassius auratus*)	X	X	X		X
Yellow Bullhead (*Ameiurus natalis*)	X	X	X		X
Black Crappie (*Pomoxis nigromaculatus*)	X	X	X	X	X
Spotfin Shiner (*Cyprinella spiloptera*)	X	X	X		X
White Bass (*Morone chrysops*)	X	X			X
Spottail Shiner (*Notropis hudsonius*)	X	X	X		X
Black Buffalo (*Ictiobus niger*)	X	X			

Species[1]	LCAL/CalR	LCR/CSC	SBCR/CSSC	CR	NBCR/NSC
White Perch I (*Morone americana*)	X	X		X	X
Brook Silverside (*Labidesthes sicculus*)	X	X			
Brown Bullhead (*Ameiurus nebulosus*)	X		X		X
Quillback (*Carpiodes cyprinus*)	X				
White Crappie (*Pomoxis annularis*)	X	X	X		X
Bigmouth Buffalo (*Ictiobus cyprinellus*)	X	X			
Common Shiner (*Luxilus cornutus*)		X	X		X
Carp X Goldfish Hybrid I		X	X	X	X
Blackstripe Topminnow (*Fundulus notatus*)			X		X
Creek Chub (*Semotilus atromaculatus*)		X	X		
River Shiner (*Notropis blennius*)		X			X
Bowfin (*Amia calva*)	X	X			X
Coho Salmon I (*Oncorhynchus kisutch*)	X				
Oriental Weatherfish I (*Misgurnus anguillicaudatus*)		X	X		X
Rainbow Trout I (*Oncorhynchus mykiss*)	X				X
Silver Redhorse (*Moxostoma anisurum*)		X			X
River Carpsucker (*Carpiodes carpio*)	X	X			
Walleye (*Sander vitreus*)	X	X			X
Flathead Catfish (*Pylodictis olivaris*)	X	X			
Golden Redhorse (*Moxostoma erythrurum*)		X			
Grass Pickerel (*Esox americanus*)		X	X		
Hybrid Sunfish	X				X
Orangespotted Sunfish (*Lepomis humilis*)	X	X	X		
Bullhead Minnow (*Pimephales vigilax*)		X	X		
Chinook Salmon I (*Oncorhynchus tshawytscha*)	X		X		
Grass Carp I (*Ctenopharyngodon idella*)	X	X			
Mimic Shiner (*Notropis volucellus*)		X			
Tilapia I (*Oreochromis niloticus*)				X	X
Yellow Bass (*Morone mississippiensis*)	X	X			X
Central Mudminnow (*Umbra limi*)	X	X			X

Species[1]	LCAL/CalR	LCR/CSC	SBCR/CSSC	CR	NBCR/NSC
Channel Shiner (*Notropis wickliffi*)		X			
Skipjack Herring (*Alosa chrysochloris*)					X
Unidentified Salmonid	X		X		
Log Perch (*Percina caprodes*)		X			
Longnose Gar (*Lepisosteus osseus*)					X
Unidentified Madtom (*Noturus* spp.)			X		
Threadfin Shad I (*Dorosoma petenense*)					X

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois

Table B-8: Species of Fish Captured from 2015 Fixed and Random Electrofishing in Lockport and Brandon Road Pools (MRWG 2016).

Species[1]	Lockport	Brandon
Banded Killifish T-IL (*Fundulus diaphanus*)	X	X
Bigmouth Buffalo (*Ictiobus cyprinellus*)		X
Black Bullhead (*Ameiurus melas*)	X	
Black Crappie (*Pomooxis nigromaculatus*)		X
Blackstripe Topminnow (*Fundulus notatus*)		X
Bluegill (*Lepomis macrochirus*)	X	X
Bluntnose Minnow (*Pimephales notatus*)	X	X
Bowfin (*Amia calva*)		X
Central Mudminnow (*Umbra limi*)		X
Channel Catfish (*Ictalurus punctatus*)	X	X
Common Carp I (*Cyprinus carpio*)	X	X
Common Carp X Goldfish		X
Creek Chub (*Semotilus atromaculatus*)	X	
Emerald Shiner (*Notropis atherinoides*)	X	X
Fathead Minnow (*Pimephales promelas*)	X	
Freshwater Drum (*Aplodinotus grunniens*)	X	X
Gizzard Shad (*Dorosoma cepedianum*)	X	X
Golden Shiner (*Notemigonus crysoleucas*)	X	X
Goldfish I (*Carassius auratus*)	X	X

Species[1]	Lockport	Brandon
Grass Carp I (*Ctenopharyngodon*		X
Grass Pickerel (*Esox americanus*)	X	X
Green Sunfish (*Lepomis cyanellus*)	X	X
Largemouth Bass (*Micropterus salmoides*)	X	X
Longnose Gar (*Lepisosteus osseus*)	X	X
Northern Pike (*Esox lucius*)	X	X
Orangespotted Sunfish (*Lepomis humilis*)		X
Oriental Weatherfish I (*Misgurnus anguillicaudatus*)	X	X
Pumpkinseed (*Lepomis gibbosus*)	X	X
Rock Bass (*Ambloplites rupestris*)		X
Round Goby I (*Neogobius melanostomus*)		X
Sand Shiner (*Notropis stramineus*)	X	X
Sauger (*Sander canadensis*)		X
Shorthead Redhorse (*Moxostoma macrolepidotum*)		X
Shortnose Gar (*Lepisosteus platostomus*)		X
Silver Redhorse (*Moxostoma anisurum*)		X
Skipjack Herring (*Alosa chrysochloris*)		X
Smallmouth Bass (*Micropterus dolomieu*)	X	X
Smallmouth Buffalo (*Ictiobus bubalus*)		X
Spotfin Shiner (*Cyprinella spiloptera*)	X	X
Spottail Shiner (*Notropis hudsonius*)	X	
Threadfin Shad I (*Dorosoma petenense*)	X	X
Unidentified Moronid		X
Warmouth (*Lepomis gulosus*)	X	
White Bass (*Morone chrysops*)	X	X
White Perch I (*Morone americana*)	X	
White Sucker (*Catostomus commersonii*)		X
Yellow Bullhead (*Ameiurus natalis*)	X	X
Yellow Perch (*Perca flavescens*)		X

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois

Des Plaines River. For a complete list of fish species collected during sampling within the Des Plaines River, refer to Table B-17.

Table B-9: Fish Species Collected from the Mainstem Des Plaines River (Illinois). Collections are divided by those recorded in the Fishes of the Chicago Region Database (Veraldi unpublished data) and by those provided by the Illinois DNR (Grider 2015).

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)[2]			Illinois DNR (Grider 2015)[3]	
		Location			Location	
		Upstream Mainstem	Downstream Mainstem (Above BRLD)	Downstream Mainstem (Below BRLD)	Upstream of Hoffman Dam	Downstream of Hoffman Dam
Skipjack Herring	*Alosa chrysochlorus*		X	X		X
Rock Bass	*Ambloplites rupestris*	X	X	X	X	X
Black Bullhead	*Ameiurus melas*	X	X	X	X	X
Yellow Bullhead	*Ameiurus natalis*	X	X	X	X	X
Brown Bullhead	*Ameiurus nebulosus*			X		
Bowfin	*Amia calva*		X		X	X
Freshwater Drum	*Aplodinotus grunniens*	X	X	X		X
Tinfoil Barb I	*Barbonymus schwanenfeldii*	X				
Central Stoneroller	*Campostoma anomalum*	X	X	X	X	
Goldfish I	*Carassius auratus*	X	X	X		X
River Carpsucker	*Carpiodes carpio*			X		X
Quillback	*Carpiodes cyprinus*		X	X		X
White Sucker	*Catostomus commersonii*	X	X	X	X	X
Brook Stickleback	*Culaea inconstans*	X				
Red Shiner	*Cyprinella lutrensis*		X			X
Spotfin Shiner	*Cyprinella spiloptera*	X	X	X	X	X
Common Carp I	*Cyprinus carpio*	X	X	X		X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X	X
Threadfin Shad	*Dorosoma petenense*			X		
Creek Chubsucker	*Erimyzon oblongus*		X			
Lake Chubsucker	*Erimyzon sucetta*	X				
Grass Pickerel	*Esox americanus*	X	X	X		X
Northern Pike	*Esox lucius*	X	X	X	X	X
Muskellunge	*Esox masquinongy*					X
Johnny Darter	*Etheostoma nigrum*	X	X		X	X
Banded Killifish T-IL	*Fundulus diaphanus*					X
Blackstripe Topminnow	*Fundulus notatus*	X	X		X	X
Western Mosquitofish	*Gambusia affinis*	X	X		X	X

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)[2]			Illinois DNR (Grider 2015)[3]	
		Location			Location	
		Upstream Mainstem	Downstream Mainstem (Above BRLD)	Downstream Mainstem (Below BRLD)	Upstream of Hoffman Dam	Downstream of Hoffman Dam
Northern Hog Sucker	*Hypentelium nigricans*	X				
Channel Catfish	*Ictalurus punctatus*	X	X	X	X	X
Smallmouth Buffalo	*Ictiobus bubalus*		X	X		X
Bigmouth Buffalo	*Ictiobus cyprinellus*	X		X		
Black Buffalo	*Ictiobus niger*			X		
Brook Silverside	*Labidesthes sicculus*	X		X	X	
Longnose Gar	*Lepisosteus osseus*			X		X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X	X
Warmouth	*Lepomis gulosus*		X		X	
Orangespotted Sunfish	*Lepomis humilis*	X	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X	X
Longear Sunfish	*Lepomis megalotis*	X	X	X		
Redear Sunfish	*Lepomis microlophus*				X	
Striped Shiner	*Luxilus chrysocephalus*	X		X		X
Common Shiner	*Luxilus cornutus*	X	X		X	X
Redfin Shiner	*Lythrurus umbratilis*	X	X		X	
Smallmouth Bass	*Micropterus dolomieu*	X	X	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X	X
Spotted Sucker	*Minytrema melanops*	X	X	X	X	X
Oriental Weatherfish I	*Misgurnus anguillicaudatus*		X			
White Perch I	*Morone americana*		X	X		
Yellow Bass	*Morone mississippiensis*		X	X	X	X
Silver Redhorse	*Moxostoma anisurum*		X			X
River Redhorse T-IL	*Moxostoma carinatum*			X		
Golden Redhorse	*Moxostoma erythrurum*			X		
Shorthead Redhorse	*Moxostoma macrolepidotum*			X		
Round Goby I	*Neogobius melanostomus*		X	X		X
Hornyhead Chub	*Nocomis biguttatus*	X	X		X	X

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)[2]			Illinois DNR (Grider 2015)[3]	
		Location			Location	
		Upstream Mainstem	Downstream Mainstem (Above BRLD)	Downstream Mainstem (Below BRLD)	Upstream of Hoffman Dam	Downstream of Hoffman Dam
Golden Shiner	*Notemigonus crysoleucas*	X	X	X	X	X
Emerald Shiner	*Notropis atherinoides*		X	X	X	X
Ironcolor Shiner T-IL	*Notropis chalybaeus*	X				
Bigmouth Shiner	*Notropis dorsalis*	X	X	X	X	X
Blackchin Shiner T-IL	*Notropis heterodon*	X			X	
Blacknose Shiner E-IL	*Notropis heterolepis*	X				
Spottail Shiner	*Notropis hudsonius*	X	X	X	X	X
Rosyface Shiner	*Notropis rubellus*					X
Sand Shiner	*Notropis stramineus*	X	X		X	X
Mimic Shiner	*Notropis volucellus*	X			X	
Stonecat	*Noturus flavus*	X			X	
Tadpole Madtom	*Noturus gyrinus*	X	X	X	X	X
Rainbow Trout I	*Oncorhynchus mykiss*		X			
Yellow Perch	*Perca flavescens*	X			X	X
Logperch	*Percina caprodes*				X	X
Blackside Darter	*Percina maculata*	X	X		X	X
Suckermouth Minnow	*Phenacobius mirabilis*		X	X		X
Bluntnose Minnow	*Pimephales notatus*	X	X	X	X	X
Fathead Minnow	*Pimephales promelas*	X	X		X	X
Bullhead Minnow	*Pimephales vigilax*			X		
White Crappie	*Pomoxis annularis*	X	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X	X	X	X
Vermiculated Sailfin Catfish I	*Pterygoplichtyhes disjunctivis*	X				
Flathead Catfish	*Pylodictus olivaris*					X
Sauger	*Sander canadensis*	X	X		X	X
Walleye	*Sander vitreus*	X	X	X	X	X
Creek Chub	*Semotilus atromaculatus*	X	X		X	X
Central Mudminnow	*Umbra limi*	X	X		X	

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois

[2] Collections for the Upstream Mainstem were made between 1895 and 2005 while collections for the Downstream Mainstem (Above and Below BRLD) were made between 1901-2005. Collections were made by the Field Musuem of Natural History, Illinois Natural History Survey, Illinois DNR, and Southern Illinois University.

[3] Collections were made between 1979 and 2014 by Illinois DNR.

Table B-18: Fish Species Collected from Tributaries to the Upper Des Plaines River (Illinois). Collections are divided by those recorded in the Fishes of the Chicago Region Database (Veraldi unpublished data) and those provided by the Illinois DNR (Grider 2015).

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database[2] – Location: Buffalo Creek	Bull Creek	Bull's Brook	Crystal Creek	Indian Creek	McDonald Creek	Mill Creek	Silver Creek	Willow Creek	Illinois DNR (Grider 2015)[3] – Location: Mill Creek, Indian Creek, Bull Creek, Willow Creek, Salt Creek, Addison Creek
Black Bullhead	*Ameiurus melas*	X	X				X	X			
Yellow Bullhead	*Ameiurus natalis*	X				X	X	X			
Brown Bullhead	*Ameiurus nebulosus*							X			X
Campostoma Species	*Campostoma sp.*										X
Central Stoneroller	*Campostoma anomalum*		X			X					
Goldfish I	*Carassius auratus*		X						X	X	X
	Carpiodes spp.						X				
White Sucker	*Catostomus commersonii*	X	X	X		X	X	X		X	X
Brook Stickleback	*Culea inconstans*		X								
Spotfin Shiner	*Cyprinella spiloptera*					X	X	X		X	X
Common Carp I	*Cyprinus carpio*	X	X			X	X	X	X		X
Northern Pike	*Esox lucius*		X	X							
Iowa Darter T-IL	*Etheostoma exile*		X	X				X			
Fantail Darter	*Etheostoma flabellare*		X	X							X
Johnny Darter	*Etheostoma nigrum*		X			X		X		X	X
Blackstripe Topminnow	*Fundulus notatus*		X			X	X	X			X
Channel Catfish	*Ictalurus punctatus*							X			
Brook Silverside	*Labidesthes sicculus*										X
Green Sunfish	*Lepomis cyanellus*	X	X		X		X				X
Pumpkinseed	*Lepomis gibbosus*		X	X				X			X
Warmouth	*Lepomis gulosus*		X					X			
Orangespotted Sunfish	*Lepomis humilis*		X					X			
Bluegill	*Lepomis macrochirus*	X	X	X		X	X	X	X	X	X
Striped Shiner	*Luxilus chrysocephalus*					X					
Common Shiner	*Luxilus cornutus*							X			X
Largemouth Bass	*Micropterus salmoides*	X	X	X		X	X	X		X	X

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database[2]									Illinois DNR (Grider 2015)[3]
		Location									Location
		Buffalo Creek	Bull Creek	Bull's Brook	Crystal Creek	Indian Creek	McDonald Creek	Mill Creek	Silver Creek	Willow Creek	Mill Creek, Indian Creek, Bull Creek, Willow Creek, Salt Creek, Addison Creek
Spotted Sucker	*Minytrema melanops*					X		X			
Hornyhead Chub	*Nocomis biguttatus*		X			X		X			X
Golden Shiner	*Notemigonus crysoleucas*	X	X	X		X		X	X		X
Emerald Shiner	*Notropis atherinoides*					X					
Bigmouth Shiner	*Notropis dorsalis*		X			X	X	X		X	
Blackchin Shiner T-IL	*Notropis heterodon*			X							
Sand Shiner	*Notropis stramineus*		X			X	X	X		X	
Stonecat	*Noturus flavus*					X		X			X
Tadpole Madtom	*Noturus gyrinus*					X				X	
Yellow Perch	*Perca flavescens*		X					X			
Blackside Darter	*Percina maculata*		X			X		X			X
Bluntnose Minnow	*Pimephales notatus*	X	X			X	X	X	X	X	X
Fathead Minnow	*Pimephales promelas*			X	X	X	X	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*		X		X			X		X	X
Creek Chub	*Semotilus atromaculatus*	X	X	X		X	X		X		X
Central Mudminnow	*Umbra limi*		X	X		X		X			

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois
[2] Collections were made between 1895 and 2005 by the Field Musuem of Natural History, Illinois Natural History Survey, Illinois DNR, and Southern Illinois University
[3] Collection by Illinois DNR is from 1983

Table B-19: Fish Species Collected from tributaries to the Lower Des Plaines River (Illinois). Collections are divided by those recorded in the Fishes of the Chicago Region Database (Veraldi unpublished data) and by those provided by the Illinois DNR (Grider 2015).

Common Name[1]	Scientific Name	Fishes of the Chicago Region Database[2]			Illinois DNR (Grider 2015)[3]
		Location			Locations
		Salt Creek	Flagg Creek	Sawmill Creek	Flagg Creek and Sawmill Creek
Black Bullhead	*Ameiurus melas*	X			
Yellow Bullhead	*Ameiurus natalis*	X			
Central Stoneroller	*Campostoma anomalum*		X	X	
Goldfish I	*Carassius auratus*	X	X		
White Sucker	*Catostomus commersonii*	X		X	X
Spotfin Shiner	*Cyprinella spiloptera*	X			
Common Carp I	*Cyprinus carpio*	X	X		
Gizzard Shad	*Dorosoma cepedianum*	X	X		
Creek Chubsucker	*Erimyzon oblongus*	X			
Northern Pike	*Esox lucius*	X	X		
Johnny Darter	*Etheostoma nigrum*	X			
Blackstripe Topminnow	*Fundulus notatus*	X			
Western Mosquitofish	*Gambusia affinis*		X		
Channel Catfish	*Ictalurus punctatus*	X			
Brook Silverside	*Labidesthes sicculus*	X			
Green Sunfish	*Lepomis cyanellus*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X			
Orangespotted Sunfish	*Lepomis humilis*	X	X		
Bluegill	*Lepomis macrochirus*	X	X	X	X
Longear Sunfish	*Lepomis megalotis*	X			
Redear Sunfish	*Lepomis microlophus*	X			
Striped Shiner	*Luxilus chrysocephalus*			X	X
Redfin Shiner	*Lythrurus umbratilis*	X			
Smallmouth Bass	*Micropterus dolomieu*	X	X		
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
Spotted Sucker	*Minytrema melanops*	X			
Yellow Bass	*Morone mississippiensis*	X			
Greater Redhorse E-IL	*Moxostoma valenciennesi*	X			
Round Goby I	*Neogobius melanostomus*		X		
Golden Shiner	*Notemigonus crysoleucas*	X		X	X
Emerald Shiner	*Notropis atherinoides*	X			
Bigmouth Shiner	*Notropis dorsalis*	X		X	X
Blacknose Shiner E-IL	*Notropis heterolepis*	X			
Rosyface Shiner	*Notropis rubellus*	X			
Sand Shiner	*Notropis stramineus*	X	X		
Mimic Shiner	*Notropis volucellus*	X			
Tadpole Madtom	*Noturus gyrinus*	X			
Yellow Perch	*Perca flavescens*	X			
Bluntnose Minnow	*Pimephales notatus*	X	X	X	X
Fathead Minnow	*Pimephales promelas*	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X		
Walleye	*Sander vitreus*	X	X		
Creek Chub	*Semotilus atromaculatus*	X	X	X	X
Central Mudminnow	*Umbra limi*	X			

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois
[2] Collections were made between 1901 and 2005 by the Field Musuem of Natural History, Illinois Natural History Survey, Illinois DNR, and Southern Illinois University
[3] Collection by Illinois DNR is from 1983

Illinois River. In 2015, a total of 72 species and three hybrid groups were recorded from the Dresden Island and Marseilles Pools (MRWG 2016) (Table B-18).

Table B-10 Species of Fish Captured from 2015 Fixed and Random Electrofishing in Dresden Island and Marseille Pools (MRWG 2016).

Species[1]	Dresden	Marseilles
Banded Killifish T-IL (*Fundulus diaphanus*)	X	X
Bighead Carp I (*Hypophthalmichthys nobilis*)	X	X
Bigmouth Buffalo (*Ictiobus cyprinellus*)	X	X
Black Buffalo (*Ictiobus niger*)	X	
Black Crappie (*Pomoxis nigromaculatus*)	X	X
Blacknose Dace (*Rhinichthys atratulus*)	X	
Blackstripe Topminnow (*Fundulus notatus*)	X	X
Bluegill (*Lepomis macrochirus*)	X	X
Bluntnose Minnow (*Pimephales notatus*)	X	X
Bowfin (*Amia calva*)		X
Brook Silverside (*Labidesthes sicculus*)	X	X
Bullhead Minnow (*Pimephales vigilax*)		X
Central Stoneroller (*Campostoma anomalum*)		X
Channel Catfish (*Ictalurus punctatus*)	X	X
Common Carp I (*Cyprinus carpio*)	X	X
Common Carp X Goldfish Hybrid	X	
Common Shiner (*Luxilus cornutus*)		X
Emerald Shiner (*Notropis atherinoides*)	X	X
Fathead Minnow (*Pimephales promelas*)	X	
Flathead Catfish (*Pylodictis olivaris*)	X	X
Freshwater Drum (*Aplodinotus grunniens*)	X	X
Gizzard Shad (*Dorosoma cepedianum*)	X	X
Golden Redhorse (*Moxostoma erythrurum*)	X	X
Golden Shiner (*Notemigonus crysoleucas*)	X	X
Goldeye (*Hiodon alosoides*)	X	
Goldfish I (*Carassius auratus*)	X	X

Species[1]	Dresden	Marseilles
Grass Carp (*Ctenopharyngodon idella*)	X	X
Grass Pickerel (*Esox americanus*)	X	
Greater Redhorse E-IL (*Moxostoma valenciennesi*)		X
Green Sunfish (*Lepomis cyanellus*)	X	X
Highfin Carpsucker (*Carpiodes velifer*)	X	
Johnny Darter (*Etheostoma nigrum*)		X
Largemouth Bass (*Micropterus salmoides*)	X	X
Logperch (*Percina caprodes*)	X	X
Longear Sunfish (*Lepomis megalotis*)	X	
Longnose Gar (*Lepisosteus osseus*)	X	X
Mimic Shiner (*Notropis volucellus*)		X
Muskellunge (*Esox masquinongy*)		X
Northern Hog Sucker (*Hypentelium nigricans*)	X	X
Northern Pike (*Esox lucius*)	X	
Orangespotted Sunfish (*Lepomis humilis*)	X	X
Oriental Weatherfish I (*Misgurnus anguillicaudatus*)	X	
Pumpkinseed (*Lepomis gibbosus*)	X	X
Quillback (*Carpiodes cyprinus*)	X	X
Red Shiner (*Cyprinella lutrensis*)		X
River Carpsucker (*Carpiodes carpio*)	X	X
River Redhorse T-IL (*Moxostoma carinatum*)		X
River Shiner (*Notropis blennius*)		X
Rock Bass (*Ambloplites rupestris*)	X	X
Round Goby I (*Neogobius melanostomus*)	X	X
Sand Shiner (*Notropis stramineus*)	X	X
Sauger (*Sander canadensis*)		X
Shorthead Redhorse (*Moxostoma macrolepidotum*)	X	X
Shortnose Gar (*Lepisosteus platostomus*)	X	X
Silver Carp (*Hypophthalmichthys molitrix*)	X	X

Species[1]	Dresden	Marseilles
Silver Redhorse (*Moxostoma anisurum*)	X	X
Skipjack Herring (*Alosa chrysochloris*)	X	X
Smallmouth Bass (*Micropterus dolomieu*)	X	X
Smallmouth Buffalo (*Ictiobus bubalus*)	X	X
Spotfin Shiner (*Cyprinella spiloptera*)	X	X
Spottail Shiner (*Notropis hudsonius*)	X	X
Spotted Sucker (*Minytrema melanops*)	X	X
Striped Bass X White Bass Hybrid		X
Sunfish Hybrid	X	X
Tadpole Madtom (*Noturus gyrinus*)		X
Threadfin Shad I (*Dorosoma petenense*)	X	X
Unidentified Catostomid	X	
Unidentified Cyprinid	X	
Walleye (*Sander vitreus*)	X	X
White Bass (*Morone chrysops*)	X	X
White Crappie (*Pomoxis annularis*)	X	X
White Perch I (*Morone americana*)	X	
White Sucker (*Catostomus commersonii*)	X	X
Yellow Bass (*Morone mississippiensis*)	X	
Yellow Bullhead (*Ameiurus natalis*)	X	

[1](I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois

Kankakee River. Fish collections having occurred within the Kankakee River and its tributaries were queried using the Fishes of the Chicago Region Database (Veraldi unpublished data). Collections from the mainstem Kankakee River identified a total of 90 fish species (Table B-19), of which 5 were non-native species (i.e., Goldfish, Common Carp, White Perch, Brown Trout, and Rudd). Tributary collection data was available for the Kankakee Cutoff, Prairie Creek, Forked Creek, Horse Creek, Terry Creek, Rock Creek, and Pike Creek. Collections from the aforementioned tributaries identified a total of 63 fish species (Table B-19), of which 2 where non-native species (i.e., Goldfish and Common Carp).

Threatened and Endangered Species

Great Lakes. Within the Great Lakes Region there are numerous state-listed threatened and endangered species. The following lists were generated using best available information for 2016. In general, in 2016 there were approximately 898 plants, 26 reptiles and amphibians, 15 mammals, 62 birds, 204 invertebrates, and 56 fish that were state-listed threatened and endangered species within the Great Lakes area (Table B-20).

Table B-11 Fish Species Collected from the Mainstem Kankakee River and Its Tributaries Between 1945 and 2005 (Veraldi unpublished data).

Common Name[a]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)							
		Location							
		Mainstem Kankakee River	Kankakee Cutoff	Prairie Creek	Forked Creek	Horse Creek	Terry Creek	Rock Creek	Pike Creek
Skipjack Herring	*Alosa chrysochloris*	X							
Rock Bass	*Ambloplites rupestris*	X		X	X	X	X	X	
Black Bullhead	*Ameiurus melas*	X		X				X	X
Yellow Bullhead	*Ameiurus natalis*	X		X	X				
Brown Bullhead	*Ameiurus nebulosus*	X							
Bowfin	*Amia calva*	X							
Western Sand Darter E-IL	*Ammocrypta clarum*	X							
Pirate Perch	*Aphredoderus sayanus*	X							
Freshwater Drum	*Aplodinotus grunniens*	X			X				
Central Stoneroller	*Campostoma anomalum*	X		X	X		X	X	X
Largescale Stoneroller	*Campostoma oligolepis*				X				
Goldfish I	*Carassius auratus*	X	X						
River Carpsucker	*Carpiodes carpio*	X							
Quillback	*Carpiodes cyprinus*	X	X			X			
Highfin Carpsucker	*Carpiodes velifer*	X	X						
White Sucker	*Catostomus commersonii*	X		X	X		X	X	X
Mottled Sculpin	*Cottus bairdii*	X							
Red Shiner	*Cyprinella lutrensis*	X				X			
Spotfin Shiner	*Cyprinella spiloptera*	X		X	X	X	X		
Common Carp I	*Cyprinus carpio*	X		X	X				
Gizzard Shad	*Dorosoma cepedianum*	X	X		X				
Threadfin Shad	*Dorosoma petenense*		X						
Silverjaw Minnow	*Ericymba buccata*			X		X		X	
Lake Chubsucker	*Erimyzon sucetta*	X							
Grass Pickerel	*Esox americanus*	X		X			X		
Northern Pike	*Esox lucius*	X							
Rainbow Darter	*Etheostoma caeruleum*	X			X		X	X	
Fountain Darter	*Etheostoma chlorosomum*	X							
Faintail Darter	*Etheostoma flabellare*	X		X	X		X		
Least Darter	*Etheostoma microperca*						X		
Johnny Darter	*Etheostoma nigrum*	X		X	X	X		X	X
Orangethroat Darter	*Etheostoma spectabile*			X					
Banded Darter	*Etheostoma zonale*	X			X	X	X		
Starhead Topminnow T-IL	*Fundulus dispar*	X							

Common Name[a]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)							
		Location							
		Mainstem Kankakee River	Kankakee Cutoff	Prairie Creek	Forked Creek	Horse Creek	Terry Creek	Rock Creek	Pike Creek
Blackstripe Topminnow	*Fundulus notatus*			X	X	X			
Goldeye	*Hiodon alosoides*	X							
Mooneye	*Hiodon tergisus*	X							
Pallid Shiner E-IL	*Hybopsis amnis*	X							
Northern Hog Sucker	*Hypentelium nigricans*	X			X				
Channel Catfish	*Ictalurus punctatus*	X							
Smallmouth Buffalo	*Ictiobus bubalus*	X	X		X				
Bigmouth Buffalo	*Ictiobus cyprinellus*	X							
Black Buffalo	*Ictiobus niger*				X				
Brook Silverside	*Lbidesthes sicculus*	X	X						
American Brook Lamprey T-IL	*Lampetra appendix*	X							
Longnose Gar	*Lepisosteus osseus*	X							
Shortnose Gar	*Lepisosteus platostomus*	X							
Green Sunfish	*Lepomis cyanellus*	X		X	X		X	X	X
Pumpkinseed	*Lepomis gibbosus*	X		X					
Warmouth	*Lepomis gulosus*	X	X				X		
Orangespotted Sunfish	*Lepomis humilis*	X			X				
Bluegill	*Lepomis macrochirus*	X	X	X	X		X	X	
Longear Sunfish	*Lepomis megalotis*	X			X	X	X		X
Redear Sunfish	*Lepomis microlophus*	X							
Striped Shiner	*Luxilus chrysocephalus*	X		X	X	X	X	X	X
Common Shiner	*Luxilus cornutus*	X		X					
Redfin Shiner	*Lythrurus umbratilis*	X		X	X	X	X	X	X
Smallmouth Bass	*Micropterus dolomieu*	X		X	X		X		
Largemouth Bass	*Micropterus salmoides*	X	X	X	X		X	X	
Spotted Sucker	*Minytrema melanops*	X	X						
White Perch I	*Morone americana*	X							
White Bass	*Morone chrysops*	X							
Yellow Bass	*Morone mississippiensis*	X							
Silver Redhorse	*Moxostoma anisurum*	X							
River Redhorse T-IL	*Moxostoma carinatum*	X							
Black Redhorse	*Moxostoma duquesnei*	X			X	X			
Golden Redhorse	*Moxostoma erythrurum*	X	X	X	X				
Shorthead Redhorse	*Moxostoma macrolepidotum*	X			X				
Hornyhead Chub	*Nocomis biguttatus*	X		X	X		X	X	X
Golden Shiner	*Notemigonus crysoleucas*	X							

Common Name[a]	Scientific Name	Fishes of the Chicago Region Database (Veraldi unpublished data)							
		Location							
		Mainstem Kankakee River	Kankakee Cutoff	Prairie Creek	Forked Creek	Horse Creek	Terry Creek	Rock Creek	Pike Creek
Emerald Shiner	*Notropis atherinoides*	X		X	X				
Bigeye Shiner E-IL	*Notropis boops*	X							
Ghost Shiner	*Notropis buchanani*	X							
Ironcolor Shiner T-IL	*Notorpis chalybaeus*	X							
Bigmouth Shiner	*Notropis dorsalis*							X	
Spottail Shiner	*Notropis hudsonius*	X							
Rosyface Shiner	*Notropis rubellus*	X		X	X	X	X		
Sand Shiner	*Notropis stramineus*	X		X	X	X	X	X	
Weed Shiner E-IL	*Notropis texanus*	X							
Mimic Shiner	*Notropis volucellus*	X			X	X	X		
Slender Madtom	*Noturus exilis*			X					
Stonecat	*Noturus flavus*	X		X	X				
Tadpole Madtom	*Noturus gyrinus*			X					
Pugnose Minnow	*Opsopoeodus emiliae*	X							
Yellow Perch	*Perca flavescens*	X							
Logperch	*Percina caprodes*	X			X	X			
Blackside Darter	*Percina maculata*	X		X	X	X			
Slenderhead Darter	*Percina phoxocephala*	X			X	X			
Suckermouth Minnow	*Phenacobius mirabilis*	X			X				
Southern Redbelly Dace	*Phoxinus erythrogaster*			X				X	X
Bluntnose Minnow	*Pimephales notatus*	X		X	X	X	X	X	X
Fathead Minnow	*Pimephales promelas*	X							
Bullhead Minnow	*Pimephales vigilax*	X				X			
White Crappie	*Pomoxis annularis*	X							
Black Crappie	*Pomoxis nigromaculatus*	X			X				
Flathead Catfish	*Pylodictus olivaris*	X	X						
Western Blacknose Dace	*Rhinichthys obtusus*						X		X
Brown Trout I	*Salmo trutta*	X							
Sauger	*Sander canadense*	X							
Walleye	*Sander vitreus*	X							
Creek Chub	*Semotilus atromaculatus*			X	X		X	X	X
Rudd I	*Scardinius erythrophthalmus*	X							
Central Mudminnow	*Umbra limi*	X							

[1] (I) Introduced, (T-IL) Threatened Illinois, and (E-IL) Endangered Illinois

Table B-12: Listed Species Within the Great Lakes Region

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Mammals				
American Marten (*Martes americana*)	WI-E		Least Shrew (*Cryptotis parva*)	MI-T
Big Brown Bat (*Ephesicus fuscus*)	WI-T		Little Brown Bat (*Myotis lucifuqus*)	WI-T
Black Bear (*Ursus americanus*)	OH-E		Canada Lynx (*Lynx canadensis*)	MI-E
Eastern Pipestrelle (*Perimyotis subflavus*)	WI-T		Northern Long-eared Bat (*Myotis septentrionalis*)	WI-T, IL-T, NY-T
Eastern Spotted Skunk (*Spilogale putorius*)	MN-T		Northern Pocket Gopher (*Thomomys talpoides*)	MN-T
Franklin's Ground Squirrel (*Poliocitellus franklinii*)	IL-T, IN-E		Prairie Vole (*Microtus ochrogaster*)	MI-E
Gray/Timer Wolf (*Canis lupus*)	IL-T		Smoky Shrew (*Sorex fumeus*)	MI-T
Indiana Bat (*Myotis sodalis*)	IN-E, MI-E, OH-E, NY-E			
Birds				
Acadian Flycatcher (*Empidonax virescens*)	WI-T		Little Blue Heron (*Egretta caerulea*)	IL-E
American Bittern (*Botaurus lentiginosus*)	IL-E, IN-E, PA-E		Loggerhead Shrike (*Lanius ludovicianus*)	MN-E, WI-E, IN-E, NY-E
Baird's Sparrow (*Ammodramus bairdii*)	MN-E, MI-E		Long-eared Owl (*Asio otus*)	MI-T
Bald Eagle (*Haliaeetus leucocephalus*)	NY-T		Louisiana Waterthrush (*Parkesia motacilla*)	MI-T
Barn Owl (*Tyto alba*)	IN-E, MI-E		Marsh Wren (*Cistothorus palustris*)	IN-E
Black Rail (*Laterallus jamaicensis*)	IN-E		Merlin (*Falco columbarius*)	MI-T
Black Tern (*Chlidonias niger*)	WI-E, IL-E, IN-E, PA-E, NY-E		Migrant Loggerhead Shrike (*Lanius ludovicianus migrans*)	MI-E, PA-E
Black-billed Cuckoo (*Coccyzus erythrophthalmus*)	IL-T		Northern Harrier (*Circus cyaneus*)	IN-E, OH-E, NY-T
Black-crowned Night-heron (*Nycticorax nycticorax*)	IL-E, IN-E, OH-T		Osprey (*Pandion haliaetus*)	IL-E, PA-T
Burrowing Owl (*Athene cunicularia*)	MN-E		Peregrine Falcon (*Falco peregrinus*)	WI-E, MI-E, OH-T, PA-E, NY-E
Caspian Tern (*Hydroprogne caspia*)	WI-E, MI-T		Pied-billed Grebe (*Podilymbus podiceps*)	NY-T
Cattle Egret (*Bubulcus ibis*)	OH-E		Piping Plover (*Charadrius melodus*)	MN-E, WI-E, IL-E, IN-E, MI-E, OH-E, NY-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Cerulean Warbler (*Setophaga cerulea*)	WI-T, IL-T, IN-E, MI-T		Prairie Warbler (*Setophaga discolor*)	MI-E
Chestnut-collared Longspur (*Calcarius ornatus*)	MN-E		Red-necked Grebe (*Podiceps grisegena*)	WI-E
Common Gallinule (*Gallinula galeata*)	IL-E, MI-T		Red-shouldered Hawk (*Buteo lineatus*)	WI-T, MI-T
Common Loon (*Gavia immer*)	MI-T		Sedge Wren (*Cistothorus platensis*)	IN-E, PA-E, NY-T
Common Moorhen (*Gallinula chloropus*)	IN-E		Short-eared Owl (*Asio flammeus*)	MI-E, NY-E
Common Tern (*Sterna hirundo*)	MN-T, WI-E, IL-E, MI-T, PA-E, NY-T		Snowy Egret (*Egretta thula*)	IL-E
Dickcissel (*Spiza americana*)	PA-E		Sprague's Pipit (*Anthus spragueii*)	MN-E
Forster's Tern (*Sterna forsteri*)	WI-E, IL-E, MI-T		Spruce Grouse (*Falcipennis canadensis*)	WI-T
Golden-winged Warbler (*Vermivora chrysoptera*)	IN-E		Trumpeter Swan (*Cygnus buccinator*)	IN-E, MI-T
Great Egret (*Ardea alba*)	WI-T		Upland Sandpiper (*Bartramia longicauda*)	WI-T, IL-E, IN-E, PA-E, NY-T
Henslow's Sparrow (*Ammodramus henslowii*)	MN-E, WI-T, IN-E, MI-E,NY-T		Virginia Rail (*Rallus limicola*)	IN-E
Hooded Warbler (*Setophaga citrina*)	WI-T		Wilson's Phalarope (*Phalaropus tricolor*)	MN-T, IL-E
Horned Grebe (*Podiceps auritus*)	MN-E		Yellow Rail (*Coturnicops noveboracensis*)	WI-T, MI-T
King Rail (*Rallus elegans*)	MN-E, IL-E, IN-E, MI-E, NY-T		Yellow-crowned Night-heron (*Nyctanassa violacea*)	IL-E, IN-E
Kirtland's Warbler (*Setophaga kirtlandii*)	WI-E, MI-E, OH-E		Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	MN-T, IL-E, IN-E
Lark Sparrow (*Chondestes grammacus*)	OH-E		Yellow-throated Warbler (*Setophaga dominica*)	MI-T
Least Bittern (*Ixobrychus exilis*)	IL-T, IN-E, MI-T, PA-E, NY-T			
Amphibians and Reptiles				
Blanchard's Cricket Frog (*Acris blanchardi*)	MN-E, WI-E, MI-T		Lake Erie Watersnake (*Nerodia sipedon insularum*)	OH-T
Blanding's Turtle (*Emydoidea blandingii*)	MN-T, IL-E, IN-E, OH-T, NY-T		Marbled Salamander (*Ambystoma opacum*)	MI-E
Blue-spotted Salamander (*Ambystoma laterale*)	OH-E		Ornate Box Turtle (*Terrapene ornata ornata*)	IN-E
Bog Turtle (*Clemmys muhlenbergii*)	NY-E		Queensnake (*Regina septemvittata*)	WI-E, NY-E
Butler's Garter Snake (*Thamnophis butleri*)	IN-E		Six-lined Racerunner (*Aspidoscellis sexlineata*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Common Mudpuppy (*Necturus maculosus*)	IL-T		Smallmouth Salamander (*Ambystoma texanum*)	
Copperbelly Water Snake (*Nerodia erythrogaster neglecta*)	IN-E, MI-E, OH-E		Smooth Green Snake (*Opheodrys vernalis*)	IN-E
Eastern Fox Snake (*Pantherophis gloydi*)	MI-T		Spotted Turtle (*Clemmys guttata*)	IN-E, MI-T, OH-T
Eastern Massasauga (*Sistrurus catenatus catenatus*)	MN-E, WI-E, IL-E, IN-E, OH-E		Timber Rattlesnake (*Crotalus homidus*)	MN-T, NY-T
Eastern Ribbonsnake (*Thamnophis sauritus*)	WI-E		Western Ratsnake (*Pantherophis obsoletus*)	MN-T
Four-toed Salamander (*Hemidactylium scutatum*)	OH-T		Wood Turtle (*Glyptemys insculpta*)	MN-T, WI-T
Kirtland's Snake (*Clonophis kirtlandii*)	IL-T, IN-E, MI-E, OH-T		Yellow Mud Turtle (*Kinosternon flavescens*)	IL-E
Fish				
American Eel (*Anguilla rostrata*)	IL-T, OH-T		Northern Redbelly Dace (*Phoxinus eos*)	PA-E
Banded Killifish (*Fundulus diaphanus*)	IL-T		Northern Sunfish (*Lepomis peltastes*)	NY-T
Bigmouth Shiner (*Notropis dorsalis*)	OH-T		Ohio Lamprey (*Ichthyomyzon bdellium*)	OH-E
Black Buffalo (*Ictiobus niger*)	MN-T		Paddlefish (*Polyodon spathula*)	MN-T
Blackchin Shiner (*Notropis heterodon*)	IL-T, PA-E		Pallid Shiner (*Hybopsis amnis*)	MN-E, IL-E
Blacknose Shiner (*Notropis heterolepis*)	IL-E		Plains Topminnow (*Fundulus sciadicus*)	MN-T
Brassy Minnow (*Hybognathus hankinsoni*)	IL-T		Pugnose Minnow (*Opsopoeodus emiliae*)	MI-E, OH-E
Brindled Madtom (*Noturus miurus*)	PA-T		Pugnose Shiner (*Notropis anogenus*)	MN-T, WI-T, IL-E, MI-E, NY-E
Brook Trout (*Salvelinus fontinalis*)	OH-T		Redfin Shiner (*Lythrurus umbratilis*)	WI-T, PA-E
Channel Darter (*Percina copelandi*)	MI-E, OH-T		Redside Dace (*Clinostomus elongatus*)	MI-E
Cisco (*Coregonus artedi*)	IL-T, MI-T, PA-E		River Darter (*Percina shumardi*)	MI-E
Creek Chubsucker (*Erimyzon claviformis*)	MI-E		River Redhorse (*Moxostoma carinatum*)	WI-T, IL-T, MI-T
Crystal Darter (*Crystallaria asprella*)	MN-E, IL-T		Round Whitefish (*Prosopium cylindraceum*)	NY-E
Deepwater Sculpin (*Myoxocephalus thompsonii*)	NY-E		Sauger (*Sander canadensis*)	MI-T
Eastern Sand Darter (*Etheostoma pellucida*)	MI-T, PA-E, NY-T, IL-T		Shortjaw Cisco (*Coregonus zenithicus*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Gravel Chub (*Erimystax x-punctatus*)	MN-T, IL-T		Silver Chub (*Macrhybopsis storeriana*)	NY-E
Greater Redhorse (*Moxostoma valenciennesi*)	OH-T, IL-E		Silver Shiner (*Notropis photogenis*)	MI-E
Iowa Darter (*Etheostoma exile*)	IL-T, PA-E		Siskiwit Lake Cisco (*Coregonus bartlettii*)	MI-T
Ives Lake Cisco (*Coregonus hubbsi*)	MI-T		Skipjack Herring (*Alosa chrysochloris*)	MN-E, WI-E
Lake Chubsucker (*Erimyzon sucetta*)	NY-T		Slender Madtom (*Noturus exilis*)	MN-E
Lake Sturgeon (*Acipenser fulvescens*)	MN-T, IL-E, IN-E, MI-T, PA-E, NY-T		Southern Redbelly Dace (*Chrosomus erythrogaster*)	MI-E
Longear Sunfish (*Lepomis megalotis*)	WI-T		Spoonhead Sculpin (*Cottus ricei*)	NY-E
Longnose Sucker (*Catostomus catostomus*)	IL-T		Spotted Gar (*Lepisosteus oculatus*)	PA-E
Mooneye (*Hiodon tergisus*)	MI-T, NY-T		Starhead Topminnow (*Fundulus dispar*)	WI-E, IL-T
Mountain Brook Lamprey (*Ichthyomyzon greeleyi*)	PA-T		Striped Shiner (*Luxilus chrysocephalus*)	WI-E
Mountain Madtom (*Noturus eleutherus*)	PA-E		Tadpole Madtom (*Noturus gyrinus*)	PA-E
Northern Brook Lamprey (*Ichthyomyzon fossor*)	IN-E, OH-E, PA-E		Warmouth (*Lepomis gulosus*)	PA-E
Northern Madtom (*Noturus stigmosus*)	MI-E, PA-E, IL-E		Western Banded Killifish (*Fundulus diaphanous menona*)	OH-E
Invertebrates				
Clubshell (*Pleurobema clava*)	OH-E, PA-E		Assiniboia Skipper (*Hesperia assiniboia*)	MN-E
Higgins Eye (*Lampsilis higginsi*)	MN-E		Aureolaria Seed Borer (*Rhodoecia aurantiago*)	IN-T
Northern Riffleshell (*Epioblasma torulosa rangiana*)	MI-E, OH-E, PA-E		Barrens Metarranthis Moth (*Metarranthis apiciaria*)	IN-E
Rayed Bean (*Villosa fabalis*)	MI-E, OH-E, PA-E		Beer's Blazing Star Borer Moth (*Papaipema beeriana*)	IN-T, OH-E
Sheepnose (*Plethobasus cyphyus*)	MN-E, IN-E		Big Broad-winged Skipper (*Poanes viator viator*)	IN-T
Snuffbox (*Epioblasma triquetra*)	MN-E, MI-E, OH-E, PA-E		Bogbean Buckmoth (*Hemileuca sp. 1*)	NY-E
Spectaclecase (*Cumberlandia monodonta*)	MN-E		Bunch Grass Locust (*Pseudopomala brachyptera*)	IN-T
White Catspaw (*Epioblasma obliquata perobliqua*)	MI-E		Bunchgrass Skipper (*Problema byssus*)	IN-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Winged Mapleleaf (*Quadrula fragosa*)	MN-E		Columbine Borer (*Papaipema leucostigma*)	IN-T
Hine's Emerald Dragonfly (*Somatochlora hineana*)	WI-E, IL-E, MI-E		Crimson Salflat Tiger Beetle (*Cicinedela fulgida fulgida*)	MN-E
Hungerford's Crawling Water Beetle (*Brychius hungerfordi*)	MI-E		Crimson Salflat Tiger Beetle (*Cicindela fulgida westbournei*)	MN-T
Karner Blue Butterfly (*Lycaeides melissa samuelis*)	MN-E, IL-E, IN-E, MI-T, OH-E, NY-E		Dakota Skipper (*Hesperia dacotae*)	MN-E
Mitchell's Satyr (*Neonympha mitchellii mitchellii*)	IN-E, MI-E		Duke's Skipper (*Euphyes dukesi*)	MI-T
Black Sandshell (*Ligumia recta*)	IL-T, MI-E, OH-T		Dune Cutworm (*Euxoa aurulenta*)	IN-T
Bluff Vertigo (*Vertigo meramecensis*)	MN-T		Dusted Skipper (*Atrytonopsis hianna*)	IN-T
A Butterfly (*Ellipsaria lineolate*)	MN-T		Elfin Skimmer (*Nannothemis bella*)	IL-T, OH-E
Eastern Pondmussel (*Ligumia nasuta*)	MI-E, OH-E		Ernestine's Moth (*Phytometra ernestinana*)	IN-E
Ebonyshell (*Fusconaia ebena*)	MN-E		Eryngium Stem Borer (*Papaipema eryngii*)	IL-T
Elephant-ear (*Elliptio crassidens crassidens*)	MN-E		Extra-striped Snaketail (*Ophiogomphus anomalus*)	WI-E
Elktoe (*Alasmidonta marginata*)	MN-T		Foster Mantleslug (*Pallifera fosteri*)	MI-T
Ellipse (*Venustaconcha ellipsiformis*)	MN-T, WI-T		Frosted Elfin (*Callophrys irus*)	IN-E, MI-T, OH-E, NY-T
Fawnsfoot (*Truncilla donaciformis*)	MN-T, MI-T, OH-T		Frosted Whiteface (*Leucorrhinia frigida*)	IN-T
Fluted-shell (*Lasmigona costata*)	MN-T		Garita Skipper (*Oarisma garita*)	MN-T
Green Floater (*Lasmigona subviridis*)	NY-T		Ghost Tiger Beetle (*Cicindela lepida*)	MN-T
Hickorynut (*Obovaria olivaria*)	MI-E		Golden Borer Moth (*Papaipema cerina*)	IN-T
Lilliput (*Toxolasma parvum*)	MI-E		Golden Legged Mydas Fly (*Mydas tibialis*)	IN-T
Monkeyface (*Quadrula metanevra*)	MN-T, WI-T		Great Copper (*Lycaena xanthoides*)	IN-E
Mucket (*Actinonaias ligamentina*)	MN-T		Grey Petaltail (*Tachopteryx thoreyi*)	MI-T
Pink Papershell (*Potamilus ohiensis*)	MI-T		Grote's Black-tipped Quaker (*Loxagrotis grotei*)	IN-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Pistolgrip (*Tritogonia verrucosa*)	MN-E		Hairy-necked Tiger Beetle (*Cicindela hirticollis rhodensis*)	MN-E, WI-E
Pondhorn (*Uniomerus tetralasmus*)	OH-T		Headwaters Chilostigman Caddisfly (*Chilostigma itascae*)	MN-T
Pondmussel (*Ligumia subrostrata*)	MN-T		Helianthus Leafhopper (*Mesamia stramineus*)	IN-E
Purple Lilliput (*Toxolasma lividus*)	MI-E		Huron River Leafhopper (*Flexamia huroni*)	MI-T
Purple Wartyback (*Cyclonaias tuberculata*)	MN-E, WI-E, MI-T		Incurvate Emerald (*Somatochlora incurvata*)	WI-E
Rabbitsfoot (*Quadrula cylindrical cylindrical*)	PA-T		Indiangrass Flexamia (*Fleaxamia reflexus*)	IN-T
Rainbow (*Villosa iris*)	WI-E		Lake Huron Locust (*Trimerotropis huroniana*)	WI-E, MI-T
Rock Pocketbook (*Arcidens confragosus*)	MN-E		Large-headed Grasshopper (*Phoetaliotes nebrascensis*)	IN-T
Round Hickorynut (*Obovaria subrotunda*)	MI-E		Leadplant Leafwebber Moth (*Nephopterix dammersi*)	IN-E
Round Lake Floater (*Pyganodon subgibbosa*)	MI-T		Leadplant Underwing Moth (*Catocala amestris*)	IN-E
Salamander Mussel (*Simpsonaias ambigua*)	M-E, MI-E		Marked Noctuid (*Tricholita notata*)	IN-T, OH-E
Slippershell Mussel (*Alasmidonta viridis*)	WI-T, IL-T, MI-T		Mottled Duskywing (*Erynnis martialis*)	IN-T
Spike (*Elliptio dilatata*)	MN-T, IL-T		Nebraska Silver Bordered Fritillary (*Boloria selene nebraskensis*)	IN-E
Threehorn Wartyback (*Obliquaria reflexa*)	MI-E, OH-T		Newman's Brocade (*Meropleon ambifuscum*)	IN-T
Wartyback (*Quadrula nodulata*)	MN-T		No Common Name (*Aethes patricia*)	IN-E
Washboard (*Megalonaias nervosa*)	MN-E		No Common Name (*Agrotis stigmosa*)	IN-T
Wavyrayed Lampmussel (*Lampsilis fasciola*)	MI-T		No Common Name (*Archanara laeta*)	IN-T
Yellow Sandshell (*Lampsilis teres*)	MN-E		No Common Name (*Cicadula straminea*)	IN-T
A Land Snail (*Euconulus alderi*)	MI-T		No Common Name (*Dorydiella kansana*)	IN-T
A Land Snail (*Vallnia gracilicosta albula*)	MI-E		No Common Name (*Limotettix divaricatus*)	IN-T
A Land Snail (*Vertigo modesta modesta*)	MI-E		No Common Name (*Macrochilo louisiana*)	IN-T
A Land Snail (*Vertigo modesta parietalis*)	MI-E		No Common Name (*Paraphlepsius lobatus*)	IN-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Acorn Ramshorn (*Planorbella multivolvis*)	MI-E		Northern Blue (*Plebejus idas nabokovi*)	MI-T
An aquatic Snail (*Planorbella smithi*)	MI-E		Northern Blue Butterfly (*Lycaeides idas*)	WI-E
Broadshoulder Physa (*Physella parkeri*)	MI-T		Northern Cordgrass Borer (*Spartiniphaga panatela*)	IN-T, OH-T
Cherrystone Drop (*Hendersonia occulta*)	WI-T, MI-T		Olympia Marble (*Euchloe olympia*)	IN-T
Deep-throat Vertigo (*Vertigo nylanderi*)	MI-E		Opalescent Apamea (*Apamea lutosa*)	IN-E
Deepwater Pondsnail (*Stagnicola contracta*)	MI-E		Ottoe Skipper (*Hesperia ottoe*)	MN-E, IN-E, MI-T
Delicate Vertigo (*Vertigo bollesiana*)	MI-T		Pearly Indigo Borer (*Sitochroa dasconalis*)	IN-T
Lambda Snaggletooth (*Gastrocopta holzingeri*)	MI-E		Peppered Paraphlepsius Leafhopper (*Paraphlepsius maculosus*)	IN-T
Midwest Pleistocene Vertigo (*Vertigo hubrichti*)	WI-E, MI-E		Persius Dusky Wing (*Erynnis persius persius*)	MN-E, IN-E, MI-T, NY-E
Petoskey Pondsnail (*Stagnicola petoskeyensis*)	MI-E		Phlox Moth (*Schinia indiana*)	IN-E
Pleistocene catinella (*Catinella exile*)	MI-T		Plains Clubtail (*Gomphus externus*)	OH-E
Proud Globe (*Mesodon elevatus*)	MI-T		Poweshiek Skipper (*Oarisma poweshiek*)	MN-E
Six-whorl Vertigo (*Vertigo morsei*)	MI-E		Prairie Sedge Moth (*Crambus murellus*)	IN-T
Sterki’s granule (*Guppya sterkii*)	MI-E		Purplish Copper (*Lycaena helloides*)	OH-E
A Caddisfly (*Brachycentrus numerosus*)	OH-E		Red-striped Panic Grass Moth (*Tampa dimediatella*)	IN-T
A Caddisfly (*Chimarra socia*)	OH-E		Redveined Prairie Leafhopper (*Aflexia rubranura*)	WI-E, IL-T
A Caddisfly (*Hydroptila albicornis*)	OH-T		Regal Fritillary (*Speyeria idalia*)	WI-E, IN-E, MI-E, OH-E
A Caddisfly (*Psilotreta indecisa*)	OH-T		Sandy Tiger Beetle (*Cicindela limbata nympha*)	MN-E
A Dipteran (*Rheopelopia acra*)	OH-E		Silphium Borer Moth (*Papaipema silphii*)	WI-E, IN-T, MI-T, OH-E
A Grasshopper (*Paroxya atlantica*)	IN-T		Silver-bordered Fritillary (*Boloria selene myrina*)	IN-T
A Moth (*Hypocoena enervata*)	OH-E		Silvery Blue (*Glaucopsyche lygdamus couperi*)	IN-E
A Moth (*Spartiniphaga inops*)	OH-E		Smoky-eyed Brown (*Satyrodes Eurydice fumosa*)	IN-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
A Moth (*Trichoclea artesta*)	OH-E		Spatterdock Darner (*Aeshna mutata*)	IN-T
A Moth (*Ufeus satyricus*)	OH-E		St. Croix Snaketail (*Ophiogomphus susbehcha*)	MN-T
A Noctuid Moth (*Apamea burgessi*)	IN-T		Swamp Metalmark (*Calephelis muticum*)	WI-E, IL-E
A Noctuid Moth (*Apamea relicina*)	IN-T		The Culver's Root Borer (*Papaipema sciata*)	IN-T
A Noctuid Moth (*Capis curvata*)	IN-T		The Dune Locust (*Trimerotropis maritima*)	IN-T
A Noctuid Moth (*Eucoptocnemis fimbriaris*)	IN-T		The Dune Oncocnemis Moth (*Oncocnemis riparia*)	IN-T
A Noctuid Moth (*Loxagrotis acclivis*)	IN-T		The Four-lined Cordgrass Borer (*Mesapamea stipata*)	IN-E
A Noctuid Moth (*Oligia obtusa*)	IN-E		The Giant Sunflower Borer Moth (*Papaipema maritima*)	IN-T
A Pyralid Moth (*Pyla arenaeola*)	IN-E		The Included Cordgrass Borer (*Spartiniphaga includens*)	IN-T
A Species of Caddisfly (*Geora stylata*)	MN-T		The Kansas Prairie Leafhopper (*Prairiana kansana*)	IN-E
A Species of Caddisfly (*Lepidostoma libum*)	MN-T		The Many-lined Cordgrass Moth (*Chortodes enervate*)	IN-T
A Species of Jumping Spider (*Tutelina formicaria*)	MN-T		The Marsh Fern Moth (*Fagitana littera*)	IN-T
A Species of Long-horned Caddisfly (*Oecetis ditissa*)	MN-T		The Multicolored Huckleberry Moth (*Pangrapta decoralis*)	IN-T
A Species of Long-horned Caddisfly (*Ylodes frontalis*)	MN-T		The Pink-streak (*Faronta rubripennis*)	IN-T, OH-E
A Species of Netspinning Caddisfly (*Parapsyche apicalis*)	MN-T		The Prairie Panis Grass Leafhopper (*Polyamia herbida*)	IN-T
A Species of Northern Caddisfly (*Ironoquia punctatissima*)	MN-T		The Rare Sand Quaker (*Platyperigea meralis*)	IN-T
A Species of Northern Caddisfly (*Limnephilus janus*)	MN-E		The Royal Fern Borer Moth (*Papaipema speciosissima*)	IN-T
A Species of Northern Caddisfly (*Limnephilus rossi*)	MN-T		The Starry Campion Moth (*Hadena ectypa*)	IN-T
A Species of Northern Caddisfly (*Limnephilus secludens*)	MN-E		Tomah Mayfly (*Siphlonisca aerodromia*)	NY-E
A Species of Purse Casemaker Caddisfly (*Hydroptila rono*)	MN-T		Tufted Sedge Moth (*Chortodes inquinata*)	IN-T
A Species of Purse Casemaker Caddisfly (*Ochrotrichia spinosa*)	MN-E		Two-lined Cosmotettix (*Cosmotettix bilineatus*)	IN-T
A Species of Purse Casemaker Caddisfly (*Oxyethira ecornuta*)	MN-T		Two-spotted Skipper (*Euphyes bimacula*)	IN-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
A Species of Tube Casemaker Caddisfly (*Polycentropus glacialis*)	MN-T		Uhler's Arctic (*Oeneis uhleri varuna*)	MN-E
A Species of Tube Casemaker Caddisfly (*Polycentropus milaca*)	MN-E		Uncas Skipper (*Hesperia uncas*)	MN-E
A Species of Purse Casemaker Caddisfly (*Hydroptila waskesia*)	MN-E		Unexpected Cycnia (*Cycnia inopinatus*)	OH-E
A Spitle Bug (*Paraphilaenus parallelus*)	IN-T		Wayward Nymph (*Catocala antinympha*)	IN-E, OH-T
Abbreviated Leadplant Underwing Moth (*Catocala abbreviatella*)	IN-E		Wild Hyacinth (*Carnassia scilloides*)	MI-T
American Burying Beetle (*Nicrophorus americanus*)	NY-E		Wood-colored Apamea (*Apamea lignicolora*)	IN-T
American Emerald (*Cordulia shurtleffi*)	OH-E			
Plants				
A Sedge (*Carex media*)	MI-T		Mountain Blue-eyed Grass (*Sisyrinchium montanum*)	IL-E, IN-E, OH-T
Alder Buckthorn (*Rhamnus alnifolia*)	IL-E		Mountain Cranberry (*Vaccinium vitis-idaea*)	WI-E, MI-E
Algae-leaved Pondweed (*Potamogeton confervoides*)	MN-E, WI-T		Mountain Death Camas (*Anticlea elegans ssp. glaucus*)	NY-T
Alpine Bilberry (*Vaccinium uliginosum*)	MN-E, MI-T		Mountain Mint (*Pycnanthemum muticum*)	MI-T, NY-T
Alpine Bistort (*Bistorta vivipara*)	MI-T		Mountain Phlox (*Phlox latifolia*)	OH-E
Alpine Bluegrass (*Poa alpina*)	MI-T		Mountain Watercress (*Cardamine rotundifolia*)	NY-E
Alpine Milk Vetch (*Astagalus alpinus*)	MN-E, WI-E		Mud Sedge (*Carex limosa*)	IN-E, OH-E
Alpine Sainfoin (*Hedysarum alpinum*)	MI-E		Mullein-foxglove (*Dasistoma macrophylla*)	MI-E
Apine Willow-herb (*Epilobium hornemannii ssp. hornemannii*)	NY-E		Narrow-leaf Cottongrass (*Eriophorum angustifolium ssp. angustifolium*)	NY-E
American Burnet (*Sanguisorba canadensis*)	IL-E, MI-E		Narrow-leaved Blue-eyed Grass (*Sisyrinchium mucronatum*)	OH-T, NY-E
American Chestnut (*Castanea dentata*)	MI-E		Narrow-leaved Gentian (*Gentiana linearis*)	MI-T
American Dragonhead (*Dracocephalum parviflorum*)	NY-E		Narrow-leaved Pinweed (*Lechea tenuifolia var. tenuifolia*)	MN-E
American Fly-honeysuckle (*Lonicera canadensis*)	IN-E		Narrow-leaved Reedgrass (*Calamagrostis stricta ssp. stricta*)	MI-T
American Golden-saxifrage (*Chrysosplenium americanum*)	IN-T		Narrow-leaved Sedge (*Carex amphibola*)	NY-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
American Manna-grass (*Glyceria grandis*)	IN-E		Narrow-leaved Sundew (*Drosera intermedia*)	IL-T, OH-E
American Orpine (*Sedum telephoides*)	IL-T		Neat Spike-rush (*Eleocharis nitida*)	WI-E, MI-E
American Rock-brake (*Cryptogramma acrostichoides*)	MI-T		Necklace Sedge (*Carex projecta*)	OH-T
American Scheuchzeria (*Scheuchzeria palustris spp. americana*)	IN-E		New England Northern Reedgrass (*Calamagrostis stricta ssp. inexpansa*)	NY-T
American Slough Grass (*Beckmannia syzigachne*)	IL-E, MI-T		New England Sedge (*Carex novae-angliae*)	MI-T
American Strawberry-bush (*Euonymus americanus*)	NY-E		New England Violet (*Viola novae-angliae*)	MI-T
American Water-milfoil (*Myriophyllum sibiricum*)	OH-E, PA-E		Nodding Pogonia (*Triphora trianthophora*)	MI-T, NY-T
Appalachian Blue Violet (*Viola appalachiensis*)	PA-T		Nodding Rattlesnake-root (*Prenanthes crepidinea*)	WI-E, MI-T, NY-E
Appendaged Waterleaf (*Hydrophyllum appendiculatum*)	NY-E		Nodding Saxifrage (*Saxifraga cernua*)	MN-E
Arrowhead (*Sagittaria montevidensis*)	MI-T		Nodding Sedge (*Carex gynandra*)	OH-E
Ashy Sunflower (*Helianthus mollis*)	MI-T, OH-T		Nodding Trillium (*Trillium cernuum*)	IL-E
Assiniboia Sedge (*Carex assiniboinensis*)	MI-T		Nodding Trilium (*Trillium cernuum var. macranthum*)	IN-E
Atlantic Blue-eyed Grass (*Sisyrinshium atlanticum*)	MI-T, OH-E		Nodding Trillium (*Trillium flexipes*)	NY-E
Auricled Twayblade (*Listera auriculata*)	MN-E		Nodding Wild Onion (*Allium cernuum var. cernuum*)	NY-T
Autumn Willow (*Salix serissima*)	IL-E, PA-T		Northeastern Bladderwort (*Utricularia resupinata*)	IN-E
Autumnal Water-starwort (*Callitriche hermaphroditica*)	NY-E		Northeastern Smartweed (*Polygonum hydropiperoides var. opelousanum*)	IN-T
Awlwort (*Subularia aquatica*)	MI-E		Northern Adder's-tongue (*Ophioglossum pusillum*)	OH-E
Awned Sedge (*Carex atherodes*)	IN-E, PA-E		Northern Appressed Bog Clubmoss (*Lycopodiella subappressa*)	IN-E, OH-E
Back's Sedge (*Carex backii*)	NY-T		Northern Bearded Sedge (*Carex pseudocyperus*)	OH-E, PA-E
Ball Cactus (*Escobaria vivipara*)	MN-E		Northern Bog Clubmoss (*Lycopodiella inundata*)	IN-E
Balsam Poplar (*Populus balsamifera*)	IL-E, IN-E, OH-E, PA-E		Northern Bog Sedge (*Carex gynocrates*)	NY-E
Balsam Squaw-weed (*Packera paupercula*)	OH-T		Northern Bog Violet (*Viola nephrophylla*)	OH-T, NY-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Baltic Rush (*Juncus articus var. littoralis*)	PA-T		Northern Comander (*Geocaulon lividum*)	WI-E
Basil-balm (*Monarda clinopodia*)	NY-E		Northern Cranesbill (*Geranium bicknellii*)	IL-E, IN-E, OH-E, PA-E
Bastard Pennyroyal (*Trichostema dichotomum*)	MI-T		Northern Dropseed (*Sporobolus heterolepis*)	NY-T
Bayonet Rush (*Juncus militaris*)	IN-E, MI-T		Northern Fox Sedge (*Carex alopecoidea*)	OH-E
Beach Grass (*Ammophila breviligulata spp. breviligulata*)	MN-T		Northern Gooseberry (*Ribes hirtellum*)	IL-E
Beach Peavine (*Lathyrus maritimus var. glaber*)	IN-E		Northern Grape Fern (*Botrychium multifidum*)	IL-E, OH-E
Beach Wormwood (*Artemisia campestris*)	OH-T, PA-E		Northern Marsh Violet (*Viola epipsila*)	MI-E
Beaked Agrimony (*Agrimonia rostellata*)	MI-T, NY-T		Northern Oak Fern (*Gymnocarpium jessoense*)	MI-E
Beaked Rush (*Rhynchospora alba*)	IL-E		Northern Paintbrush (*Castilleja septentionalis*)	MN-E, MI-T
Beaked Spike-rush (*Eleocharis rostellata*)	WI-T, IL-T		Northern Panic Grass (*Dichanthelium boreale*)	IL-E
Bearberry (*Arctostaphylos uva-ursi*)	IL-E, OH-E		Northern Poison-ivy (*Toxicodendron rydbergii*)	OH-E
Beard Tongue (*Penstemon calycosus*)	MI-T		Northern Pondweed (*Potamogeton alpinus*)	NY-T
Bearded Wheat Grass (*Elymus trachycaulus*)	IL-E, OH-T		Northern Prostrate Clubmoss (*Lycopodiella marqueritae*)	MI-T
Bear's-foot (*Smallanthus uvedalius*)	NY-E		Northern Shorhusk (*Brachyelytrum aristosum*)	IN-E
Beautiful Sedge (*Carex concinna*)	WI-T		Northern Stickseed (*Hackelia deflexa var. americana*)	NY-E
Bebb's Sedge (*Carex bebbii*)	IN-T, PA-E		Northern Tansy-mustard (*Descurainia pinnata ssp. brachycarpa*)	NY-E
Beck Water-marigold (*Bidens beckii*)	IN-T		Northern Water-plantain (*Alisma triviale*)	PA-E
Bedstraw (*Galium kamtschaticum*)	MI-E		Northern White Cedar (*Thuja occidentalis*)	IN-E
Bicknell's Sedge (*Carex bicknellii*)	OH-T		Northern Wild Comfrey (*Cynoglossum virginianum var. boreale*)	NY-E
Big Shellbark Hickory (*Carya laciniosa*)	NY-T		Northern Woodsia (*Woodsia alpina*)	MI-E
Birdfoot Violet (*Viola pedata*)	OH-T		Norwegian Whitlow Grass (*Draba norvegica*)	MN-E
Bird's-eye Primrose (*Primula mistassinica*)	NY-T		Nottoway Brome Grass (*Bromus nottowayanus*)	NY-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Bitter Fleabane (*Erigeron acris var. kamtschaticus*)	MN-E		Nuttall Pondweed (*Potamogeton epihydrus*)	IN-E
Black Crowberry (*Empetrum nigrum*)	MN-E, MI-T		Oake's Evening-primrose (*Oenothera oakesiana*)	MN-E
Black Sedge (*Carex arctata*)	IN-E		Oake's Pondweed (*Potamogeton oakesianus*)	MN-E
Black Sedge (*Carex nigra*)	MI-E, NY-E		Obovate Beakgrain (*Diarrhena obovata*)	MN-E
Black-edge Sedge (*Carex nigromarginata*)	NY-T		Ogden's Pondweed (*Potamogeton ogdenii*)	NY-E
Black-fruited Spike-rush (*Eleocharis melanocarpa*)	IN-T		Ohio Goldenrod (*Oligoneuron ohioense*)	NY-T
Bladderpod (*Physaria ludoviciana*)	MN-E		Oklahoma Grass-pink (*Calopogon oklahomensis*)	IN-E
Blue-eyed Mary (*Collinsia verna*)	NY-E		Old-field Toadflax (*Linaria canadensis*)	OH-E
Bluehearts (*Buchnera americana*)	IL-T, IN-E, NY-E		Olney's Three-square (*Schoenoplectus americanus*)	OH-E
Blue-stemmed Goldenrod (*Solidago caesia*)	WI-E		Ovate Spike-rush (*Eleocharis ovata*)	OH-E, NY-E
Blunt-lobe Grape Fern (*Botrychium oneidense*)	NY-T		Painted Trillium (*Trillium undulatum*)	MI-E, OH-E
Blunt-lobed Woodsia (*Woodsia obtusa*)	MI-T		Pale Corydalis (*Corydalis sempervirens*)	IN-T, OH-T
Blurush (*Scirpus hattorianus*)	IL-E		Pale Duckweed (*Lemna valdiviana*)	IN-E
Bog Adder's Mouth (*Malaxis paludosa*)	MN-E		Pale False Foxglove (*Agalinis skinneriana*)	Wi-E, IL-T, IN-T, MI-E, OH-E
Bog Bluegrass (*Poa paludigena*)	MI-T, NY-E		Pale Green Orchid (*Platanthera flava var. herbiola*)	WI-T
Branching Bur-reed (*Sparganium androcladum*)	IN-T, OH-T, PA-E		Pale Indian-plantain (*Arnoglossum atriplicifolium*)	NY-E
Braun's Holly Fern (*Polystichum braunii*)	WI-T		Pale Purple Coneflower (*Echinacea pallida*)	Wi-T
Bristle-berry (*Rubus stipulatus*)	MN-E		Pale Sedge (*Carex pallescens*)	MN-E
Bristly Blackberry (*Rubus schneideri*)	IL-T		Pale Vetchling (*Lathyrus ochroleucus*)	IL-T, IN-E, OH-T
Bristly Nodding Sedge (*Carex echinodes*)	NY-E		Panic Grass (*Panicum longifolium*)	MI-T
Bristly Sarsaparilla (*Aralia hispida*)	IN-E, OH-E		Panicled Hawkweed (*Hieracium paniculatum*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Bristly Smartweed (*Persicaria setacea*)	OH-E, NY-E		Panicled Screwstem (*Bartonia paniculata*)	MI-T
Broad Beech Fern (*Phegopteris hexagonoptera*)	MN-E		Pawpaw (*Asimina triloba*)	NY-T
Broad-leaved Sedge (*Carex platyphylla*)	MI-E		Pearlwort (*Sagina nodosa*)	MI-T
Broad-leaved Twayblade (*Listera convallarioides*)	WI-T, NY-E		Philadelphia Panic Grass (*Panicum philadelphicum*)	MI-T, OH-E
Broad-leaved Water-milfoil (*Myriophyllum heterophyllum*)	PA-E		Pink Milkwort (*Polygala incarnata*)	WI-E
Broad-winged Sedge (*Carex alata*)	PA-T		Pink Wild Bean (*Strophostyles umbellata*)	NY-E
Brook Lobelia (*Lobelia kalmii*)	PA-E		Pink Wintergreen (*Pyrola asarifolia ssp. asarifolia*)	NY-T
Brown Bog Sedge (*Carex buxbaumii*)	NY-T		Pinweed (*Lechea intermedia*)	IL-E
Brown-fruited Rush (*Juncus pelocarpus*)	IN-E		Pinxter-flower (*Rhododendron periclymenoides*)	OH-T
Brownish Sedge (*Carex brunnescens*)	IL-E, IN-E, OH-E		Pipewort (*Eriocaluon aquaticum*)	IN-E
Buckbean (*Menyanthes trifoliata*)	IL-T		Pipsissewa (*Chimaphila umbellate ssp. cisatlantica*)	IN-T, OH-T
Buffaloberry (*Shepherdia canadensis*)	IL-E, PA-E		Pitcher Plant (*Sarracenia purpurea*)	IL-E
Bug-on-a-stick (*Buxbaumia aphylla*)	OH-T		Pitcher's Thistle (*Cirsium pitcheri*)	WI-T, IL-T, IN-T, MI-T
Bullhead-lily (*Nuphar variegata*)	OH-E		Plains Muhlenbergia (*Muhlenbergia cuspidata*)	OH-E
Bulrush (*Scirpus expansus*)	IN-E		Plains Puccoon (*Lithospermum caroliniense*)	OH-T, PA-E
Bulrush Sedge (*Carex scirpoidea*)	MI-T		Plains Ragwort (*Packera indecora*)	MN-E, WI-T, MI-T
Bunchberry (*Cornus canadensis*)	IN-E, OH-E		Plantain-leaved Sedge (*Carex plantaginea*)	MN-E
Bushy Aster (*Symphyotrichum dumosum*)	OH-T		Pod-grass (*Scheuchzeria palustris*)	PA-E
Bushy Cinquefoil (*Potentilla paradoxa*)	OH-T, PA-E, NY-E		Porcurpine Grass (*Hesperostipa spartea*)	OH-E
Butternut (*Juglans cinerea*)	MN-E		Prairie Bush Clover (*Lespedeza leptostachya*)	WI-E, IL-E
Button Sedge (*Carex bullata*)	NY-E		Prairie Buttercup (*Ranunculus rhomboideus*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Button-bush Dodder (*Cuscuta cephalanthi*)	NY-E		Prairie Cinquefoil (*Potentilla litoralis*)	MI-T
Calamint (*Satureja glabella var. angustifolia*)	IN-E		Prairie Coreopsis (*Coreopsis palmata*)	MI-T
Calypso (*Calypso bulbosa var. americana*)	NY-E		Prairie Fame-flower (*Talinum rugospermum*)	IN-T
Calypso Orchid (*Calypso bulbosa*)	WI-T, MI-T		Prairie Fern-leaved False Foxglove (*Aureolaria pedicularia var. ambigens*)	OH-E
Canada Forked Chickweed (*Paronychia canadensis*)	MN-E		Prairie Golden Alexanders (*Zizia aptera*)	MI-T
Canada Frostweed (*Helianthemum canadense*)	MN-E		Prairie Gray Sedge (*Carex conoidea*)	IN-T, OH-T
Canada Hawkweed (*Hieracium umbellatum*)	OH-E		Prairie Ironweed (*Vernonia fasciculata*)	OH-E
Canada Milk Vetch (*Astragalus canadensis*)	MI-T, OH-T		Prairie Milkweed (*Asclepias sullivantii*)	Wi-T, MI-T
Canada Plum (*Prunus nigra*)	OH-E		Prairie Moonwort (*Botrychium campestre*)	MI-T
Canada Rice Grass (*Piptatherum canadense*)	MI-T		Prairie Parsley (*Polytaenia nuttallii*)	WI-T, IN-E
Canada St. John's-wort (*Hypericum canadense*)	OH-E		Prairie Quillwort (*Isoetes melanopoda*)	MN-E
Canada Violet (*Viola canadensis*)	IL-E		Prairie Redroot (*Ceanothus herbaceus*)	IIL-E, IN-E, OH-E, NY-E
Canadian Gooseberry (*Ribes oxyacanthoides spp. oxyacanthoides*)	WI-T		Prairie Sedge (*Carex prairea*)	PA-T
Canbyi's Bluegrass (*Poa secunda*)	MI-E		Prairie Shootine Star (*Dodecatheon meadia var. meadia*)	MN-E
Capillary Beaked-rush (*Rhynchospora capillacea*)	PA-E		Prairie Smoke (*Geum triflorum*)	MI-T, NY-T
Capitate Spikerush (*Eleocharis geniculata*)	IL-E, IN-T, OH-E		Prairie Thimbleweed (*Anemone cylindrica*)	OH-T, PA-E
Capitate Spikerush (*Eleocharis caribaea*)	PA-E		PrairieViolet (*Viola pedatifida*)	IN-T, MI-T
Carey's Heartsease (*Polygonum careyi*)	IL-E, IN-T		Prairie Wedgegrass (*Sphenopholis obtusata*)	NY-E
Carey's Sedge (*Carex careyana*)	MN-E, NY-E		Prairie Weed Grass (*Sphenopholis obtusata var. obtusata*)	OH-T
Carey's Smartweed (*Persicaria careyi*)	MI-T, PA-E, NY-E		Prickly Saxifrage (*Saxifraga tricuspidata*)	MI-T
Carolina Grass-of-parnassus (*Parnassia glauca*)	PA-E		Primrose-leaf Violet (*Viola primulifolia*)	IN-T, OH-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Carolina Whitlow-grass (*Draba reptans*)	MI-T, OH-T, NY-T		Pumpelly's Bromegrass (*Bromus pumpellianus*)	MI-T
Carolina Yellow-eyed Grass (*Xyris difformis*)	IN-T		Pumpkin Ash (*Fraxinus profunda*)	MI-T
Cattail Gray-feather (*Liatris pycnostachya*)	IN-T		Purple Bluets (*Houstonia purpurea var. purpurea*)	NY-E
Champlain Beachgrass (*Ammophila breviligulata ssp. champlainensis*)	NY-E		Purple Cliff Brake (*Pellaea atropurpurea*)	MI-T
Chestnut Sedge (*Fimbristylis puberula*)	WI-E, IN-E		Purple Cress (*Cardamine douglassii*)	NY-T
Chilean Sweet Cicely (*Osmorhiza berteroi*)	MN-E		Purple Crowberry (*Empetrum atropurpureum*)	MN-E
Christmas Fern (*Polystichum acrostichoides*)	MN-E		Purple False Oats (*Trisetum melicoides*)	WI-E
Chuck-will's-widow (*Caprimulgus carolinensis*)	IL-T		Purple Fringed Orchid (*Platanthera psycodes*)	IL-E
Clasping Milkweed (*Asclepias amplexicaulis*)	MN-T		Purple Milkweed (*Asclepias purpurascens*)	WI-E, MI-T, NY-T
Cleland's Evening-primrose (*Oenothera clelandii*)	OH-E		Spatulate Moonwort (*Botrychium spathulatum*)	MN-E, MI-T
Climbing Fern (*Lygodium palmatum*)	MI-E		Purple Reedgrass (*Calamagrostis purpurascens*)	MN-E
Climbing Hempweed (*Mikania scandens*)	IN-E, MI-T		Purple Rocket (*Iodanthus pinnatifidus*)	MN-E
Clinton Lily (*Clintonia borealis*)	IN-E, OH-E		Purple Sandgrass (*Triplasis purpurea*)	PA-E
Clinton Woodfern (*Dryopteris clintoniana*)	IN-E, OH-E		Purple Spike Rush (*Eleocharis atropurpurea*)	MI-E
Clinton's Clubrush (*Trichophorum clintonii*)	NY-E		Purple-flowered Bladderwort (*Utricularia purpurea*)	MN-E
Cloud Sedge (*Carex haydenii*)	NY-E		Purple-flowering Raspberry (*Rubus odoratus*)	IL-T
Cluster Fescue (*Festuca paradoxa*)	PA-E		Puttyroot (*Aplectrum hyemale*)	NY-E
Clustered Broomrape (*Orobanche fasciculata*)	WI-T, IL-E, IN-E, MI-T		Pygmy Water Lily (*Nymphaea leibergii*)	MI-E
Clustered Bur-reed (*Sparganium glomeratum*)	WI-T		Queen-of-the-prairie (*Filipendula rubra*)	IL-T, MI-T
Clustered Sedge (*Carex cumulata*)	IN-E		Racemed Milkwort (*Polygala polygama*)	OH-T
Coast Sedge (*Carex exilis*)	WI-T		Rams-head Lady's-slipper (*Cypripedium arietinum*)	WI-T, NY-T
Coastal Little Bluestem (*Schizachyrium littorale*)	OH-E		Rattlesnake-master (*Eryngium yuccifolium*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Common Bog Arrow Grass (*Triflochin maritima*)	IL-T		Ravenfoot-sedge (*Carex crus-corvi*)	WI-E, MI-E
Common Butterwort (*Pinguicula vulgaris*)	WI-E, NY-T		Red Baneberry (*Actaea rubra*)	OH-T
Common Hop-tree (*Ptelea trifoliata*)	PA-T		Red Honeysuckle (*Lonicera dioica var. glaucescens*)	IL-E
Common Mare's-tail (*Hippuris vulgaris*)	NY-E		Red Mulberry (*Morus rubra*)	MI-T
Common Moonwart (*Botrychium lunaria*)	WI-E		Red Pigweed (*Chenopodium rubrum*)	NY-T
Common Oak Fern (*Gymnocarpium dryopteris*)	OH-E		Red-head Pondweed (*Potamogeton richardsonii*)	PA-T
Commons' Panic Grass (*Dichanthelium commonsianum*)	OH-E		Reflexed Bladder Sedge (*Carex retrorsa*)	OH-E, PA-E
Compass Plant (*Silphium laciniatum*)	MI-T		Reflexed Sedge (*Carex retroflexa*)	NY-T
Cooper's Milk Vetch (*Astragalus neglectus*)	WI-E, OH-T, NY-E		Reticulated Nutrush (*Scleria reticularis*)	IN-T, MI-T
Cordroot Sedge (*Carex chordorrhiza*)	IL-E, IN-E, NY-T		Richardson Sedge (*Carex richardsonii*)	IN-T
Cork Elm (*Ulmus thomasii*)	NY-T		Richardson's Rush (*Juncus alpinoarticulatus*)	IL-T, OH-T, PA-T
Corn Salad (*Valerianella umbilicata*)	MI-T		Riverweed (*Podostemum ceratophyllum*)	OH-E, NY-T
Cow-wheat (*Melampyrum lineare*)	OH-E		Robin-run-away (*Dalibarda repens*)	MI-T
Cranefly Orchid (*Tipularia discolor*)	MI-E, NY-E		Rock-cress (*Draba arabisans*)	NY-T
Crawe Sedge (*Carex crawei*)	IN-T, NY-T		Rock-rose (*Chamaerhodos nuttallii var. keweenawensis*)	MI-E
Creeping St. John's-wort (*Hypericum adpressum*)	IN-E		Rose Twisted-stalk (*Streptopus lanceolatus*)	OH-E
Cross-leaved Milkwort (*Polygala cruciata*)	MN-E, OH-E		Rosepink (*Sabatia angularis*)	MI-T
Cuckoo Flower (*Cardamine pratensis var. palustris*)	IL-E, PA-E		Rosinweed (*Silphium integrifolium*)	MI-T
Culver's-root (*Veronicastrum virginicum*)	NY-T		Ross's Sedge (*Carex rossii*)	MI-T
Cup Plant (*Silphium perfoliatum*)	MI-T		Rosy Pussytoes (*Antennaria rosea*)	MI-E
Cutleaf Water-milfoil (*Myriophyllum pinnatum*)	IN-E		Rough Avens (*Geum virginianum*)	NY-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Cut-leaved Anemone (*Anemone multifida var. multifida*)	WI-E		Rough Panic Grass (*Dichanthelium scabriusculum*)	NY-E
Cypress-knee Sedge (*Carex decomposita*)	NY-E		Rough Rattlesnake-root (*Prenanthes aspera*)	WI-E, OH-T
Davis' Sedge (*Carex davisii*)	NY-T		Rough Sedge (*Carex scabrata*)	IN-E
Decurrent False Aster (*Boltonia decurrens*)	IL-T		Rough-fruited Fairybells (*Prosartes trachycarpa*)	MN-E, MI-T
Deer's Hair Sedge (*Trichophorum cespitosum ssp. cespitosum*)	NY-T		Rough-leaf Dogwood (*Cornus drummondii*)	NY-E
Delicate Vertigo (*Vertigo bollesiana*)	MI-T		Round-fruited Hedge-hyssop (*Gratiola virginiana*)	MI-T, OH-T
Devil's Club (*Oplopanax horridus*)	MI-T		Round-fruited St. John's-wort (*Hypericum sphaerocarpum*)	MI-E
Diverse-leaved Pondweed (*Potamogeton diversifolius*)	MN-E		Round-leaved Orchis (*Amerorchis rotundifolia*)	WI-T, MI-E
Dotted Horsemint (*Monarda punctata*)	OH-E		Round-leaved Sundew (*Drosera rotundifolia*)	IL-E
Douglas' Knotweed (*Polygonum douglasii*)	NY-T		Round-seed Panic-grass (*Dichanthelium polyanthes*)	MI-E
Downy Gentian (*Gentiana puberulenta*)	IN-T, MI-E, OH-E		Roundstem Foxglove (*Agalinis gattingeri*)	MN-E, WI-T, MI-E, OH-T
Downy Lettuce (*Lactuca hirsuta*)	NY-E		Royal Catchfly (*Silene regia*)	IL-E, IN-T
Downy Phlox (*Phlox pilosa ssp. pilosa*)	NY-E		Running Serviceberry (*Amelanchier humilis*)	IN-E
Downy Solomon's Seal (*Polygonatum pubescens*)	IL-T		Rush Aster (*Symphyotrichum boreale*)	PA-E, NY-T
Downy Willow Herb (*Epilobium strictum*)	IL-T, OH-T, PA-E		Rusty Cotton Grass (*Eriophorum virginicum*)	IL-E
Downy Yellow Painted Cup (*Castilleja sessiliflora*)	IL-E		Salt-marsh Spikerush (*Eleocharis uniglumis var. halophila*)	NY-T
Dragon's Mouth (*Arethusa bulbosa*)	PA-E, NY-T		Salt-meadow Grass (*Leptochloa fusca ssp. fascicularis*)	NY-E
Dropseed (*Sporobolus clandestinus*)	MI-E		Sand Cherry (*Prunus pumila var. cuneata*)	OH-E
Drummond Hemicarpha (*Hemicarpha drummondii*)	IN-E		Sand Cinquefoil (*Potentilla supina*)	MI-T
Drummond's Aster (*Symphyotrichum drummondii*)	OH-T		Sand Dune Willow (*Salix cordata*)	WI-E, IN-T, NY-T
Drummond's Dwarf Bulrush (*Lipocarpha drummondii*)	OH-E		Sand Reedgrass (*Calamovilfa longifolia var. magna*)	WI-T

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Drummond's Rock Cress (*Boechera stricta*)	OH-E, NY-T		Sand-heather (*Hudsonia tomentosa*)	IN-T
Dune Willow (*Salix syrticola*)	IL-E		Sartwell's Sedge (*Carex sartwellii*)	NY-E
Dusty Goldenrod (*Solidago puberula*)	OH-E		Satiny Willow (*Salix pellita*)	WI-E
Dwarf Bilberry (*Vaccinium cespitosum*)	WI-E, MI-T		Scarlet Indian-paintbrush (*Castilleja coccinea*)	NY-E
Dwarf Bulrush (*Lipocarpha micrantha*)	OH-T, PA-E, NY-E		Schweinitz' umbrella-sedge (*Cyperus schweinitzii*)	NY-T
Dwarf Burhead (*Echinodorus tenellus*)	MI-E		Scirpus-like Rush (*Juncus scirpoides*)	IN-T, MI-T
Dwarf Grape Fern (*Botrychium simplex*)	IL-E, IN-E, OH-E		Sea Milkwort (*Lysimachia maritima*)	MN-E
Dwarf Lake Iris (*Iris lacustris*)	WI-T, MI-T		Sea Rocket (*Cakile edentula*)	IL-T
Dwarf Milkweed (*Asclepias ovalifolia*)	WI-T, IL-E, MI-E		Seaside Bulrush (*Bolboschoenus maritimus ssp. paludosus*)	NY-T
Dwarf Raspberry (*Rubus acaulis*)	IL-T, MI-E		Seaside Crowfoot (*Ranunculus cymbalaria*)	WI-T, MI-T, NY-E
Dwarf Sand-cherry (*Prunus pumila var. depressa*)	NY-T		Seaside Spurge (*Chamaesyce polygonifolia*)	IL-E
Dwarf Trout Lily (*Erythronium propullans*)	MN-E		Seaside Three-awn (*Aristida tuberculosa*)	MN-T, MI-E
Dwarf Umbrella-sedge (*Fuirena pumila*)	IN-T, MI-T		A Sedge (*Carex albolutescens*)	MI-T
Earleaf Foxglove (*Agalinis auriculata*)	MN-E, IN-T		A Sedge (*Carex atratiformis*)	MI-T
Early Buttercup (*Ranunculus fascicularis*)	OH-T		A Sedge (*Carex bromoides*)	IL-T
Early Coral-root (*Carallorhiza trifida*)	OH-E		A Sedge (*Carex canescens var. disjuncta*)	IL-E
Early Panic Grass (*Dichanthelium praecocius*)	OH-E		A Sedge (*Carex crawfordii*)	IL-E
Eastern Eulophus (*Perideridia americana*)	IN-E		A Sedge (*Carex cryptolepis*)	IL-T
Eastern Few-fruited Sedge (*Carex oligocarpa*)	MI-T		A Sedge (*Carex diandra*)	IL-E, OH-T, PA-T
Eastern Green-violet (*Hybanthus concolor*)	MN-E		A Sedge (*Carex seorsa*)	MI-T
Eastern Hemlock (*Tsuga canadensis var. canadensis*)	MN-E		Sessile Tick-trefoil (*Desmodium sessilifolium*)	OH-T
Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)	WI-E, IL-E, IN-E, MI-E, OH-T, NY-E		Inland Serviceberry (*Amelanchier interior*)	IL-T, OH-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Ebony Sedge (*Carex eburnea*)	PA-E		Roundleaf Serviceberry (*Amelanchier sanguinea*)	IL-E, OH-T
Edible Valerian (*Valeriana edulis var. ciliata*)	MI-T		Sharp-glumed Manna Grass (*Glyceria acutiflora*)	OH-T
Elegant Sunburst Lichen (*Xanthoria elegans*)	OH-E		Sheathed Pondweed (*Stuckenia filiformis ssp. occidentalis*)	NY-E
Elk Sedge (*Carex garberi*)	WI-T, IL-E, IN-T, OH-E, PA-E, NY-E		Sheathed Pondweed (*Stuckenia vaginata*)	MN-E
Encrusted Saxifrage (*Saxifraga paniculata*)	MI-T		Sheathed Sedge (*Carex vaginata*)	NY-E
Engelmann's Quilwort (*Isoetes engelmannii*)	OH-E		Shining Bedstraw (*Galium concinnum*)	NY-E
Engelmann's Spike-rush (*Eleocharis engelmannii*)	OH-E		Shooting Star (*Primula meadia*)	MI-E
English Sundew (*Drosera anglica*)	WI-T		Shore Sedge (*Carex lenticularis*)	WI-T
Evening Campion (*Silene nivea*)	MI-T		Short-beaked Arrowhead (*Sagittaria brevirostra*)	MN-E
Hudson Bay Eyebright (*Euphrasia hudsoniana*)	MI-T		Short-beaked Bald-rush (*Rhynchospora nitens*)	IN-T, MI-E
Common Eyebright (*Euphrasia nemorosa*)	MI-T		Short-fringed Sedge (*Carex crinite var. brevicrinis*)	OH-T
Fairy Bells (*Prosartes hookeri*)	MI-E		Short-fruited Rush (*Juncus brachycarpus*)	MI-T, PA-T
Fairy Wand (*Chamaelirium luteum*)	NY-E		Shortleaf Sedge (*Carex disperma*)	IL-E, OH-E
False Arrow-Feather (*Aristida necopina*)	OH-E		Short's Sedge (*Carex shortiana*)	NY-E
Sticky Asphodel (*Triantha glutinosa*)	WI-T, IL-T, NY-E		Shortstalk Chickweed (*Cerastium brachypodum*)	MI-T
False Bugbane (*Cimicifuga racemosa*)	IL-E		Showy Lady's Slipper (*Cypripedium reginae*)	IL-E, OH-T, PA-T
False Hop Sedge (*Carex lupuliformis*)	WI-E, MI-T, NY-T		Showy Orchis (*Galearis spectabilis*)	MI-T
False Pennyroyal (*Trichostema brachiatum*)	MI-T		Shrubby St. John's-wort (*Hypericum prolificum*)	NY-T
Fassett's Locoweed (*Oxytropis campestris var. chartacea*)	WI-E		Shumard's Oak (*Quercus shumardii*)	PA-E, NY-E
Featherfoil (*Hottonia inflata*)	NY-T		Siberian Yarrow (*Achillea alpina*)	MN-T
Fern Pondweed (*Potamogeton robbinsii*)	IL-E		Silky Dogwood (*Cornus amomum ssp. amomum*)	IN-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Fernald's Sedge (*Carex merritt-fernaldii*)	OH-E, NY-T		Silverweed (*Potentilla anserina*)	IN-T, PA-T
Few-flowered Nut Rush (*Scleria pauciflora*)	MI-E		Sky-blue Aster (*Symphyotrichum oolentangiense*)	NY-E
Few-flowered Spikerush (*Eleocharis pauciflora*)	IL-E, PA-E		Slender Blazing-star (*Liatris cylindracea*)	NY-E
Few-flowered St. John's-wort (*Hypericum ellipticum*)	OH-T		Slender Bog Arrow Grass (*Triflochin palustris*)	IL-T
Few-seeded Sedge (*Carex oligosperma*)	IL-E		Slender Bulrush (*Schoenoplectus heterochaetus*)	NY-E
Field Dodder (*Cuscuta campestris*)	NY-E		Slender Cotton-grass (*Eriophorum gracile*)	IN-T, PA-E
Field Pansy (*Viola bicolor*)	NY-E		Slender Dayflower (*Commelina erecta*)	MN-E
Finely-nerved Sedge (*Carex leptonervia*)	IN-E		Slender Manna Grass (*Glyceria melicaria*)	MI-T
Fire Pink (*Silene virginica*)	MI-E		Slender Moonwart (*Botrychium lineare*)	MN-E
Fire Sedge (*Carex lucorum*)	OH-E		Slender Pondweed (*Stuckenia filiformis ssp. alpina*)	NY-E
Fireweed (*Epilobium angustifolium*)	IN-E, OH-E		Slender Rush (*Juncus subtilis*)	MN-E
Flat-leaved Bladderwort (*Utricularia intermedia*)	IL-T, PA-T		Slender Sandwort (*Minuartia patula*)	IL-T
Flat-leaved Rush (*Juncus platyphyllus*)	OH-E		Elliptic Spikerush (*Eleocharis elliptica*)	PA-E
Flat-stemmed Pondweed (*Potamogeton zosteriformis*)	OH-T		Slender Spike-rush (*Eleocharis tenuis*)	OH-T
Flattened Spike Rush (*Eleocharis compressa*)	MI-T		Slender Willow (*Salix petiolaris*)	OH-T
Fleabane (*Erigeron acris*)	MI-T		Slender-leaved Scurf Pea (*Psoralidium tenuiflorum*)	MN-E
Fleshy Stitchwort (*Stellaria crassifolia*)	MI-E		Slick-seed Wild-bean (*Strophostyles leiosperma*)	IN-T
Floating Bladderwort (*Utricularia inflata*)	MI-E		Slide-oats Grama (*Bouteloua curtipendula var. curtipendula*)	NY-E
Floating Marsh Marigold (*Caltha natans*)	MN-E, WI-E, MI-T		Slimspike Three-awn (*Aristida longespica var. geniculate*)	MN-E
Fly Honeysuckle (*Lonicera involucrata*)	WI-E, MI-T		Small Bladderwort (*Utricularia minor*)	IL-E, IN-T
Forest Skullcap (*Scutellaria ovata*)	MI-T		Small Bristleberry (*Rubus setosus*)	IN-E

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Forked Aster (*Eurybia furcata*)	WI-T, IL-T, MI-T		Small Bur-reed (*Sparganium natans*)	NY-T
Forked Chickweed (*Paronychia fastigiata var. fastigiata*)	MN-E		Small Cranberry (*Vaccinium oxycoccos*)	IL-E, IN-T
Four-angled Spike-rush (*Eleocharis quadrangulata*)	PA-E, NY-E		Small False Asphodel (*Tofieldia pusilla*)	MN-E, MI-T
Four-flowered Loosestrife (*Lysimachia quadriflora*)	NY-E		Small Floating Manna-grass (*Glyceria borealis*)	IN-E
Fragile Prickly Pear (*Opuntia fragilis*)	MI-E		Small Sea-side Spurge (*Euphorbia polygonifolia*)	PA-T
Franklin's Phacelia (*Phacelia franklinii*)	MI-T		Small Skullcap (*Scutellaria parvula var. parvula*)	WI-E, MI-T
Frank's Sedge (*Carex frankii*)	NY-E		Small Yellow Lady's Slipper (*Cypripedium parviflorum*)	IL-E
Frenchman's Bluff Moonwort (*Botrychium gallicomontanum*)	MN-E		Small Yellow Pond Lily (*Nuphar microphylla*)	MI-E
Fries' Pondweed (*Potamogeton friesii*)	IN-T, PA-E		Small Yellow Water Crowfoot (*Ranunculus gmelinii*)	WI-E
Fringed Black Bindweed (*Polygonum cilinode*)	IN-E		Smaller Forget-me-not (*Myosotis laxa*)	IN-T
Frost Grape (*Vitis vulpina*)	MI-T		Small-flowered False-foxglove (*Agalinis paupercula*)	PA-E
Georgia Bulrush (*Scirpus georgianus*)	NY-E		Small-flowered Grass-of-parnassus (*Parnassia parviflora*)	WI-E
Giant Pinedrops (*Pterospora andromedea*)	WI-T, MI-T, NY-E		Small-flowered Tick-trefoil (*Desmodium pauciflorum*)	NY-E
Ginseng (*Panax quinquefolius*)	MI-T		Small-flowered Wood Rush (*Luzula parviflora*)	MI-T
Globe-beaked Rush (*Rhynchospora recognita*)	IN-E, MI-T, OH-E		Small-fruited Bulrush (*Scirpus microcarpus*)	IL-E
Globe-fruited False-loosestrife (*Ludwigia sphaerocarpa*)	IN-E, MI-T		Small-fruited Spike-rush (*Eleocharis microcarpa*)	IN-E, MI-E
Glomerate Sedge (*Carex aggregata*)	NY-E		Small's Knotweed (*Polygonum aviculare spp. buxiforme*)	NY-E
Golden Corydalis (*Corydalis aurea*)	NY-T		Smartweed Dodder (*Cuscuta polygonorum*)	NY-E
Golden Dock (*Rumex fueginus*)	NY-E		Smith's Bulrush (*Schoenoplectus smithii*)	IL-E, IN-E, OH-T, PA-E
Golden Puccoon (*Lithospermum caroliniense var. croceum*)	NY-E		Smith's Melic Grass (*Melica smithii*)	WI-E
Golden Sedge (*Carex aurea*)	IL-T, PA-E		Smooth Blue Aster (*Symphyotrichum leave var. concinnum*)	NY-E

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Goldenseal (*Hydrastis canadensis*)	MN-E, MI-T, NY-T		Smooth Bur-marigold (*Bidens laevis*)	NY-T
Goose-foot Corn-salad (*Valerianella chenopodifolia*)	IN-E, MI-T, NY-E		Smooth Cliff Brake (*Pellaea glabella ssp. glabella*)	NY-T
Grass Pink Orchid (*Calopogon tuberosus*)	IL-E, OH-T		Smooth Phlox (*Phlox glaberrima ssp. interior*)	WI-E
Grass-leaved Arrowhead (*Sagittaria graminea*)	OH-E		Smooth Veiny Pea (*Lathyrus venosus*)	IN-T
Grass-leaved Pondweed (*Potamogeton gramineus*)	IL-T, OH-E, PA-E		Smooth Whitlow Grass (*Draba glabella*)	MI-E
Gray Birch (*Betula populifolia*)	IN-E		Snailseed Pondweed (*Potamogeton bicupulatus*)	MN-E, MI-T
Gray Ragwort (*Packera cana*)	MN-E		Snake-mouth (*Pogonia ophioglossoides*)	IL-E, OH-T
Gray-wing Milkwort (*Polygala paucifolia*)	IN-E, OH-E		Snow Trillium (*Trillium nivale*)	WI-T, MI-T
Great Chickweed (*Stellaria pubera*)	IL-E		Soapwort Gentian (*Gentiana saponaria*)	OH-E
Great Indian Plantain (*Anoglossum reniforme*)	MN-T		Southern Blue Flag (*Iris virginica var. shrevei*)	NY-E
Great Lakes Goldenrod (*Euthamia remota*)	OH-T		Southern Dewberry (*Rubus enslenii*)	IN-E
Great Northern Star (*Canadanthus modestus*)	MI-T		Southern Hairy Panic Grass (*Dichanthelium meridionale*)	OH-T
Great Plains Flatsedge (*Cyperus lupulinus ssp. lupulinus*)	NY-T		Southern Twayblade (*Listera australis*)	NY-E
Great Plains Ladies'-tresses (*Spiranthes magnicamporum*)	IN-E		Southern Water-nymph (*Najas guadalupensis ssp. olivacea*)	NY-E
Great St. John's-wort (*Hypericum pyramidatum*)	IN-T		Sparse-flowered Sedge (*Carex tenuiflora*)	NY-E
Green Adder's-mouth (*Malaxis unifolia*)	IN-E		Spearwort (*Ranunculus ambigens*)	MI-T
Green Gentian (*Frasera caroliniensis*)	NY-T		Speckled Alder (*Alnus incaca spp. rugosa*)	IL-E
Green Spike-rush (*Eleocharis flavescens*)	OH-T		Spike Trisetum (*Trisetum spicatum*)	WI-T
Green Spleenwort (*Asplenium trichomanes-ramosum*)	WI-E		Spiny Water-nymph (*Najas marina*)	NY-E
Green's Rush (*Juncus greenei*)	OH-T		Spotted Coral-root Orchid (*Corallorhiza maculata*)	IL-E
Green-flowered Wintergreen (*Pyrola chlorantha*)	OH-E		Spotted Pondweed (*Potamogeton pulcher*)	MN-E, WI-E, IN-E, MI-E, NY-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Green-fruited Bur-reed (*Sparganium emersum*)	IL-E		Spreading Chervil (*Chaerophyllum procumbens*)	NY-E
Ground Juniper (*Juniperus communis*)	IL-T, OH-E		Spreading Globeflower (*Trollius laxus*)	OH-E, PA-E
Grove Bluegrass (*Poa alsodes*)	IL-E		Sprengel's Sedge (*Carex sprengelii*)	OH-T
Gypsy-wort (*Lycopus rubellus*)	NY-E		Squashberry (*Viburnum edule*)	MI-T
Hairgrass (*Deshampsia flexuosa*)	IL-E		Stalked Bulrush (*Scirpus pedicellatus*)	PA-T
Hair-like Sedge (*Carex capillaris*)	NY-E		Star-flower (*Trientalis borealis*)	IL-E
Hairy Fimbry (*Fimbristylis puberula var. interior*)	MN-E		Starry Campion (*Silene stellata*)	MI-T
Hairy Mountain Mint (*Pycnanthemum pilosum*)	MI-T		Sterile Sedge (*Carex sterilis*)	PA-T
Hairy Mountain Mint (*Pycnathemum verticillatum var. pilosum*)	OH-T		Sticky Goldenrod (*Solidago simplex var. gillmanii*)	WI-T, IN-T
Hairy Valerian (*Valeriana edulis*)	IN-E, MI-T		Sticky Locoweed (*Oxytropis viscida*)	MN-E
Hairy Waterclover (*Marsilea vestita*)	MN-E		Stiff Gentian (*Gentianella quinquefolia*)	MI-T
Hairy White Violet (*Viola blanda*)	IL-E		Stiff Pondweed (*Potamogeton strictifolius*)	IL-E, IN-T, PA-E, NY-E
Hairy Wild Petunia (*Ruellia humilis*)	MI-T		Stiff Tick-trefoil (*Desmodium obtusum*)	NY-E
Hairy Woodrush (*Luzula acuminata*)	IN-E		Stiff-leaf Goldenrod (*Oligoneuron rigidum var. rigidum*)	NY-T
Hall's Bulrush (*Schoenoplectiella halii*)	IN-E, MI-T		Straw Sedge (*Carex straminea*)	IN-T, NY-E
Handsome Sedge (*Carex formosa*)	MN-E, WI-T, IL-E, NY-T		Striped Coralroot (*Corallorhiza striata var. striata*)	NY-E
Harbinger-of-spring (*Erigenia bulbosa*)	WI-E, PA-T, NY-E		Striped Maple (*Acer pensylvanicum*)	OH-E
Hard-stemmed Bulrush (*Schoenoplectus acutus*)	PA-E		Swamp Birch (*Betula pumila*)	NY-T
Harebell (*Campanula rotundifolia*)	OH-T		Swamp Buttercup (*Ranunculus hispidus var. nitidus*)	NY-E
Hart's-tongue Fern (*Asplenium scolopendrium var. americanum*)	MI-E, NY-T		Swamp Cottonwood (*Populus heterophylla*)	MI-E
Hay Sedge (*Carex siccata*)	OH-E		Swamp Fly Honeysuckle (*Lonicera oblongifolia*)	PA-E

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Heartleaf Foamflower (*Tiarella cordifolia*)	WI-E		Swamp Lousewort (*Pedicularis lanceolata*)	NY-T
Heart-leaved Arnica (*Arnica cordifolia*)	MI-E		Swamp Oats (*Sphenopholis pensylvanica*)	NY-E
Heart-leaved Plantain (*Plantago cordata*)	WI-E, IL-E, IN-E, MI-E		Swamp Red Currant (*Ribes triste*)	OH-E, PA-T
Heart-leaved Twayblade (*Listera cordata*)	OH-E		Sweet Cicely (*Osmorhiza depauperata*)	MI-T
Hedge-hyssop (*Gratiola aurea*)	MI-T		Sweet Colt's-foot (*Petasites sagittatus*)	WI-T, MI-T
Hemlock Parsley (*Conioselinum chinense*)	IN-E		Sweet Flag (*Acorus americanus*)	PA-E
Henry's Elfin (*Incisalia henrici*)	MI-T		Sweetfern (*Comptonia peregrina*)	IL-E, OH-E
Herb-robert (*Gernaium robertianum*)	IN-T		Sweet-smelling Indian-plantain (*Hasteola suaveolens*)	MN-E, NY-E
Hidden Spike-moss (*Selaginella eclipes*)	NY-E		Swollen Sedge (*Carex intumescens*)	IL-E
Hidden-fruited Bladderwort (*Utricularia geminiscapa*)	IN-E		Sword Bogmat (*Wolffiella gladiata*)	IN-E
Highbush Blueberry (*Vaccinium corymbosum*)	IL-E		Tall Bellflower (*Campanulastrum americanum*)	NY-E
Highbush-cranberry (*Viburnum opulus var. americanum*)	IN-E, OH-T		Tall Cinquefoil (*Potentilla arguta*)	OH-E
Hill's Pondweed (*Potamogeton hillii*)	MI-T, OH-E, PA-E, NY-T		Tall Green Milkweed (*Asclepias hirtella*)	MI-T
Hill's Thistle (*Cirsium hillii*)	WI-T, IN-E		Tall Ironweed (*Vernonia gigantea ssp. gigantea*)	NY-E
Hoary Elfin (*Incisalia polios*)	IL-E, IN-E		Tall Meadowrue (*Thalictrum pubescens*)	IN-T
Hoary Whitlow-grass (*Draba cana*)	MN-E, WI-E, MI-T		Tall Nutrush (*Scleria triglomerata*)	MN-E
Hoary Willow (*Salix candida*)	OH-T, PA-T		Tall Sunflower (*Helianthus giganteus*)	IL-E
Hobblebush (*Viburnum lantanoides*)	OH-T		Tall White-Aster (*Symphyotrichum lanceolatum var. interior*)	NY-E
Hollow-stemmed Joe-pye Weed (*Eutrochium fistulosum*)	MI-T		Tamarack (*Larix laricina*)	IL-T
Hooded Ladies'-tresses (*Spiranthes romanzoffiana*)	OH-T, PA-E		Tansy Mustard (*Descurainia pinnata*)	OH-T
Hooker's Orchid (*Platanthera hookeri*)	NY-E		Tea-leaved Willow (*Salix planifolia spp. planifolia*)	WI-T, MI-T

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Horned Bladderwort (*Utricularia cornuta*)	IL-E, IN-T		Tennessee Bladder Fern (*Cystopteris tennesseensis*)	MI-T
Houghton's Goldenrod (*Solidago houghtonii*)	MI-T, NY-E		Thickspike (*Elymus lanceolatus ssp. psammophilus*)	WI-T, MI-T
Houghton's Nutsedge (*Cyperus houghtonii*)	IN-E		Thinleaf Sedge (*Carex sparganioides var. cephaloidea*)	IN-E
Houghton's Sedge (*Carex houghtoniana*)	NY-T		Thin-leaved Cotton-grass (*Eriophorum viridicarinatum*)	PA-T
Howe Sedge (*Carex atlantica ssp. capillacea*)	IN-E		Thread-like Naiad (*Najas gracillima*)	IN-T, OH-E, PA-T
Hudson Bay Sedge (*Carex heleonastes*)	MI-E		Three-ribbed Spike Rush (*Eleocharis tricostata*)	MI-T
Hyssop-leaved Fleabane (*Erigeron hyssopifolius*)	MI-T		Three-seeded Sedge (*Carex trisperma*)	IL-E
Ill-scented Trillium (*Trillium erectum*)	IL-E		Thyme-leaved Pinweed (*Lechea minor*)	OH-T
Indian Cucumber Root (*Medeola virginiana*)	IL-E		Tinted Spurge (*Euphorbia commutata*)	MI-T
Indian Rice Grass (*Achnatherum hymenoides*)	MN-E		Toadshade (*Trilium sessile*)	MI-T, NY-E
Inland Beach Pea (*Lathyrus japonicus*)	OH-T, PA-T		Toothed Sedge (*Cyperus dentatus*)	IN-E
Iowa Golden Saxifrage (*Chrysosplenium iowense*)	MN-E		Torrey's Bulrush (*Schoenoplectus torreyi*)	IN-E, PA-E
Jack Pine (*Pinus banksiana*)	IL-E		Torrey's Rush (*Juncus torreyi*)	PA-T
Jacob's Ladder (*Polemonium reptans*)	MI-T		Trailing Juniper (*Juniperus horizontalis*)	IL-E, NY-E
James' Polanisia (*Planisia jamesii*)	MN-E		Triangle Grape Fern (*Botrychium lanceolatum*)	OH-T
James' Sedge (*Carex jamesii*)	NY-T		Troublesome Sedge (*Carex molesta*)	NY-T
Jointed Rush (*Juncus articulatus*)	MN-E, IN-E		Tubercled Orchid (*Platanthera flava var. herbiola*)	IL-T
June Grass (*Koeleria macrantha*)	OH-E		Tuberous Indian Plantain (*Amoglossum plantagineum*)	MN-T
Kalm's St. John's Wort (*Hypericum kalmianum*)	IL-E, OH-T		Tuckerman's Panic Grass (*Panicum tuckermanii*)	OH-E, PA-T
Kentucky Coffee Tree (*Gymnocladus dioicus*)	NY-E		Tuckerman's Sedge (*Carex tuckermanii*)	IL-E
Kitten Tails (*Besseya bullii*)	WI-T, IL-T, MI-E		Tufted Bulrush (*Trichophorum cespitosum*)	WI-T, IL-E

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Knotted Spikerush (*Eleocharis equisetoides*)	NY-T		Twig Rush (*Cladium mariscodes*)	PA-E
Knotty Pearlywort (*Sagina nodosa ssp. borealis*)	MN-E		Twinflower (*Linnaea borealis*)	PA-T
Labrador Marsh Bedstraw (*Galim labradoricum*)	PA-E		Twin-leaf (*Jeffersonia diphylla*)	NY-T
Lake Cress (*Armoracia lacustris*)	WI-E, IN-E		Twisted Whitlow Grass (*Draba incana*)	MI-T
Lake Huron Tansy (*Tanacetum bipinnatum spp. huronense*)	WI-E		Twisted Yellow-eyed Grass (*Xyris torta*)	MN-E, OH-E
Lake-cress (*Armoracia lacustris*)	WI-E, IN-E		Two Leaf Waterweed (*Elodea bifoliata*)	MN-E
Lake Huron Tansy (*Tanacetum bipinnatum spp. huronense*)	WI-E		Umbrella Flatsedge (*Cyperus diandrus*)	PA-E
Lake-cress (*Rorippa aquatica*)	NY-T		Yellow Screwstem (*Bartonia virginica*)	MN-E
Lakeside Daisy (*Hymenoxys herbacea*)	IL-E, MI-E, OH-T		Upswept Moonwort (*Botrychium ascendens*)	MN-E
Lapland Buttercup (*Coptidium lapponicum*)	WI-E, MI-T		Variegated Horsetail (*Equisetum variegatum*)	IN-E, OH-E, PA-E
Large Blazing-star (*Liatris scariosa*)	OH-T		Vasey's Pondweed (*Potamogeton vaseyi*)	IN-E, MI-T, PA-E
Large Cranberry (*Vaccinium macrocarpon*)	IL-E		Vasey's Rush (*Juncus vaseyi*)	MI-T
Large Toothwort (*Cardamine maxima*)	MI-T		Velvetleaf Blueberry (*Vaccinium myrtilloides*)	IN-E, OH-E
Large Twayblade (*Liparis liliifolia*)	NY-E		Velvety Bush-clover (*Lespedeza stuevei*)	NY-T
Large Water Starwort (*Callitriche heterophylla*)	WI-T, MI-T		Vernal Water-starwort (*Callitriche verna*)	OH-T
Large-leaved Sandwort (*Moehringia macrophylla*)	WI-E, MI-T		Virginia Bluebells (*Mertensia virginica*)	MI-E
Larger Canadian St. John's-wort (*Hypericum majus*)	PA-T		Virginia Dwarf-dandelion (*Krigia virginica*)	OH-T
Leady White Orchid (*Platanthera dilatata*)	PA-E		Virginia False Gromwell (*Onosmodium virginianum*)	NY-E
Leafy Blue Flag (*Iris brevicaulis*)	OH-T		Virginia Flax (*Linum virginianum*)	MI-E
Leafy Goldenrod (*Solidago squarrosa*)	OH-T		Virginia Ground-cherry (*Physalis virginiana var. virginiana*)	NY-E
Leafy Northern Green Orchis (*Platanthera hyperborea*)	IN-T		Virginia Snakeroot (*Endodeca serpentaria*)	MI-T

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Leafy Prairie Clover (*Dalea foliosa*)	IL-E		Virginia Water-horehound (*Lycopus virginicus*)	MI-T
Leafy Tussock Sedge (*Carex aquatilis*)	OH-T, PA-T		Wafer-ash (*Ptelea trifoliata ssp. trifoliata*)	NY-E
Least Duckweed (*Lemna minima*)	IN-E		Walking Fern (*Asplenium rhizophyllum*)	MI-T
Least Spike-rush (*Eleocharis parvula*)	OH-E, PA-E		Wall-rue (*Asplenium ruta-muraria*)	MI-E
Least St. John's-wort (*Hypericum gymnanthum*)	OH-E		Walter's Barnyard-grass (*Echinochloa walteri*)	PA-E
Leatherleaf (*Chamaedaphne calyculata*)	IL-T		Walter's St. John's-wort (*Triadenum walteri*)	OH-T
Ledge Spike-moss (*Selaginella rupestris*)	IN-T		Wapato (*Sagittaria cuneata*)	OH-T
Leedy's Roseroot (*Rhodiola integrifolia ssp. leedyi*)	MN-E		Warty Panic-grass (*Panicum verrucosum*)	IN-T, MI-T
Leggett's Pinweed (*Lechea pulchella*)	MI-T, OH-T		Water Arum (*Calla palustris*)	IL-E, IN-E
Leiberg's Panic Grass (*Dichanthelium leibergii*)	MI-T		Water Marigold (*Megalodonta beckii*)	IL-E, PA-E
Leiberg's Witchgrass (*Panicum leibergii*)	IN-T		Water Milfoil (*Myriophyllum alterniflorum*)	NY-T
Lesser Fringed Gentian (*Gentianopsis virgata*)	NY-E		Water Willow (*Justicia americana*)	MI-T
Lesser Ladies'-tresses (*Spiranthes ovalis*)	MI-T		Watermeal (*Wolffia brasiliensis*)	MI-T
Lesser Wintergreen (*Pyrola minor*)	WI-E		Water-plantain (*Alisma gramineum*)	NY-T
Limestone Oak Fern (*Gymnocarpium robertianum*)	MI-T		Weak Arctic Sedge (*Carex supina ssp. spaniocarpa*)	MN-E
Limestone Rock Cress (*Boechera grahamii*)	OH-E, NY-T		Weak Bluegrass (*Poa languida*)	IL-E
Lindheimer's Panic Grass (*Dichanthelium lindheimeri*)	OH-T		Western Dock (*Rumex occidentalis*)	MI-E
Lindley's Aster (*Symphyotrichum ciliolatum*)	NY-E		Western Fescue (*Festuca occidentalis*)	WI-T
Linear-leaved Sundew (*Drosera linearis*)	WI-T		Western Jacob's Ladder (*Polemonium occidentale ssp. lacustre*)	MN-E
Little Goblin Moonwart (*Botrychium mormo*)	WI-E, MI-T		Western Moonwort (*Botrychium hesperium*)	MI-T
Little Green Sedge (*Carex viridula*)	IL-T, OH-T, PA-E		Western Mountain-ash (*Sorbus decora*)	OH-E, PA-E

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Little Prickly Sedge (*Carex echinata*)	IL-E, IN-E		Western Mugwort (*Artemisia ludoviciana*)	MI-T
Little-leaf Tick-trefoil (*Desmodium ciliare*)	NY-T		Western Prairie Fringed Orchid (*Platanthera praeclara*)	MN-E
Livid Sedge (*Carex livida*)	NY-E		Western Rockjasmine (*Androsac occidentalis*)	IN-T
Log Fern (*Dryopteris celsa*)	IN-E, MI-T, OH-E, NY-E		Western Silvery Aster (*Symphyotrichum sericeum*)	MI-T
Long-beaked Baldrush (*Rhynchospora scirpoides*)	IN-T		White Basswood (*Tilia Americana var. heterophylla*)	NY-E
Long-bract Green Orchis (*Coeloglossum viride var. virescens*)	IN-T, OH-E		White Gentian (*Gentiana alba*)	MI-E
Long-leaved Arnica (*Arnica lonchophylla*)	MN-T, MI-E		White Goldenrod (*Solidago bicolor*)	MI-E
Long-lobed Arrow-head (*Sagittaria calycina var. spongiosa*)	PA-E		White lady's-slipper (*Cypripedium candidum*)	WI-T, MI-T, OH-E, NY-E
Long-panicled Panis Grass (*Dichanthelium perlongum*)	OH-E		White Wood-sorrel (*Oxalis montana*)	OH-E
Long's Sedge (*Carex longii*)	OH-E		White-grained Mountain-ricegrass (*Oryzopsis asperifolia*)	IN-E, OH-E
Longstalk Starwort (*Stellaria longipes*)	NY-T		White-stemmed Pondweed (*Potamogeton praelongus*)	IL-E, IN-T
Louisiana Sedge (*Carex louisianica*)	OH-E		Whorled Nutrush (*Scleria verticillata*)	PA-E, NY-E
Low Northern Rock Cress (*Braya humilis*)	MI-T		Whorled Water-milfoil (*Myriophyllum verticillatum*)	PA-E
Low Sand-Cherry (*Prunus pumila var. pumila*)	NY-E		Whorled Mountain-mint (*Pycnanthemum verticilatum var. verticilatum*)	NY-E
Low Spike-moss (*Selaginella selaginoides*)	MN-E, WI-E		Whorled Pogonia (*Isotria verticillata*)	MI-T
Lowland Fragile Fern (*Cystopteris protrusa*)	NY-E		Widgeon Grass (*Ruppia cirrhosa*)	MI-T
Lurking Leskea (*Plagiothecium latebricola*)	OH-T		Wild Chives (*Allium schoenoprasum*)	MN-E, MI-T
Lyre-leaved Rock Cress (*Arabidopsis lyrata*)	OH-E		Wild Hyacinth (*Camassia scilloides*)	MI-T
Macoun's Buttercup (*Ranunculus macounii*)	MI-T		Wild Lilac (*Ceanothus sanguineus*)	MI-T
Male Fern (*Dryopteris filix-mas*)	OH-E		Wild Oats (*Chamanthium latifolium*)	MI-E
Many-head Sedge (*Carex sychnocephala*)	NY-E		Wild Pink (*Silene caroliniana ssp. pensylvanica*)	NY-T

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Marginal Shield Fern (*Dryopteris marginalis*)	MN-E		Wild Potato Vine (*Ipomoea pandurata*)	MI-T, NY-E
Marginated Rush (*Juncus marginatus*)	MN-E		Wild Quinine (*Parthenium integrifolium*)	MN-E
Marram Grass (*Ammophila breviligulata*)	IL-T, OH-T, PA-T		Wild Rice (*Zizania aquatica*)	OH-T
Marsh Arrow-grass (*Triglochin palustre*)	NY-T		Wild Sweet William (*Phlox maculata*)	MI-T
Marsh Bedstraw (*Galium palustre*)	OH-T		Wild Sweet-william (*Phlox maculata ssp. maculata*)	NY-E
Marsh Five-finger (*Potentilla palustris*)	OH-T		Winged Cudweed (*Pseudognaphalium macounii*)	OH-E
Marsh Grass-of-parnassus (*Parnassia palustris*)	WI-T, MI-T		Winter Bentgrass (*Agrostis hyemalis*)	MN-E
Marsh Horsetail (*Equisetum palustre*)	NY-T		Wisteria (*Wisteria frutescens*)	MI-T
Marsh Speedwell (*Veronica scutellata*)	IL-T		Wolf Spike-rush (*Eleocharis wolfii*)	MN-E, WI-E
Marsh Valerian (*Valeriana uliginosa*)	WI-T, IN-E		Wood Lily (*Lilium philadelphicum*)	OH-E
Maryland Meadow Beauty (*Rhexia mariana var. mariana*)	IN-T, MI-T		Wood Orchid (*Platanthera clavellata*)	IL-E
Mat Muhly (*Muhlenbergia richardsonias*)	WI-E, MI-T		Woodland Bluegrass (*Poa sylvestris*)	NY-E
Matted Spike-rush (*Eleocharis intermedia*)	PA-T		Woodland Everlasting (*Omalotheca sylvatica*)	MI-T
Meadow Horsetail (*Equisetum pratense*)	NY-T		Woodland Horsetail (*Equisetum sylvaticum*)	IN-E
Meadow-parsnip (*Thaspium barbinode*)	NY-E		Woodland Lettuce (*Lactuca floridana*)	MI-T
Mead's Milkweed (*Asclepias meadii*)	IN-E		Woodland Rush (*Juncus subcaudatus*)	NY-E
Mead's Sedge (*Carex meadii*)	NY-E		Woodland Strawberry (*Fragaria vesca var. americana*)	IN-E
Mermaid-weed (*Proserpinaca pectinata*)	MI-E		Wooly Milkweed (*Asclepias lanuginosa*)	WI-T, IL-E
Michaux's Sedge (*Carex michauxiana*)	WI-T		Wright's Spikerush (*Eleocharis diandra*)	NY-E
Michigan Lily (*Lilium michiganense*)	MI-E		Yellow Birch (*Betula alleghaniensis*)	IL-E
Midland Sedge (*Carex mesochorea*)	OH-T		Yellow Fumewort (*Corydalis flavula*)	MI-T

Species	Location/Status[1,2]		Species	Location/Status[1,2]
Minute Duckweed (*Lemna perpusilla*)	NY-E		Yellow Giant-hyssop (*Agastache nepetoides*)	NY-T
Missouri Dewberry (*Rubus missouricus*)	MN-E		Yellow Mountain-saxifrage (*Saxifraga aizoides*)	NY-T
Missouri Ironweed (*Veronia missourica*)	OH-E		Yellow Pitcher Plant (*Sarracenia purpurea F. heterophylla*)	MI-T
Missouri Rock Cress (*Borodinia missouriensis*)	OH-E		Yellow Sedge (*Carex flava*)	IN-T, PA-T
Mitchell's Sedge (*Carex mitchelliana*)	OH-E		Yellow Wild Flax (*Linum sulcatum*)	NY-T
Mock-pennyroyal (*Hedeoma hispida*)	NY-T		Yellow-flowered Leafcup (*Smallanthus uvedalia*)	MI-T, NY-E
Montia (*Montia chamissoi*)	MN-E		Yellow-fringe Orchis (*Platanthera ciliaris*)	IL-E, IN-E, MI-E, OH-T
Moonwort (*Botrychium acuminatum*)	MI-E		Yellow-lipped Ladies' Tresses (*Spiranthes lucida*)	IL-E
Moor Rush (*Juncus stygius*)	MI-T		Zigzag Bladderwort (*Utricularia subulata*)	IN-T, MI-T
Mountain Bindweed (*Fallopia cilinodis*)	OH-E			

[1] IL-Illinois, IN-Indiana, MI-Michigan, MN-Minnesota, NY-New York, OH-Ohio, PA-Pennsylvania, and WI-Wisconsin
[2] E-Endangered and T-Threatened

CAWS/Des Plaines River/Illinois River/Kankakee River

Additionally, there are numerous state-listed threatened and endangered species potentially occurring within the GLMRIS-BR Illinois Waterway Study Area (Table B-21). One such state-endangered species, the Black-crowned Night Heron has been observed near the study area. Currently, no Black-crowned Night Heron colonies have been identified within the project area. The following list of Illinois state-listed threatened and endangered species within the GLMRIS-BR Illinois Waterway Study Area was generated using 2016 best available information. In general, in 2016 there were 40 plants, five reptiles and two amphibians, one mammal, nine birds, eight invertebrates, and 11 fish listed that were Illinois state-listed threatened and endangered species within the project area.

Table B- 13 State Listed Species Potentially Occurring within the GLMRIS-BR Illinois Waterway Study Area (Illinois DNR 2014)

Species	Illinois Status		Species	Illinois Status
		Plants		
American Burnet (*Sanguisorba canadensis*)	Endangered		Little Green Sedge (*Carex viridula*)	Threatened
American Slough Grass (*Beckmannia syzigachne*)	Endangered		Marsh Speedwell (*Veronica scutellata*)	Threatened
Beaked Spike Rush (*Eleocharis rostellata*)	Threatened		Mead's Milkweed (*Asclepia meadii*)	Endangered
Blazing Star (*Liatris scariosa var. nieuwlandii*)	Threatened		Narrow-leaved Sundew (*Drosera intermedia*)	Threatened
Blue Sage (*Salvia azurea ssp. pitcheri*)	Threatened		Northern Corn Salad (*Valerianella chenopodifolia*)	Endangered
Bristly Blackberry (*Rubus schneideri*)	Threatened		Northern Panic Grass (*Dichanthelium boreale*)	Endangered
Buffalo Clover (*Trifolium reflexum*)	Threatened		Oklahoma Grass Pink Orchid (*Calopogon oklahomensis*)	Endangered
Canada Violet (*Viola canadensis*)	Endangered		Pretty Sedge (*Carex woodii*)	Threatened
Dog Violet (*Viola conspersa*)	Threatened		Primrose Violet (*Viola primulifolia*)	Endangered
Ear-leafed Foxglover (*Tomanthera auriculata*)	Threatened		Quillwort (*Isoetes butleri*)	Endangered
Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)	Endangered		Redveined Prairie Leafhopper (*Aflexia rubranura*)	Threatened
False Mallow (*Malvastrum hispidum*)	Endangered		Running Pine (*Lycopodium clavatum*)	Endangered
Forked Aster (*Aster furcatus)*	Threatened		Shore St. John's Wort (*Hypericum adpressum*)	Endangered
Golden Corydalis (*Corydalis aurea*)	Endangered		Slender Bog Arrow Grass (*Triglochin palustris*)	Threatened
Grass Pink Orchid (*Calcopogon tuberosus*)	Endangered		Slender Sandwort (*Minuartia patula*)	Threatened
Great Lakes Corn Salad (*Valerianella umbilicata*)	Endangered		Small Sundrops (*Oenothera perennis*)	Threatened
Hedge Hyssop (*Gratiola quartermaniae*)	Endangered		Spotted Coral-root Orchid (*Corallorhiza maculate*)	Threatened
Lakeside Daisy (*Tetraneuris herbacea*)	Endangered		Tubercled Orchid (*Platanthera flava var. herbiola*)	Threatened
Large Cranberry (*Vaccinium macrocarpon*)	Endangered		White Lady's Slipper (*Cypripedium candidum*)	Threatened

Leafy Prairie Clover (*Dalea foliosa*)	Endangered		Yellow-lipped Ladies' Tresses (*Spiranthes lucida*)	Endangered
Reptiles & Amphibians				
Blanding's Turtle (*Enydoidea blandingii*)	Endangered		Mudpuppy (*Necturus maculosus*)	Threatened
Eastern Massasauga (*Sistrurus catenatus catenatus*)	Endangered		Orante Box Turtle (*Terrapene ornate*)	Threatened
Four-toed Salamander (*Hemidactylium scutatum*)	Threatened		Spotted Turtle (*Clemmys guttata*)	Endangered
Kirtland's Snake (*Clonophis kirtlandii*)	Threatened			
Mammals				
Franklin's Ground Squirrel (*Spermophilus franklinii*)	Threatened			
Birds				
Barn Owl (*Tyto alba*)	Endangered		Loggerhead Shrike (*Lanius ludovicianus*)	Endangered
Black-crowned Night-heron (*Nycticorax nycticorax*)	Endangered		Northern Harrier (*Circus cyaneus*)	Endangered
Common Moorhen (*Gallinula chloropus*)	Endangered		Upland Sandpiper (*Bartramia longicauda*)	Endangered
King Rail (*Rallus elegans*)	Endangered		Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	Endangered
Least Bittern (*Ixobrychus exilis*)	Threatened			
Invertebrates				
Black Sandshell (*Ligumia recta*)	Threatened		Salamander Mussel (*Simpsonaias ambigua*)	Endangered
Eryngium Stem Borer (*Papaipema eryngii*)	Endangered		Sheepnose (*Plethobasus cyphyus*)	Endangered
Hine's Emerald Dragonfly (*Somatochlora hineana*)	Endangered		Slippershell (*Alasmidonta viridis*)	Endangered
Purple Wartyback (*Cyclonaias tuberculata*)	Threatened		Spike (*Elliptio dilatata*)	Threatened
Fish				
Banded Killifish (*Fundulus diaphanus*)	Threatened		Pallid Shiner (*Hybopsis amnis*)	Pallid Shiner
Bigeye Shiner (*Notropis boops*)	Endangered		River Redhorse (*Moxostoma carinatum*)	Threatened
Blacknose Shiner (*Notropis heterolepis*)	Endangered		Starhead Topminnow (*Fundulus dispar*)	Threatened
Gravel Chub (*Erimystax x-punctatus*)	Threatened		Weed Shiner (*Notropis texanus*)	Endangered
Iowa Darter (*Etheostoma exile*)	Threatened		Western Sand Darter (*Ammocrypta clarum*)	Endangered
Ironcolor Shiner (*Notropis chalybaeus*)	Threatened			

2. Development of the Nonstructural Alternative

To formulate the GLMRIS-BR nonstructural measures, the 2016 Asian Carp Framework (ACRCC 2016) was reviewed. The Action Plan, which is produced annually, describes the strategies and proposed action items to prevent the introduction, establishment, and spread of Bighead, Black, Grass, and Silver Carp populations in the Great Lakes. Actions within the plan primarily focus on the threat posed by Bighead and Silver Carp and target the upper Illinois Waterway and CAWS. There were 65 action items listed in the 2016 Action Plan that were reviewed for their pertinence to the GLMRIS-BR effort. Action items listed in Table B-22 were selected to be part of the GLMRIS-BR nonstructural measures. Several of the action items reviewed were considered research and development items (i.e., continued research for various technologies, microparticles, lock treatment options, etc.). Only those research and development action items that focused on electric barrier efficacy, novel gears, or increased efficiency of contracted fishing were selected to be included under the GLMRIS-BR nonstructural measures.

Table B-14: Action Items from the 2016 Asian Carp Action Plan (ACRCC 2016) Selected as Part of the GLMRIS-BR Nonstructural Measures

Category	General Project Description	Agency	Estimated Cost
Public Education and Outreach	Outreach	USFWS-ILDNR	$500,000
	Asian Carp Website Operation and Maintenance	USFWS	$50,000
Monitoring	Fixed and Random Site Monitoring Downstream of the Electric Barrier	USFWS-IDNR	$1,950,000
	Monitoring Downstream of the Electric Barrier	USACE	$200,000
	Fixed and Random Site Monitoring Downstream of the Electric Barrier	USFWS	$1,120,000
	Grat Lakes Asian Carp Monitoring Program – Comprehensive Sampling Regimen for Early Detection of ANS in Great Lakes	USFWS	$350,000
	Mass Removal and Monitoring of Juvenile Asian Carp	USFWS	$100,000
	Black Carp Assessment: CAWS and UMRB	USFWS	$200,000
	Advanced Telemetry Techniques for Real-Time Tracking of Asian Carp	USGS	$150,000
Integrated Pest Management	Integrative Pest Management Program	USGS	$600,000
Piscicides	-	-	-
Manual or Mechanical Removal	Contract Fishing for Asian Carp Detection and Removal	USFWS-ILDNR	$1,500,000
	Illinois River Stock Assessment/Management Alternatives	USFWS-ILDNR	$300,000
Research and Development	Use of Improved Gear and Novel Designs at Brandon Road	USFWS-ILDNR	$350,000
	Barrier Defense Removal of Asian Carp Using Novel Gear	USFWS	$80,000
	Barge Entrainment and Interaction Studies	USFWS	$750,000
Research and Development	Hydro-acoustic Assessment of Lock Mediated Fish Passage in the Upper Illinois River	USFWS	$160,000
	Assessment of Hydraulic Water Quality Influences on Waterways to Develop Control Options	USGS	$50,000
	Monitoring, Biomass Estimation, and Correlation with Live Fish	USGS	$100,000
		Estimated Annual Total	**$8,510,000**

The action items selected as part of the GLMRIS-BR nonstructural measures were then presented to the co-chairs of the Monitoring and Response Work Group (MRWG) of the ACRCC as well as to the USFWS during a meeting held September 6, 2015. During this meeting, the GLMRIS-BR Team also proposed including additional contract fishing, monitoring for *A. lacustre*, and additional funds for research and development under the GLMRIS-BR nonstructural measures (Table B-23). The amount of additional contract fishing proposed was dependent on the GLMRIS-BR alternative, as well as the stage of implementation (Table B-24).

Table B-15: Additional Action Items/Level of Effort Selected as Part of the GLMRIS-BR Nonstructural Measures

Category	General Project Description	Agency	Estimated Cost
Public Education and Outreach	Nothing Additional Proposed		
Monitoring	Monitoring for *A. lacustre* Upstream and Downstream of the Electric Barrier	USFWS-ILDNR	$100,000
Integrated Pest Management	Integrative Pest Management Program	USACE	$300,000
Piscicides	Nothing Additional Proposed		
Manual or Mechanical Removal	Contract Fishing for Asian Carp Detection and Removal	USFWS-ILDNR	Varied between additional $1,500,000 - $3,000,000
Research and Development	eDNA Genetic Marker Development for Future ANS	USFWS	$300,000
	Estimated Annual Total		**$2,200,000[1] – 3,700,000[2]**

[1] Assumes $1,500,000 for additional contract fishing for Asian carp detection and removal
[2] Assumes $3,000,000 for additional contract fishing for Asian carp detection and removal

Table B-16: Contract Fishing Proposed Level of Effort by GLMRIS-BR Alternative

Alternative	Construction	10 Years Post Construction
Nonstructural Alternative	$3,000,000 every year $4,500,000 every 2 years	$3,000,000 every year $4,500,000 every 2 years
Technology Alternative – Electric Barrier	$3,000,000 every year $4,500,000 every 2 years	$3,000,000 every year $4,500,000 every 3 years
Technology Alternative – Complex Noise	$3,000,000 every year $4,500,000 every 2 years	$3,000,000 every year $4,500,000 every 3 years
Technology Alternative – Complex Noise with Electric Barrier	$3,000,000 every year $4,500,000 every 2 years	$3,000,000 every year $4,500,000 every 3 years
Lock Closure Alternative	$3,000,000 every year $4,500,000 every 2 years	$1,500,000 every year

Based on the above formulation strategy, the average annual cost of the nonstructural measures were tabulated for the GLMRIS-BR alternative plans (Table B-25).

Table B-17: Estimated Average Annual Cost of Nonstructural Measures by GLMRIS-BR Alternative

Alternative	Average Annual Nonstructural Measures Cost
Nonstructural Alternative	$11,500,000
Technology Alternative – Electric Barrier	$11,300,000
Technology Alternative – Complex Noise	$11,300,000
Technology Alternative – Complex Noise with Electric Barrier	$11,300,000
Lock Closure	$9,200,000

3. CE/ICA Analysis

3.1. Asian Carp

Cost effectiveness and incremental cost analysis (CE/ICA) are two distinct analyses that must be conducted to evaluate the effects of alternative plans according to USACE policy. There are a number of ways of conducting CE/ICA, thereby determining which alternative plans are cost effective, and, from the set of cost effective plans, identifying those alternative plans which are most efficient in production (i.e., Best Buys). The USACE's Institute for Water Resources (IWR) has developed procedures and software to assist in conducting CE/ICA. The IWR Planning Suite Beta MCDA software package was used to conduct this analysis. Table B-26 shows the values that were put into the IWR Planning Suite and used for cost effectiveness and incremental cost analysis.

Table B-18: Summary of Alternative Costs and Outputs Used in CE/ICA

Alternative	Acronym	Average Annual Cost[a]	Output (Probability of No Establishment)					
			Bighead and Silver Carp			*A. lacustre*		
			Min	Med	Max	Min	Med	Max
No Action/Sustained Current Activities	NNFA	$0	64	71	78	12	39	64
Nonstructural	NSA	$11,500,000	74	80	85	12	39	64
Technology Alternative – Electric Barrier	TAEB	$60,700,000	86	89	92	14	42	66
Technology Alternative – Acoustic Fish Deterrent	TAAD	$43,000,000	81	85	89	14	42	66
Technology Alternative – Acoustic Fish Deterrent with Electric Barrier	TAADEB	$56,200,000	83	87	90	14	42	65
Lock Closure	LCA	$328,200,000	97	98	99	22	58	83

[a] Average Annual Cost includes construction, nonstructural measures, O&M, adaptive management, and loss in transportation cost savings

3.1.1. Asian Carp Using Minimum Elicited Values for Probability of No Establishment

For the minimum range of probability of no establishment, CE/ICA identified the NNFA, NSA, TAEB, and LCA as best buy plans. Both the TAAD and TAADEB were identified as cost effective plans (Figure B-3, Table B-27, and Figure B-5).

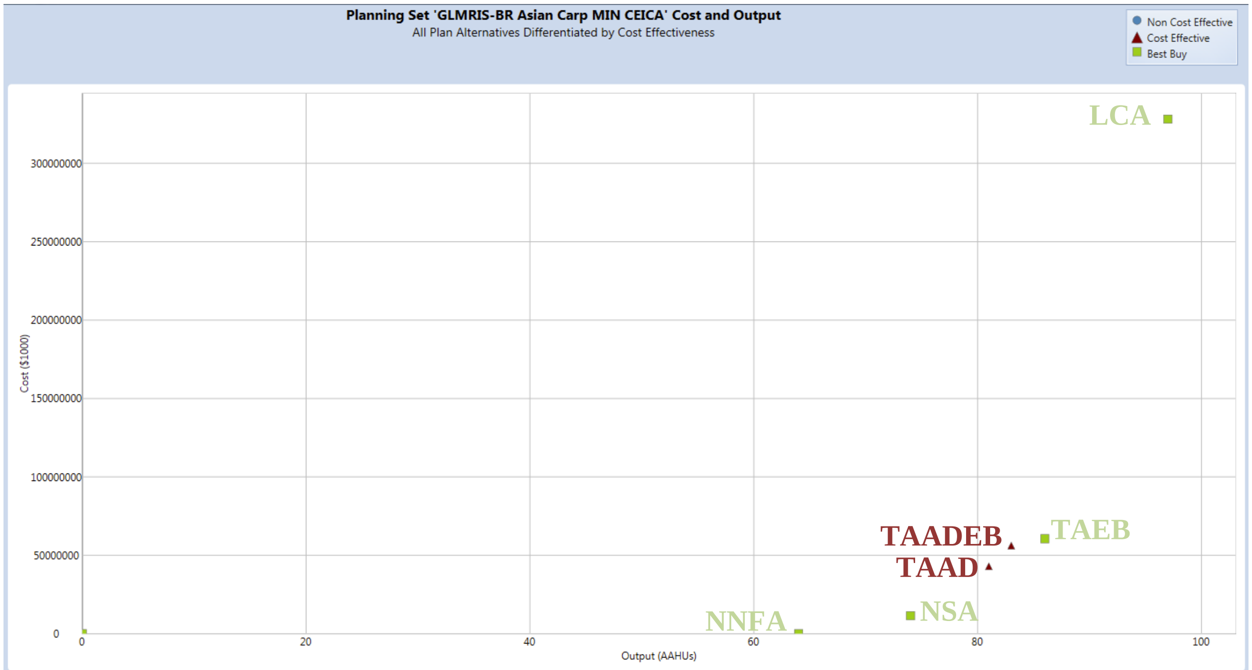

Figure B-3: Cost and Output Results of Alternative Plans for Asian Carp (Minimum Elicited Values for Probability of No Establishment)

Table B-19: Summary of CE/ICA "Best Buy" Alternative Plans for Asian Carp (Minimum Elicited Values for Probability of No Establishment)

Alternative Plan	Output (Probability of No Establishment)	Cost	Avg. Cost ($/Probability of No Establishment)	Inc. Cost	Inc. Output (Probability of No Establishment)	Inc. Cost Per Output
NNFA	64	$0	$0	-	-	-
NSA	74	$11,500,000	$160,000	$11,500,000	10	$1,200,000
TAAD	81	$43,000,000	$530,000	$31,500,000	7	$4,500,000
TAADEB	83	$56,200,000	$680,000	$13,200,000	2	$6,600,000
TAEB	86	$60,600,000	$700,000	$4,400,000	3	$1,500,000
LCA	97	$328,200,000	$3,400,000	$267,600,000	11	$24,300,000

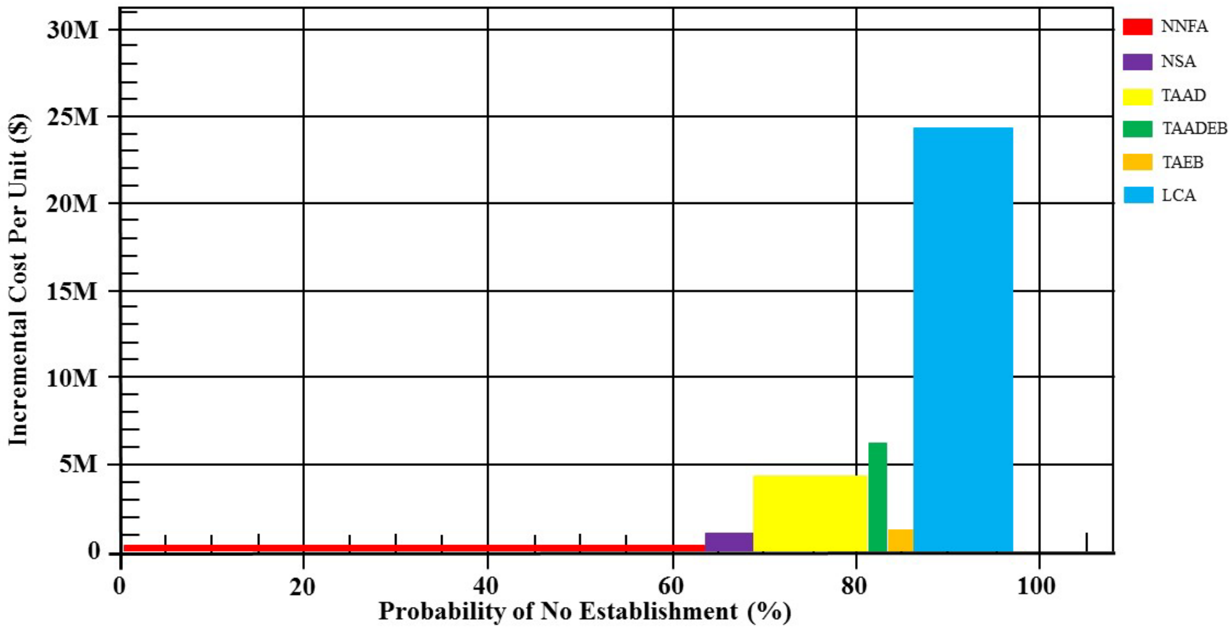

Figure B-4: Incremental Cost and Output of "Best Buy" Alternative Plans for Asian Carp (Minimum Elicited Values for Probability of No Establishment)

3.1.2. Asian Carp Using Median Elicited Values for Probability of No Establishment

For the median range of probability of no establishment, CE/ICA identified the NNFA, NSA, TAEB, and LCA as best buy plans. Both the TAAD and TAADEB were identified as cost effective plans (Figure B-5, Table B-28 and Figure B-6).

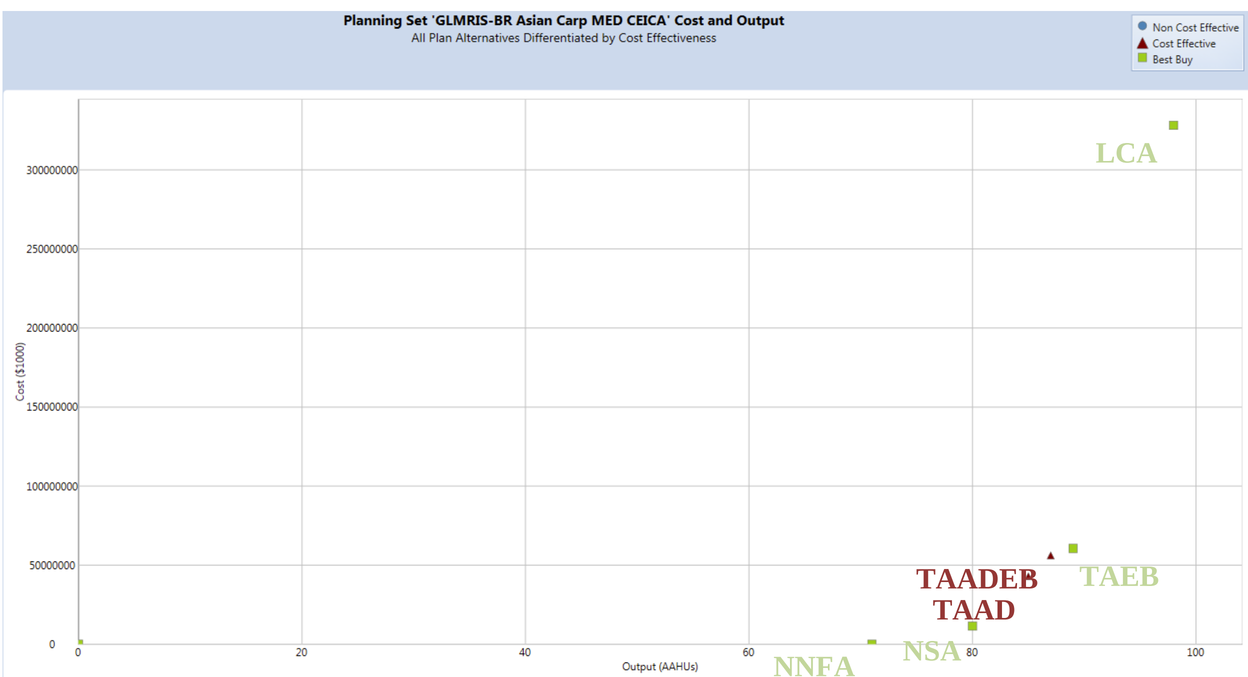

Figure B-5: Cost and Output Results of Alternative Plans for Asian Carp (Median Elicited Values for Probability of No Establishment)

Table B-20: Summary of CE/ICA "Best Buy" Alternative Plans for Asian Carp (Median Elicited Values for Probability of No Establishment)

Alternative Plan	Output (Probability of No Establishment)	Cost	Avg. Cost ($/Probability of No Establishment)	Inc. Cost	Inc. Output (Probability Of No Establishment)	Inc. Cost Per Output
NNFA	71	$0	$0	-	-	-
NSA	80	$11,500,000	$140,000	$11,500,000	9	$1,300,000
TAAD	85	$43,000,000	$510,000	$31,500,000	5	$6,300,000
TAADEB	87	$56,200,000	$650,000	$13,200,000	2	$6,600,000
TAEB	89	$60,600,000	$680,000	$4,400,000	2	$2,200,000
LCA	98	$328,200,000	$3,300,000	$267,600,000	9	$29,700,000

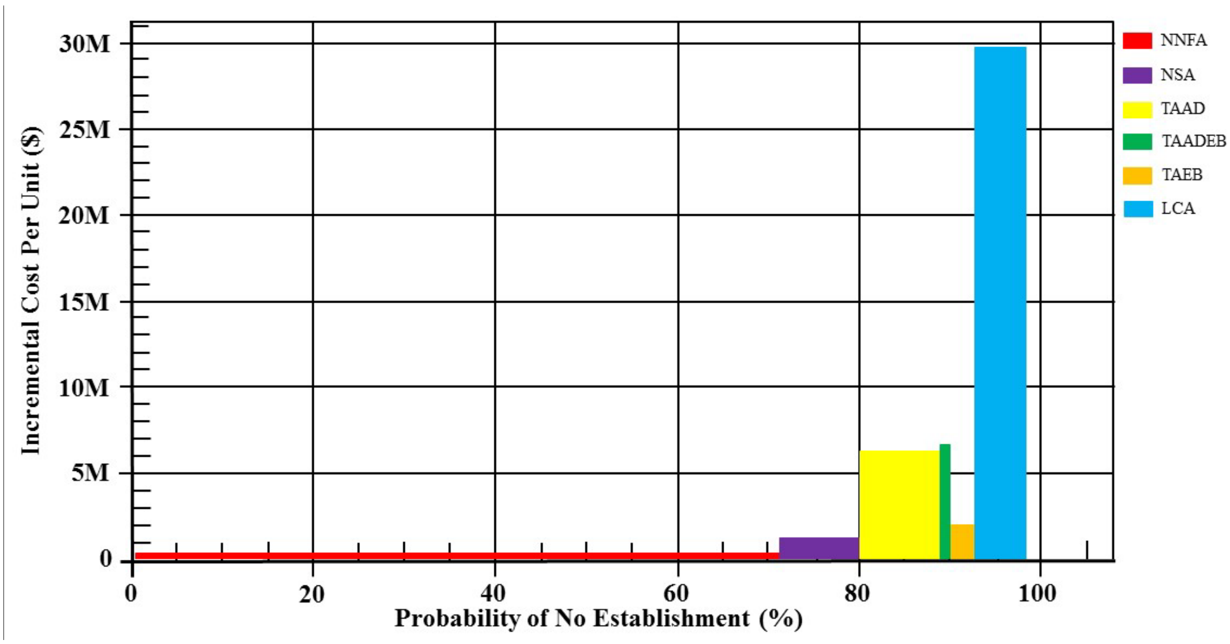

Figure B-6: Incremental Cost and Output of "Best Buy" Alternative Plans for Asian Carp (Median Elicited Values for Probability of No Establishment)

3.1.3. Asian Carp Using Maximum Elicited Values for Probability of No Establishment

For the maximum range of probability of no establishment, CE/ICA identified the NNFA, NSA, TAEB, and LCA as best buy plans. Both the TAAD and TAADEB were identified as cost effective plans (Figure B-7, Table B-29, and Figure B-8).

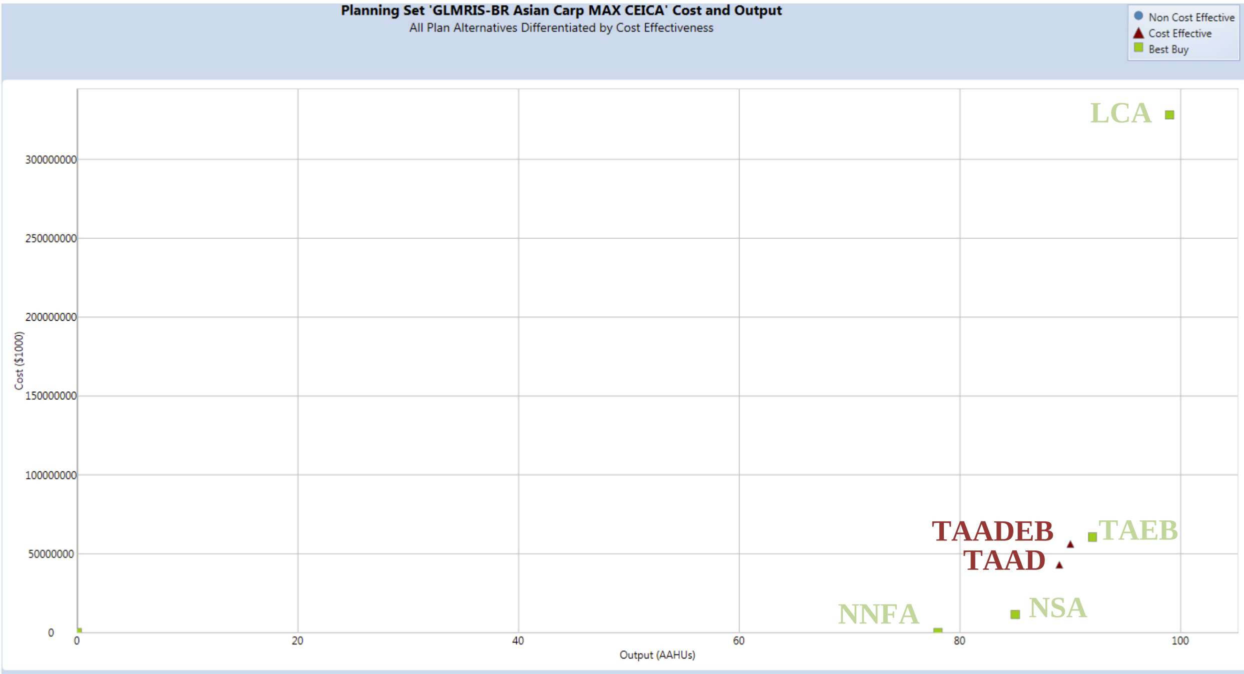

Figure B-7: Cost and Output Results of Alternative Plans for Asian Carp (Maximum Elicited Values for Probability of No Establishment)

Table B- 21: Summary of CE/ICA "Best Buy" Alternative Plans for Asian Carp (Maximum Elicited Values for Probability of No Establishment)

Alternative Plan	Output (Probability of No Establishment))	Cost	Avg. Cost ($ Probability of No Establishment)	Inc. Cost	Inc. Output (Probability of No Establishment)	Inc. Cost Per Output
NNFA	78	$0	$0	-	-	-
NSA	85	$11,500,000	$140,000	$11,500,000	7	$1,600,000
TAAD	89	$43,000,000	$480,000	$31,500,000	4	$7,900,000
TAADEB	90	$56,200,000	$620,000	$13,200,000	1	$13,200,000
TAEB	92	$60,600,000	$660,000	$4,400,000	2	$2,200,000
LCA	99	$328,200,000	$3,300,000	$267,600,000	7	$38,200,000

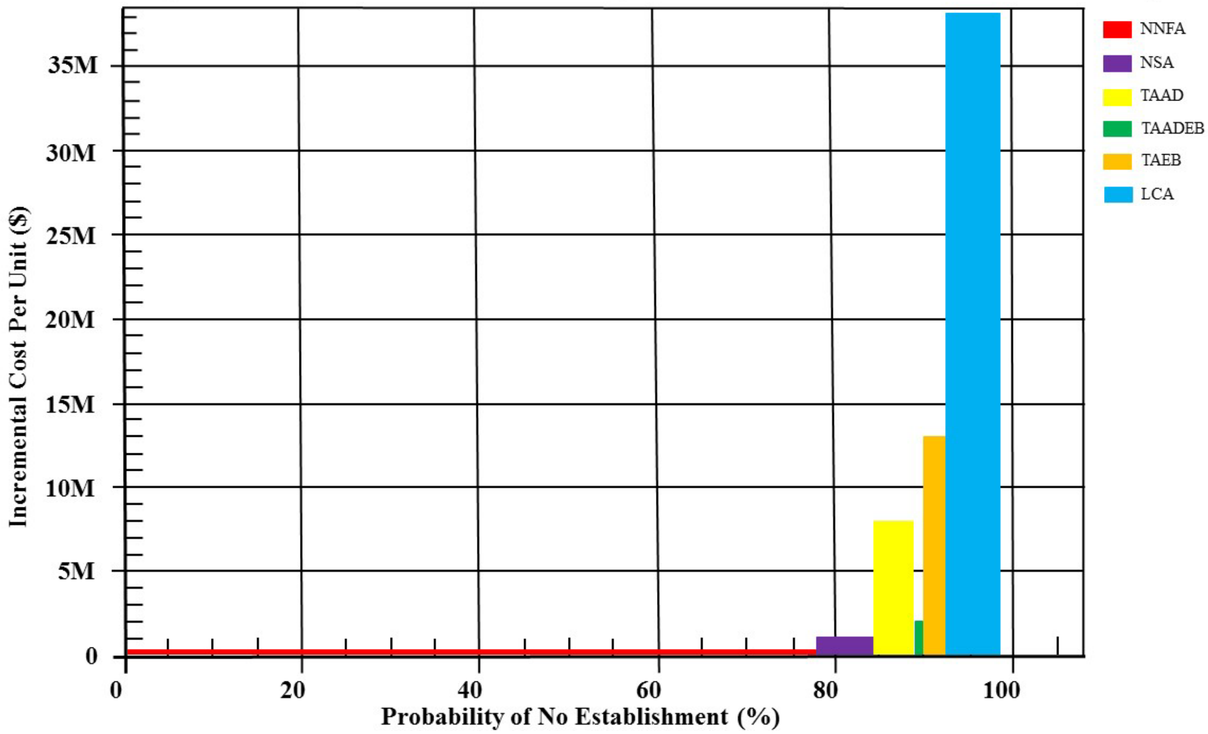

Figure B-8: Incremental Cost and Output of "Best Buy" Alternative Plans for Asian Carp (Maximum Elicited Values for Probability of No Establishment)

3.1.4. *A. lacustre* Using Minimum Elicited Values for Probability of No Establishment

For the minimum range of probability of no establishment, CE/ICA identified the NNFA and LCA as best buy plans. The TAAD was identified as a cost effective plan (Figure B-9, Table B-30 and Figure B-10).

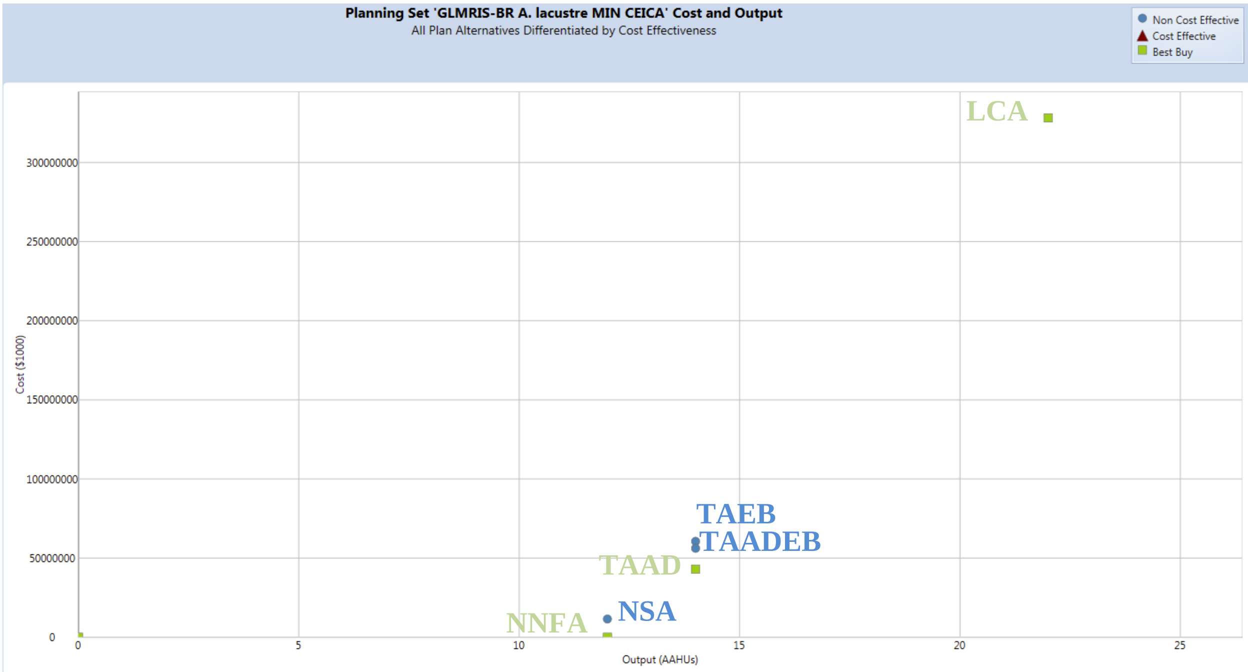

Figure B-9: Cost and Output Results of Alternative Plans for *A. lacustre* (Minimum Elicited Values for Probability of No Establishment)

Table B-22: Summary of CE/ICA "Best Buy" Alternative Plans for *A. lacustre* (Minimum Elicited Values for Probability of No Establishment)

Alternative Plan	Output (Probability of No Establishment))	Cost	Avg. Cost ($ Probability of No Establishment)	Inc. Cost	Inc. Output (Probability of No Establishment)	Inc. Cost Per Output
NNFA	12	$0	$0	-	-	-
TAAD	14	$43,000,000	$3,100,000	$43,000,000	2	$21,500,000
LCA	22	$328,200,000	$14,900,000	$285,200,000	8	$35,700,000

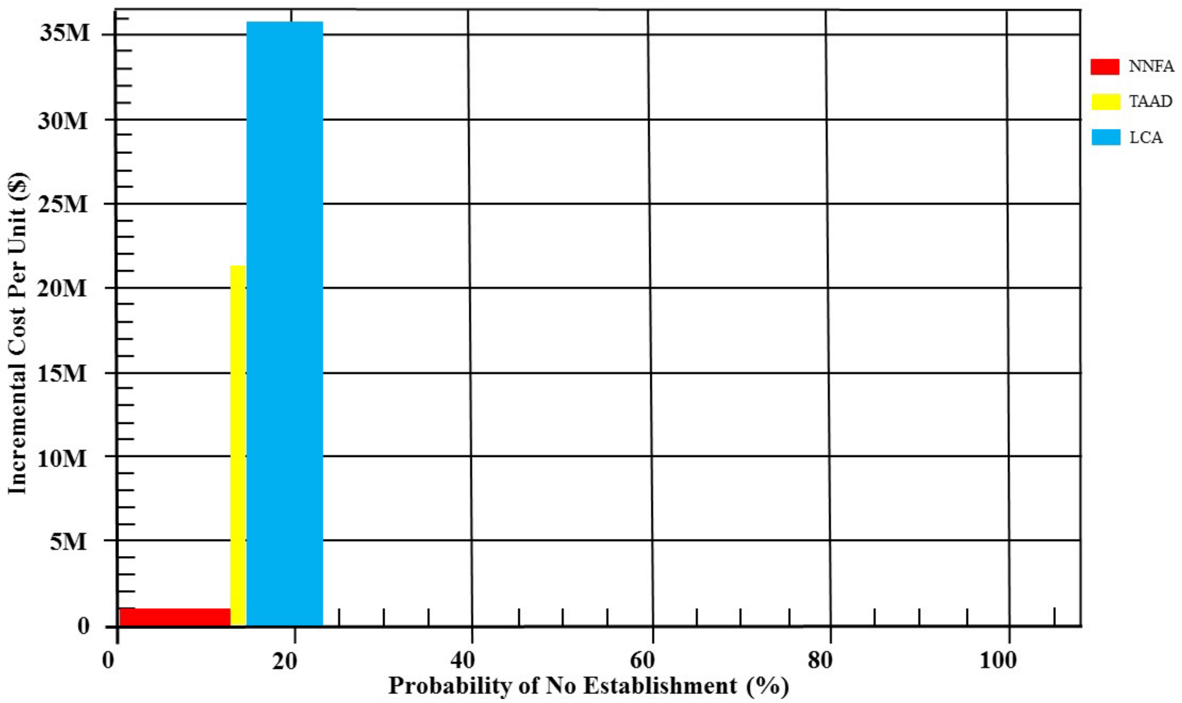

Figure B-10: Incremental Cost and Output of "Best Buy" Alternative Plans for *A. lacustre* (Maximum Elicited Values for Probability of No Establishment)

3.1.5. *A. lacustre* Using Median Elicited Values for Probability of No Establishment

For the median range of probability of no establishment, CE/ICA identified the NNFA, TAAD, and LCA as best buy plans (Figure B-11, Table B-31, and Figure B-12).

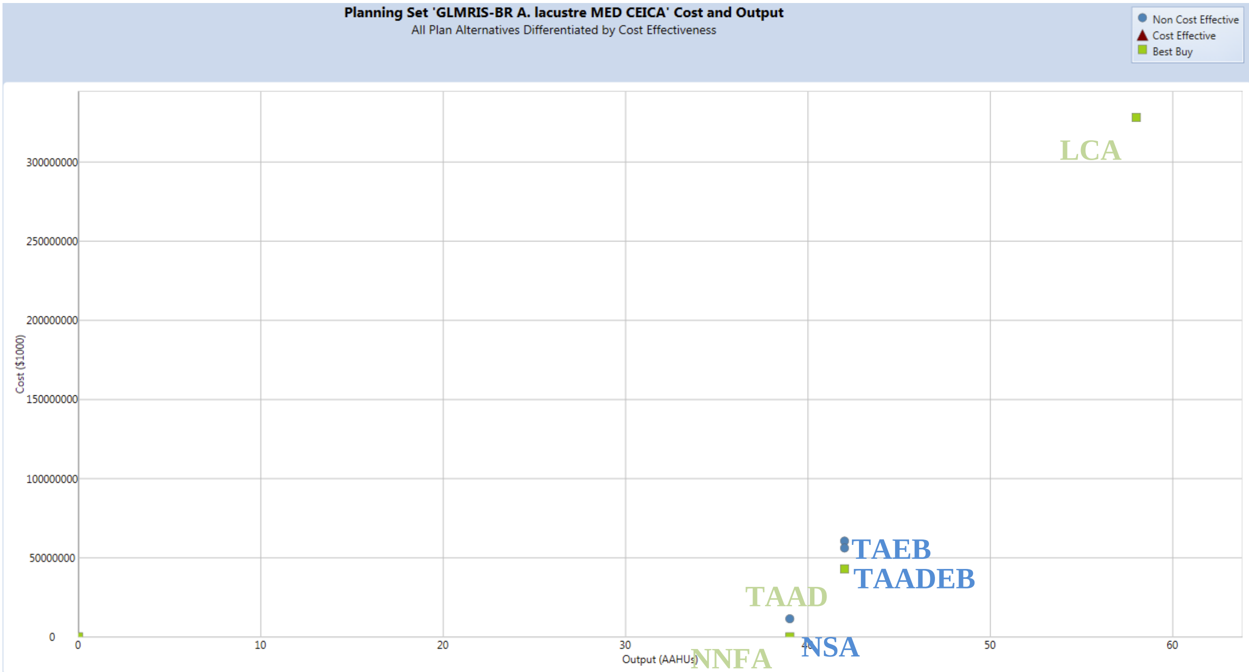

Figure B-11: Cost and Output Results of Alternative Plans for *A. lacustre* (Median Elicited Values for Probability of No Establishment)

Table B-23: Summary of CE/ICA "Best Buy" Alternative Plans for *A. lacustre* (Median Elicited Values for Probability of No Establishment)

Alternative Plan	Output (Prob. Of No Est.)	Cost	Avg. Cost ($/Prob. Of No Est.)	Inc. Cost	Inc. Output (Prob. Of No Est.)	Inc. Cost Per Output
NNFA	39	$0	$0	-	-	-
TAAD	42	$43,000,000	$1,000,000	$43,000,000	3	$14,300,000
LCA	58	$328,200,000	$5,700,000	$285,200,000	16	$17,800,000

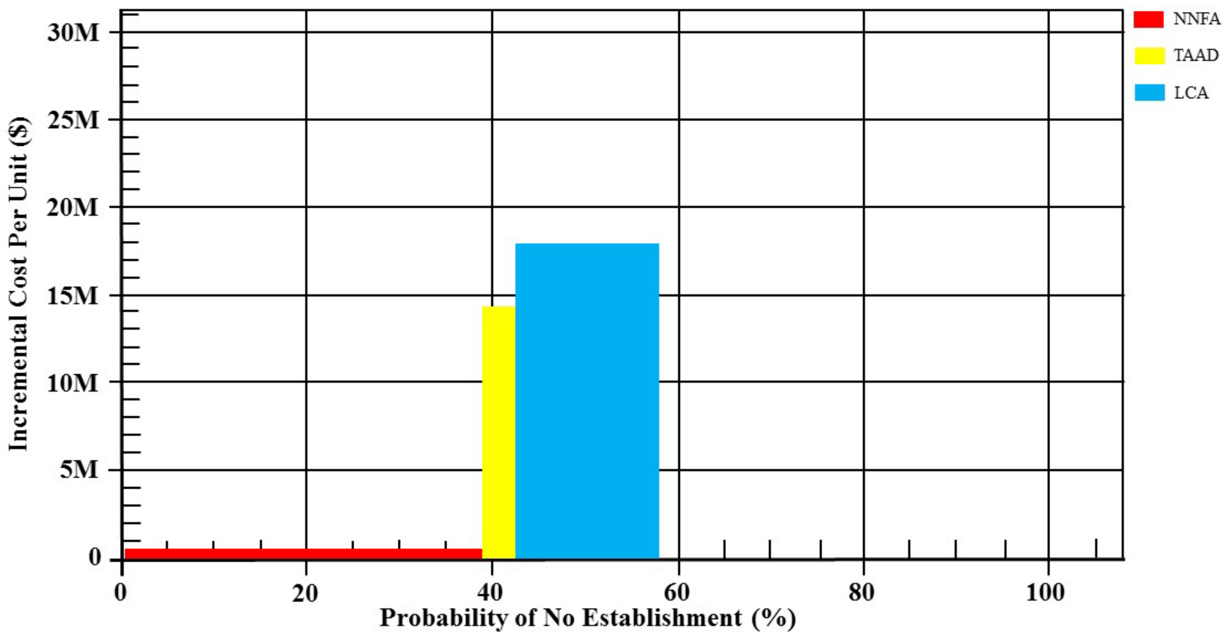

Figure B-12: Incremental Cost and Output of "Best Buy" Alternative Plans for *A. lacustre* (Median Elicited Values for Probability of No Establishment)

3.1.6. *A. lacustre* Using Maximum Elicited Values for Probability of No Establishment.

For the maximum range of probability of no establishment, CE/ICA identified the NNFA and LCA as best buy plans (Figure B-13, Table B-32 and Figure B-14). The TAAD was identified as a cost-effective plan only.

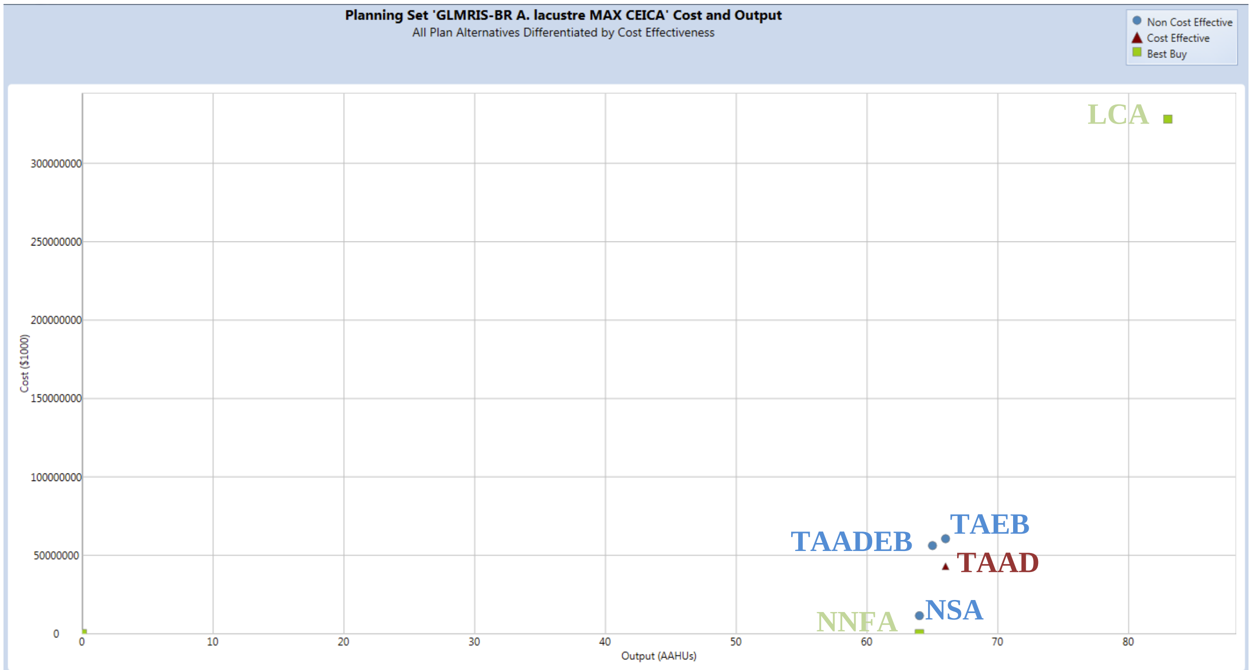

Figure B-13: Cost and Output Results of Alternative Plans for *A. lacustre* (Maximum Elicited Values for Probability of No Establishment)

Table B-24: Summary of CE/ICA "Best Buy" Alternative Plans for *A. lacustre* (Maximum Elicited Values for Probability of No Establishment)

Alternative Plan	CE/BB Designation	Output (Prob. Of No Est.)	Cost	Avg. Cost ($/Prob. Of No Est.)	Inc. Cost	Inc. Output (Prob. Of No Est.)	Inc. Cost Per Output
NNFA	BB	64	$0	$0	-	-	-
TAAD	CE	66	$43,900,000	$700,000	$43,000,000	2	$21,500,000
LCA	BB	83	$328,800,000	$4,000,000	$285,200,000	17	$16,800,000

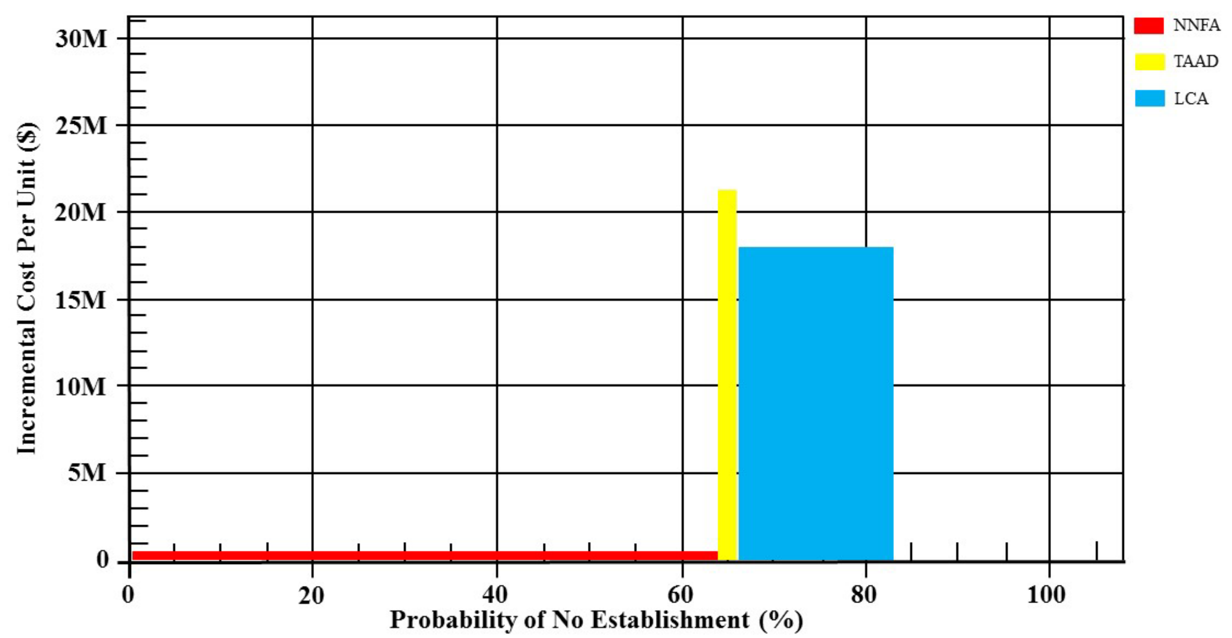

Figure B-14: Incremental Cost and Output of "Best Buy" Alternative Plans for *A. lacustre* (Maximum Elicited Values for Probability of No Establishment)

4. Bibliography

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Attachment 1:
Brandon Road Lock and Dam Section 404(b)(1) Analysis

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BRANDON ROAD LOCK AND DAM FEASIBILITY STUDY

APPENDIX B

PLANNING

ATTACHMENT 1

Preliminary Section 404(b)(1) Evaluation

US Army Corps of Engineers®
Rock Island District
Chicago District

List of Figures, Tables, and Attachments

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I. Project Description

a. Location

The Great Lakes and Mississippi River Interbasin Study – Brandon Road (GLMRIS-BR) Site-Specific Study Area is shown in Figure 1. The GLMRIS-BR Site-Specific Study Area includes the Brandon Road Lock and Dam (BRLD), the downstream approach channel, and adjacent upland parcels. The project is located in Will County, Illinois near Joliet.

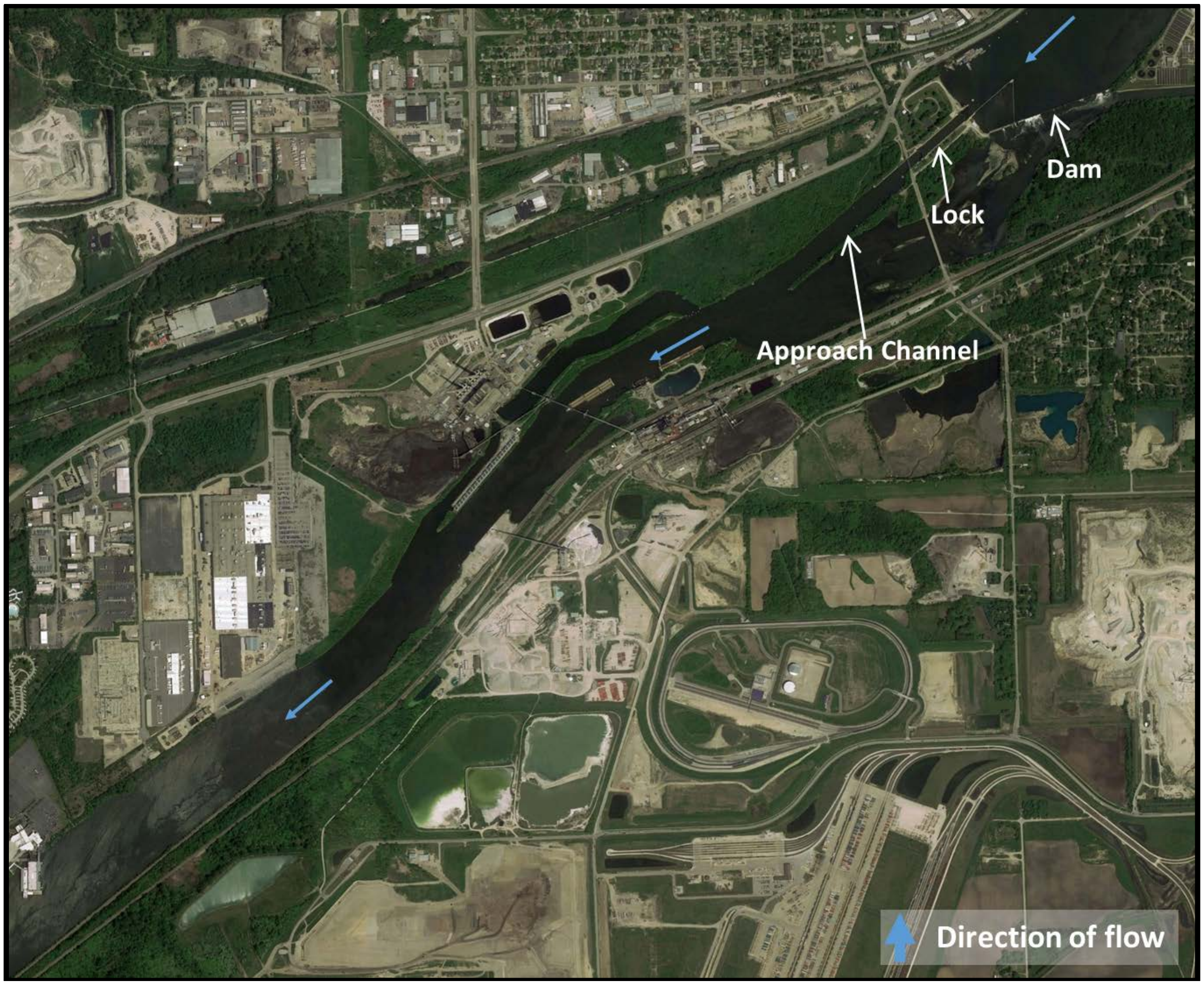

Figure 1: GLMRIS-BR Site-Specific Study Area

b. General Description

The Recommended Plan is the Technology Alternative-Acoustic Fish Deterrent with Electric Barrier and includes the following measures (Table 1 and Figure 2): (1) nonstructural activities, (2) acoustic fish deterrent, (3) air bubble curtain, (4) engineered channel, (5) electric barrier, (6) flushing lock, and (7) boat launches (Figure 3).

Table 1: Technology Alternative–Acoustic Fish Deterrent with Electric Barrier Measures Included, Location of Measures, and Modes of Transport Controlled by a Measure

Location	Measure	Controlled Modes of Transport
Brandon Road Lock and Dam (BRLD)	Air bubble curtain	Floaters, small and stunned swimmers
	Flushing lock	Floaters
	Acoustic fish deterrent	Swimmers
	Electric barrier	Swimmers
	Engineered channel	Improves efficiency of swimmer and floater controls
	Boat launches	Supporting measure
GLMRIS-BR Illinois Waterway Study Area	Nonstructural	Swimmers

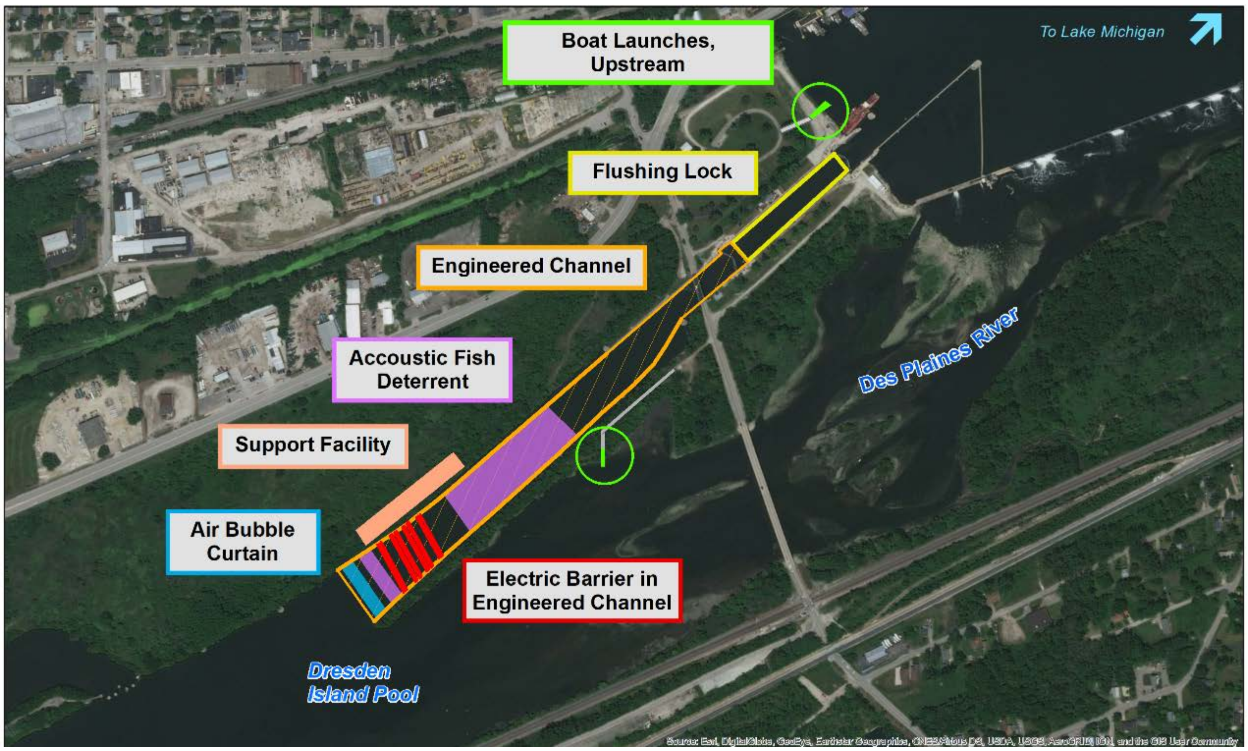

Figure 2: Aerial View of Brandon Road Lock and Dam with Potential Layout of Technology Alternative–Acoustic Fish Deterrent with Electric Barrier

Figure 3: Boat Launch Locations for the Recommended Plan

c. Authority and Purpose

The U.S. Army Corps of Engineers (USACE) purpose and need for the GLMRIS-BR project are to evaluate structural and nonstructural options and technologies near the BRLD site to prevent the upstream transfer of aquatic nuisance species (ANS) from the Mississippi River Basin (MRB) into the Great Lakes Basin (GLB), while minimizing impacts on existing waterway uses and users. For GLMRIS, USACE has defined the term "prevent" to mean the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.[1] The need for this study is to address the problem of the interbasin transfer of ANS between the GLB and MRB.

The GLMRIS-BR Report is a feasibility study that builds on the foundation of the GLMRIS Report released in January 2014. The GLMRIS Report identified alternatives to address the interbasin transfer of ANS; however, full implementation of several of the alternatives would require a substantial investment of time and of money. Given the potential urgency of the ANS threat and in response to a growing consensus, the Secretary of the Army (Secretary) determined that a formal evaluation of potential control options and technologies to be applied near the BRLD was an appropriate next step. The BRLD brings singular advantages for further study.

The GLMRIS was authorized in Section 3061(d) of the Water Resources Development Act (WRDA) of 2007, Public Law 110-114 as follows:

> FEASIBILITY STUDY – The Secretary, in consultation with appropriate Federal, State, local and nongovernmental entities, shall conduct, at Federal expense, a feasibility study of the range of options and technologies available to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins through the Chicago Sanitary and Ship Canal and other aquatic pathways.

The Section 404(b)(1) guidelines for the specification of disposal sites for dredged or fill material are in Title 40, Chapter I, Subchapter H, Part 203 of the Code of Federal Regulations (CFR).

d. General Description of Dredged and Fill Material

1) General Characteristics of Material

The BRLD downstream approach channel, where the engineered channel, air bubble curtain, electric barrier, and acoustic fish deterrent will be constructed, is comprised of loose sediment and gravel in a thin layer over bedrock.

One of the boat launches is located upstream of BRLD on the right descending bank, which as described above, the substrate is primarily comprised of gravel and loose sediment/silt. The second boat launch will be located on the peninsula on the left descending bank of BRLD. The boat launch will be constructed on the left descending bank of the peninsula where the substrate is primarily comprised of gravel and loose sediment/silt. The material used for construction of the boat launches will be clean and inert gravel from a commercial supplier.

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[1] Defining the term "prevent" to mean reducing the risk to the maximum extent possible is entirely reasonable. Michigan v. U.S. Army Corps of Engineers, 911 F. Supp. 2d 739, 766 (N.D. Ill. 2012), aff'd, 758 F.3d 892 (7th Cir. 2014).

The project includes widening the peninsula located on the left descending bank of BRLD. The material used for expanding the width of the peninsula will be rock excavated from construction of the engineered channel. The excavated rock, through further detailed design and engineering, has been determined to be suitable fill material that may be used elsewhere on site for project construction.

2) Quantity of Material

The construction of the engineered channel will require controlled blasting of the limestone bedrock in the downstream approach channel of the BRLD. Concrete walls are being placed along the bottom of the downstream approach channel and channel side slopes, and in order to maintain a 9-ft (2.7-m) draft within the channel for navigation purposes, the current channel bottom would need to be excavated. Excavation within the downstream approach channel would occur along the entire length of the downstream approach channel and across a width of approximately 220 ft (67.1 m). Bedrock within the downstream approach channel bottom would be removed down to an elevation between 486.5 feet and 487.0 feet. The elevation excavated down to within the approach channel depends on the technology that is being placed in that section of the approach channel (e.g., electric barrier, acoustic fish deterrent, air bubble curtain). For more details please refer to Appendix H.2, Engineering. The top of the new concrete engineered channel floor would be finished off at an elevation of 490.0 feet. The finished elevation will provide roughly 14 ft (4.3 m) of water depth to navigation during low water periods. Rock excavated from the downstream approach channel for construction of the engineered channel has been determined to be suitable fill material that may be used elsewhere on site for project construction. Excavated rock may be used as fill material for backfilling behind the engineered channel walls, which requires approximately 69,500 cubic yards of material. Excavated rock may also be used to widen the peninsula, which requires approximately 78,800 cubic yards of material. New construction materials including concrete, metals, rock, and plastic or rubber gaskets/fillers will be used for construction of the engineered channel, electric barrier, acoustic fish deterrent, and air bubble curtain.

The boat launches will require the placement of rock within the waterway, approximately 16 cubic yards (12.2 cubic meters) of gravel per boat launch. This is a total of approximately 32 cubic yards (24.5 cubic meters) of gravel placed within the waterway to create the boat launches. Dredging is not expected to be required for construction of the boat launches, although minor grading to shape the area could be needed.

3) Source of Material

The source material for construction of an engineered approach channel, control technologies, and boat launches will be new construction materials including concrete, metals, rock, and plastic or rubber gaskets/fillers as needed. These clean and inert, new materials are not expected to be a source of contamination for the water. Excavated rock from the construction of the engineered channel will also be cleaned, crushed, and reused on site as backfill for the engineered channel walls. The excavated rock is not expected to be a source of contamination for the water.

e. Description of the Proposed Discharge Site(s)

1) Location

For construction of the engineered channel, activities would occur within the Brandon Road Lock downstream approach channel. Rock excavated from the construction of the engineered channel would be cleaned and crushed on site and then reused as backfill behind the walls of the engineered channel as well as for increasing the width of the peninsula located on the left descending bank on the Brandon Road Lock downstream approach channel. Any remaining excavated rock not reused on the project would be disposed of in an appropriate landfill.

The location of the two proposed boat launches at BRLD is shown in Figure 3. There will be one boat launch located upstream of the BRLD in the Brandon Road Pool and a second boat launch located downstream of BRLD in the Dresden Island Pool.

2) Size

The approximate size of the downstream approach channel which would be impacted by the construction activities is 590,000 square feet (54,812.8 square meters).

The approximate size of the in-water area for the boat launches is 700 square feet (65.0 square meters) per launch. This is a total area of approximately 1400 square feet (130.1 square meters).

3) Type of Site

The downstream approach channel is an open river area, but with little habitat value since the current approach channel as well as the proposed updated approach channel are manmade features. The sediment staging site is a previously disturbed upland area that is adjacent to the river at Brandon Road Lock. Due to the nature of the sediment, no sediment or water will be directly returned untreated to the river. The final sediment placement site for dredged materials will be a commercial landfill. Entrained water will be treated prior to discharge or will be discharged upland such as to a municipal sewer system.

4) Type of Habitat

The habitat within the GLMRIS-BR Site-Specific Study Area is characteristic of an urban/industrial area that has been modified by the addition of large-scale hydrologic features. The boat launches would be constructed on property owned by the USACE and which is within the immediate vicinity of Brandon Road Lock. The downstream approach channel is blasted limestone and contains very little aquatic habitat due to the operation of the Brandon Road Lock, which releases water to continually flush fine sediment from the area.

5) Timing and Duration of Discharge

The GLMRIS-BR project could be initiated as soon as authorization of the project is received and funds are appropriated. Construction of the engineered channel is expected to occur first since it is the platform for the other technologies (e.g., air bubble curtain, electric barrier, and acoustic fish deterrent). The engineered channel construction is estimated to take more than one year. Construction of the air bubble curtain is expected to occur concurrently with construction of the engineered channel. The installation of the control technologies such as the electrical barrier components would occur next, with the duration of in-water features occurring over the course of a few months. Boat launches are expected to be constructed as soon as authorization of the project is received and funds are appropriated; the duration of the boat launch construction would be short and on the order of weeks or months. Overall, construction would occur over a several year period with activities in the water occurring intermittently during that time frame. It is anticipated that construction would be somewhat seasonal, with little to no work occurring during the winter months.

II. Factual Determinations

a. Physical Substrate Determinations

1) Substrate Elevation and Slope

The current approach channel bottom is at approximately 492 feet (National Geodetic Vertical Datum (NGVD) 1929). The substrate consists of loose sediment and gravel in a thin layer over bedrock (which was blasted to construct the approach channel). The proposed approach channel bottom elevation is similar to the current.

2) Sediment Type

The downstream approach channel bottom consists of bedrock and gravel with only a thin sediment layer.

3) Dredged/Fill Material Movement

Rock blasted and excavated from the engineered channel, through further detailed design and engineering, has been determined to be suitable fill material that will be used elsewhere on site for project construction. The excavated rock would be used to fill in behind the walls of the engineered channel, to widen the peninsula on the left descending bank of the downstream approach channel, etc. The excavated rock would be sized appropriately so as to reduce any potential movement once it is placed. For the boat launches, gravel would be placed in-water to create the launches. No significant movement of the gravel placed for construction of the boat launches is expected. The existing bank material would be graded as needed but left in place. The boat launches are being constructed in quiescent areas of the channel where flow velocities are typically minimal.

4) Physical Effects on Benthos

Because the existing approach channel consists of a thin layer of gravel over bedrock, there is limited existing benthic habitat. Existing benthos and habitat within the downstream approach channel of Brandon Road Lock would be destroyed during blasting and construction of the engineered channel. The future engineered channel area will provide little habitat for benthic organisms. Widening of the peninsula located on the left descending bank of the downstream approach channel would also result in the smothering of any benthos within the immediate vicinity where fill material is placed. Construction of the two boat launches would also be expected to affect existing benthos and habitat within these localized areas. Invertebrates could be buried or smothered by the placement of the gravel for the two boat launches. It is important to note, however, that these aforementioned areas are a small portion of the existing degraded riverine habitat and the proposed activities are not expected to cause a detrimental loss of benthic organisms and habitat within the larger river. Due to the industrial environment of the proposed project location and the absence of federally listed species, USACE determined “No Effect” on listed species or on proposed or designated critical habitat. The USFWS provided a letter (November 23, 2016) acknowledging the USACE’s “no effect” determination and concurred that “no federally listed species occur at or near the Brandon Road Lock and Dam project location.”

5) Other Effects

The construction of the new engineered channel, control technologies, boat launches, and widening of the peninsula will cause temporary, short-term, localized increases in the concentration of suspended solids. The downstream approach channel lacks ideal habitat, since it is a manmade feature, and short-term turbidity impacts are not anticipated to cause impacts to the aquatic habitat. The locations of the proposed boat launches are quiescent areas where flow velocities are reduced; however, the localized increase in suspended solids from placement of gravel for the launches is expected to be minimal. For these reasons, the environmental impacts caused by the short-term increases in suspended solids due to the construction activities including dredging are anticipated to be temporary and minimal. It is noted that coordination with downstream water users, including nearby power plants, will require coordination to ensure that temporary turbidity does not impact the operation or water use of these entities.

6) Actions Taken to Minimize Impacts

The construction of the engineered channel, boat launches, and widening of the peninsula will use best management practices to prevent material spills or uncontrolled discharges into the river, including turbidity monitoring and the use of silt curtains if necessary. Upland work areas will be subject to erosion control and will be permanently stabilized when work is completed. Dredging activities will also use best management practices to minimize solid suspension. Sediment disposal will occur upland with return water treatment and/or controls to prevent the release of anthropogenic compounds to the river. In addition, prior to construction, all applicable permits will be secured and the work will be coordinated with the regulatory agencies, including the Illinois Environmental Protection Agency, the Illinois Department of Natural Resources, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency.

b. Water Circulation, Fluctuation and Salinity Determinations

1) Water

(a) Salinity

The Illinois River is a fresh water river fed by both natural and anthropogenic discharges. The source of salinity in the system is predominantly anthropogenic, and can be traced to the seasonal discharge of road salt via untreated snowmelt and precipitation discharges. The proposed work will not increase or decrease the salinity of the water and will not add salts to the system.

(b) Water Chemistry

The approach channel and boat launch construction materials will be new, inert materials such as concrete, gravel, metals and other new materials. Materials used to widen the peninsula and fill in behind the engineered channel walls will be rock excavated from construction of the engineered channel. Further detailed design and engineering has determined that the excavated rock is suitable fill material that can be used elsewhere on site for project construction. Short-term effects on the water quality are expected because of temporary increases in the concentration of suspended solids and turbidity following the construction and dredging operations. The temporary increase of suspended solids is expected to cause short-term decreases in water clarity and minor changes to the color of the water.

(c) Clarity

As discussed above, the new construction materials for the approach channel and boat launches are not expected to be a source of contamination, and dredged sediment will be placed upland with no direct return of untreated water. Also as discussed above, rock excavated from construction of the engineered channel has been shown as suitable fill material and will be used as fill behind the engineered channels walls and for widening of the peninsula. The excavated rock that will be used as fill is not expected to be a source of contamination. Short-term effects on clarity are expected because of temporary increases in the concentration of suspended solids and turbidity during in-water work activities. The temporary increase of suspended solids is expected to cause short-term decreases in water clarity.

(d) Color

The proposed work would not be anticipated to cause any considerable long-term effects on, or changes to, the water color, but a temporary increase of suspended solids is expected to cause short-term and minor changes to the color of the water.

(e) Odor

The construction of the approach channel, boat launches, and widening of the peninsula would not be anticipated to cause any considerable long-term effects on, or changes to, the odor of the water, but a temporary increase of suspended solids might cause short-term and minor changes to the odor of the water for organisms in the immediate vicinity.

(f) Taste

The proposed work would not be anticipated to cause any considerable long-term effects on, or changes to, the taste of the water, but a temporary increase of suspended solids might cause short-term and minor changes to the taste of the water for organisms in the immediate vicinity. Local communities, including Joliet and Morris and the communities in between these, do not use the Des Plaines River as a drinking water source.

(g) Dissolved Gas Levels

Temporary increases of turbidity could produce minor, localized effects on the dissolved gas and nutrient levels in the water column. These effects are primarily expected to be short-term, minor, and aesthetic impacts, but the turbid water could cause minor, short-term adverse impacts to aquatic plants and organisms in the vicinity. Any temporary impacts are anticipated to be unimportant for the manmade approach channel, peninsula, and boat launch locations which have little habitat value. Monitoring of water quality including dissolved oxygen is conducted by some water uses downstream of Brandon Road Lock and Dam. Coordination will be required prior to working in the approach channel to ensure that all users monitoring and water quality needs are met.

(h) Nutrients

Temporary increases of turbidity due to construction activities could produce minor, localized effects on nutrient levels in the water column. These effects are primarily expected to be short-term, minor, and aesthetic impacts, but could cause minor, short-term adverse impacts to aquatic plants and organisms in the vicinity.

(i) Eutrophication

Eutrophication is typically caused by excessive nutrient levels. As discussed above, the proposed work activities could produce minor, localized effects on nutrient levels in the water column, but these effects are expected to be short-term, minor, and aesthetic impacts.

(j) Others as Appropriate

Any short-term effects on the public water supply intakes downstream of the project are anticipated to be negligible, and there should be no effect on the odor or taste of the water.

2) Current Patterns and Circulation

(a) Current Patterns and Flow

The flow of water in the approach channel is controlled by the release of water from the Brandon Road Lock. The proposed activities will not impact the lock functions or operations as far as the volume of water used per lockage, the number of lockages, and the manner in which water is released. The boat launches will be constructed in quiescent areas within the vicinity of BRLD where flow velocities are minimal. The construction of the boat launches is not expected to impact current patterns or flow.

(b) Velocity

The velocity of water within the approach channel is controlled by the release of water from the Brandon Road Lock. The reconstruction of the existing approach channel will not change the velocity of water releases from the existing lock. The boat launches will be constructed in quiescent areas within the vicinity of BRLD where flow velocities are typically minimal. The construction of the boat launches is not expected to impact the velocity of water in these areas. Widening of the peninsula located on the left descending bank of the downstream approach channel may result in slight increases in velocity at the tailwaters of the dam. The widening of the peninsula will be coordinated with the State of Illinois Department of Natural Resources – Office of Water Resources to ensure compliance with state floodplain regulations. The velocity of flows in the lower Des Plaines River/Illinois River is controlled by upstream discharges in the upper Des Plaines River and CAWS, including precipitation flows.

(c) Stratification

The Des Plaines River/Illinois River is not known to be stratified. The proposed work is not expected to cause stratification of the river, either in the approach channel or in the main river channel.

(d) Hydrologic Regime

Since the project is not expected to alter current patterns or flow and should not have any noticeable short- or long-term, individual or cumulative effects on the local or regional currents in the Des Plaines River/Illinois River, or on the circulation patterns, water level fluctuations, or stratification, it should not cause any considerable effects on, or changes to, the hydrologic regime.

3) Normal Water Level Fluctuations

The pool level at the Brandon Road downstream approach channel is controlled by 1) the upstream flows originating in the upper Des Plaines River watershed and the Chicago Area Waterway System (CAWS), and 2) the Dresden Lock and Dam located downstream of Brandon Road. The proposed project will not significantly impact either the upstream watershed, the Brandon Road Lock and Dam, or the Dresden Lock and Dam, and thus is not expected to have any impact on the normal water level fluctuations within the Illinois River.

4) Salinity Gradients

The Des Plaines River/Illinois River is a freshwater system, so the effect of the project on salinity gradients is not applicable. The proposed project is not expected to add salt to the river system.

5) Actions That Will Be Taken to Minimize Impacts

The proposed approach channel reconstruction, installation of aquatic species control technologies, and construction of boat launches are not anticipated to result in any long-term effects on, or changes to, the water quality, current patterns or flow, water circulation, or the normal water level fluctuation of the Des Plaines River/Illinois River. Widening of the peninsula may result in slight increases in water surface elevations and velocities and a slight reduction in floodplain storage. The final design will be coordinated with the State of Illinois Department of Natural Resources – Office of Water Resources to ensure compliance with state floodplain regulations.

c. Suspended Particulate/Turbidity Determinations

1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Dredging Site

The project is expected to produce minor and temporary increases of suspended solids and turbidity in the local vicinity of the approach channel construction, boat launches, and widening of the peninsula. Plumes of suspended particles may be visible and aesthetically displeasing until the particles gradually settle and the plumes dissipate. Coordination with downstream water users prior to construction will be needed to ensure that temporary turbidity does not impact those entities. As needed, turbidity monitoring and silt curtains will be deployed; the use of best management practices will be the main suspended solids control method. Sediment will not be placed in the Des Plaines River/Illinois River but will be disposed of upland with no discharge of untreated water in an effort to minimize the release of suspended particulates.

2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column

(a) Light Penetration

The project is expected to cause minor, temporary, and localized increases of suspended solids at the approach channel during construction, at the boat launch locations during construction, and widening of the peninsula. This temporary increase in suspended solids could in turn cause a temporary decrease in water clarity and reduce the penetration of light through the water column. If the penetration of light is reduced for an extended period of time, it can lower the rate of photosynthesis and "primary productivity" of an aquatic area. Primary productivity generally refers to the fixation of solar energy by green plants (i.e., autotrophs) in a terrestrial ecosystem, or phytoplankton for an aquatic ecosystem. Persistently high turbidity can cause adverse impacts to sight-dependent species because the reduced clarity can hinder the feeding ability of these species, and thereby limit their growth and increase their susceptibility to disease.

In regards to elevated suspended solids concentrations, it explains the following in 40 CFR 230.21:

> "The extent and persistence of these adverse impacts caused by discharges depend upon the relative increase in suspended particulates above the amount occurring naturally, the duration of the higher levels, the current patterns, water level, and fluctuations present when such discharges occur, the volume, rate, and duration of the discharge, particulate deposition, and the seasonal timing of the discharge."

Since the minor, temporary, and localized increases of suspended solids due to the proposed project activities are anticipated to be low relative to the increased levels of suspended solids that typically result from storm events and adverse weather conditions, the project is not expected to cause any long-term adverse impacts on the chemical or physical properties of the water column.

(b) Dissolved Oxygen

Minor, temporary, and localized increases of suspended solids at the boat launches, approach channel construction, and as a result of widening the peninsula will likely result in slight reductions in the level of dissolved oxygen water in the column. This is because the biological and chemical content of the suspended material may react and in turn deplete some of the dissolved oxygen in the water column. Dissolved oxygen monitoring by downstream water users may be disrupted by the approach channel construction; coordination to prevent monitoring impacts will be needed.

(c) Toxic Metals and Organics

Rock removed during blasting of the downstream approach channel will be reused as fill material for the project. The rock does not contain toxic metals or organics. The materials proposed for use in construction of the engineered channel, control technologies, and boat launches will be new, clean construction materials that are not expected to release toxic metals or organics. Rock excavated from the engineered channel will be reused as fill material behind the walls of the engineered channel and for widening the peninsula. The excavated rock is not expected to release toxic metals or organics.

(d) Pathogens

The upstream water sources for the lower Des Plaines River/Illinois River include periodic untreated stormwater and combined sewer discharges. The construction materials that will be used for the approach channel, control technologies, and boat launches will be new, clean materials that are not anticipated to be a source of pathogens. Rock excavated from construction of the engineered channel will be reused as fill material behind the walls of the engineered channel and to widen the peninsula on the left descending bank of the downstream approach channel. The excavated rock is not expected to be a source of pathogens.

(e) Aesthetics

As discussed earlier, the temporary increase of suspended solids is expected to cause a short-term decrease of water clarity and minor changes to the color of the water, and these effects are primarily expected to cause short-term, minor, and aesthetic impacts. In addition, for recreational boaters and the aquatic resources in the vicinity there may be loud noises associated with construction activities, and the visual presence of the barges and marine construction vessels and equipment will have a temporary and minor adverse impact to the aesthetic beauty of the water surface near the Brandon Road Lock and Dam.

(f) Others as Appropriate

The proposed approach channel, control technologies, boat launches, and widening of the peninsula are not expected to cause any other adverse effects on the chemical and physical properties of the water column.

3) Effects on Biota

Sensitive aquatic biota, specifically primary producers (plankton), filter feeders, and sight feeders, can be easily impacted with increased turbidity and suspended solids. These impacts are greatly minimized due to the upland placement site selection for the project. Any minor, temporary, and localized increases of suspended solids from the proposed construction are anticipated to be low relative to the increased levels of suspended solids that typically result from storm events and adverse weather conditions. No sediment or untreated return water would be placed in the Des Plaines River. Therefore, the project is not expected to cause any long-term effects on the local aquatic biota as it relates to suspended solids.

(a) Primary Production, Photosynthesis

The project is expected to cause minor, temporary, and localized increases of suspended solids at the approach channel, boat launches, and widening of the peninsula. This temporary increase in suspended solids could in turn cause a temporary decrease in water clarity and reduce the penetration of light through the water column. If the penetration of light is reduced for an extended period of time, it can lower the rate of photosynthesis and “primary productivity” of an aquatic area. Primary productivity generally refers to the fixation of solar energy by phytoplankton for an aquatic ecosystem. Overall, the increase in turbidity is expected to be minor and temporary; therefore, the project is not expected to cause any long-term effects to primary production or photosynthesis.

(b) Suspension/Filter Feeders

As mentioned previously under Primary Production, Photosynthesis, the project is expected to cause minor, temporary, and localized increases of suspended solids at the construction locations for the engineered channel, boat launches, and at the peninsula where it will be widened. Persistently high turbidity can cause adverse impacts to suspension/filter feeders that siphon their food from the water column, thereby limiting their growth and increasing the susceptibility to disease. However, the project is only expected to cause minor and temporary increases of suspended solids at the construction and dredging locations; therefore, the project is not expected to cause any long-term effects to suspension/filter feeders.

(c) Sight Feeders

As mentioned previously, the project is expected to cause minor, temporary, and localized increases of suspended solids at the construction locations for the engineered channel, boat launches, and at the peninsula where it will be widened. Persistently high turbidity can cause adverse impacts to sight-dependent species because the reduced clarity can hinder the feeding ability of these species, and thereby limit their growth and increase their susceptibility to disease. However, the project is only expected to cause minor and temporary increases of suspended solids at the construction and dredging locations; therefore, the project is not expected to cause any long-term effects to suspension/filter feeders.

4) Actions taken to Minimize Impacts

Construction of the engineered channel, boat launches, and widening of the peninsula will use best management practices to prevent material spills or uncontrolled discharges into the river. Upland work areas will be subject to erosion control and will be permanently stabilized when work is completed. Dredging activities will also use best management practices to minimize solid suspension, and may use turbidity monitoring and silt curtains if needed. Sediment disposal will occur upland with return water treatment and/or controls to prevent the release of anthropogenic compounds to the river. In addition, prior to construction, all applicable permits will be secured and the work will be coordinated with the regulatory agencies, including the Illinois Environmental Protection Agency, the Illinois Department of Natural Resources, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency.

d. Contaminant Determinations

The construction of the approach channel, technologies, and boat launches will use new, clean construction materials and the material is not expected to be a source of contamination. Rock excavated from construction of the engineered channel will be reused as fill material behind the walls of the engineered channel and to widen the peninsula on the left descending bank of the downstream approach channel. However, this reused material is not expected to be a source of contamination. The proposed project is not anticipated to cause any considerable long-term effects on, or changes to, the existing water quality or cause effects on biota.

e. Aquatic Ecosystem and Organism Determinations

1) Effects on Plankton

Existing plankton within the downstream approach channel of Brandon Road Lock would be displaced during blasting and construction of the engineered channel, including placement of excavated rock behind the engineered channel walls. Construction of the two boat launches and widening of the peninsula would also be expected to affect existing benthos and habitat within these areas. Plankton could be buried by the placement of rock. It is important to note, however, that these aforementioned areas are a small portion of the existing degraded riverine habitat and proposed activities are not expected to cause a detrimental loss of plankton. Due to the industrial environment of the proposed project location and the absence of federally listed species, USACE determined “No Effect” on listed species or on proposed or designated critical habitat. USFWS has concurred with this determination, refer to Appendix K, Coordination for a response letter from USFWS dated November 23, 2016.

(2) Effects on Benthos

Refer to Section II.a.(4) for a discussion on the potential effects on benthos.

(3) Effects on Nekton

Existing nekton and associated habitat within the downstream approach channel of Brandon Road Lock would be displaced during blasting and construction of the engineered channel. In addition, existing nekton could be buried or smothered when rock is filled in behind the engineered channel walls. Construction of the two boat launches and widening of the peninsula would also be expected to affect existing nekton and habitat within these areas. Nekton could be buried or smothered by the placement of rock for the two boat launches and widening of the peninsula. It is important to note, however, that these aforementioned areas are a small portion of the existing degraded riverine habitat and proposed activities are not expected to cause a detrimental loss of nekton and associated habitat. Due to the industrial environment of the proposed project location and the absence of federally listed species, U.S. Army Corps of Engineers determined “No Effect” on listed species or on proposed or designated critical habitat. USFWS has concurred with this determination, refer to Appendix K, Coordination for a response letter from USFWS dated November 23, 2016.

4) Effects on Native Fish and Aquatic Food Web

In general, pressures from Bighead Carp and Silver Carp on native fish species have the potential to disrupt their life cycles; however, uncertainty exists as to the extent of impacts if Bighead and Silver Carp were to become established in the Great Lakes Basin. Studies are currently ongoing to measure the impact of Bighead and Silver Carp on Great Lakes food webs. The Recommended Plan has been determined the best option that reasonably maximizes prevention of Mississippi River Basin aquatic nuisance species establishment within the Great Lakes Basin to effectively minimize impacts to this food web.

The Recommended Plan includes nonstructural measures, engineered channel, electric barrier, acoustic fish deterrent, air bubble curtain, flushing lock, and boat launches. During construction, noises from blasting, equipment on land and in the water could potentially disturb aquatic communities within the immediate vicinity and/or prevent their movements through the area. No long-term impacts from construction of the engineered channel are expected.

The nonstructural measures include the construction of two boat launches that not expected to have any long-term impacts to aquatic species within the vicinity of Brandon Road Lock and Dam. Construction of the boat launches could increase turbidity and placement of the gravel could smother benthic invertebrates and any nekton that may be in these locations. However, these are temporary and localized effects that are not expected to have any long-term effects to aquatic species.

The electric barrier is expected to have long-term adverse impacts to connectivity within the Des Plaines River in turn causing long-term indirect adverse impacts to aquatic species movement and reestablishment within the upper Des Plaines River. Operating parameters of the barrier are expected to only temporarily stun fish, although injury or death are possible. The electric barrier is expected to be a non-selective deterrent to fish species and long-term impacts to native species upstream movement are expected. Connectivity between the lower and upper Des Plaines River has already been severed with the construction of the Brandon Road Lock and Dam in the late 1920's/early 1930's; however, recent studies by the U.S. Fish and Wildlife Service on the use of the Brandon Road Lock by fish species suggests that although the construction of the Brandon Road Lock and Dam impacted the connectivity of the lower and upper Des Plaines River, connectivity was only impeded, not completely prevented. Implementation of the electric barrier at Brandon Road Lock and Dam would further impede the upstream movement of native fish species. Therefore, it is expected that operation of the electric barrier would impact connectivity of the Des Plaines River and native species migration and reestablishment from the lower Des Plaines River to the upper Des Plaines River.

In regards to the air bubble curtain, the operation of the air bubble curtain would create a long-term adverse impact to all aquatic non-plant communities within the effective vicinity of the disturbance. It is anticipated that most of the adverse impacts would be to migrating fish species attempting to traverse the air bubble curtain. Information is not available regarding the potential impact of the air bubble curtain on benthic and free-swimming invertebrates. It is possible the air bubble curtain could create a disturbance that would adversely impact these organisms forcing them to relocate from the vicinity of the air bubble curtain.

The flushing lock component of the alternative is not expected to have any impacts to aquatic species within the vicinity of BRLD. This feature only targets floating species that are incapable of movement on their own and/or have not reached a mobile life-stage yet. Additionally, the flushing lock is not expected to impact water levels in the Dresden Island pool as a result of its operation, hence native species aquatic habitat is not expected to be impacted.

The long-term impacts of the acoustic fish deterrent to native aquatic species is uncertain. Preliminary data from USGS have shown that the acoustic fish deterrent can be operated in such a way that it specifically targets Bighead and Silver Carp. Native species do not appear to be affected to the same degree that the target species are, or at all.

5) Effects on Special Aquatic Sites

Effects on special aquatic sites, such as mussel beds and/or fish spawning habitat located in the vicinity, are not expected because of the industrial environment of the proposed project location and the absence of such ideal habitat. No sanctuaries and refuges, wetlands, mudflats, vegetated shallows, coral reefs, or riffle and pool complexes would be affected by the proposed actions.

(a) Sanctuaries and Refuges

There are no known sanctuaries or refuges present within the GLMRIS-BR Site-Specific Study Area; therefore, no significant impact is expected from implementation of the Recommended Plan.

(b) Wetlands

There are no known wetlands present within the GLMRIS-BR Site-Specific Study Area; therefore, no significant impact is expected from implementation of the Recommended Plan.

(c) Mud Flats

There are no known mud flats present within the GLMRIS-BR Site-Specific Study Area; therefore, no significant impact is expected from implementation of the Recommended Plan.

(d) Vegetated Shallows

There are no known vegetated shallows present within the GLMRIS-BR Site-Specific Study Area; therefore, no significant impact is expected from implementation of the Recommended Plan.

(e) Coral Reefs

This is only applicable to salt water environments. This project is being implemented in a fresh water environment, therefore, there are no coral reefs present.

(f) Riffle and Pool Complexes

Any riffle and pool complexes they may have been present within the GLMRIS-BR Site-Specific Study Area were destroyed with the construction and operation of the Brandon Road Lock and Dam. Therefore, no significant impact to riffle and pool complexes is expected from implementation of the Recommended Plan.

6) Threatened and Endangered Species

Due to the industrial environment of the proposed project location and the absence of federally listed species, USACE determined "No Effect" on listed species or on proposed or designated critical habitat. USFWS has concurred with this determination, refer to Appendix K, Coordination for a response letter from USFWS dated November 23, 2016.

7) Other Wildlife

Controlled blasting for excavation of the engineered channel is expected to disturb wildlife that may be present within the vicinity of the Brandon Road Lock downstream approach channel. Disturbance to wildlife may be minimized by a properly designed controlled blasting plan. The construction of the two boat launches and widening of the peninsula could temporarily disturb semi-aquatic wildlife (e.g., turtles, frogs, water snakes, aquatic salamanders, beaver, muskrat, otter, etc.) that may be within the vicinity of where construction and fill material is occurring. The placement of the rock for the boat launch ramps and the associated construction vehicles would produce loud noises that may temporarily disturb the movement of any wildlife in the area. Similarly, the placement of rock for expansion of the peninsula would require construction vehicles that would provide loud noises that may temporarily disturb the movement of any wildlife in the area. Operation of the electric barrier could impact semi-aquatic wildlife species (e.g., turtles, frogs, water snakes, aquatic salamanders, beaver, muskrat, otter, etc.) that are within the waterway and if they attempt to traverse the electric barrier. The degree to which these species would be impacted is uncertain and would likely be related to the operating parameters of the electric barrier. It is anticipated that for the most part, any wildlife attempting to transit the electric barrier would be temporarily stunned, although injury or death are possible. The bubbling created by operation of the air bubble curtain could also disturb wildlife and prevent the movement of any semi-aquatic wildlife. The flushing lock component of the alternative is not expected to have any impacts to wildlife within the vicinity of BRLD. Overall, long-term adverse impacts due to the operation of the electric barrier and air bubble curtain is expected to be minimal.

8) Actions Taken to Minimize and Mitigate Impacts

Early and open coordination with state and federal resource agencies helps to minimize potential impacts to aquatic, wetland, and terrestrial ecosystems. Best management practices will be used for all construction. In order to minimize the adverse effects of blasting on native fish populations, the proposed construction and dredging activities could be specifically scheduled to avoid time periods when native fish are typically spawning or migrating. Further coordination during the design phase will occur on how to optimize construction of the Recommended Plan while minimizing impacts to native aquatic species.

For unavoidable impacts, in-kind mitigation is being proposed for the long-term consequences associated with connectivity of the Des Plaines River and native species migration and reestablishment from the lower Des Plaines River to the upper Des Plaines River.

A preliminary mitigation plan was developed in response to information received after the public review of the draft feasibility study and environmental impact statement. Additional formal coordination and potentially the development of a Memorandum of Agreement/Understanding with the sponsor, stakeholders and regulatory agencies would be needed prior to implementation. Further National Environmental Policy Act (NEPA) evaluation and Feasibility planning would be required to assess any mitigation actions proposed in this plan to ensure adherence to laws and regulations.

The mitigation plan presented in Appendix N describes a species-specific model for evaluating alternative measures to accomplish the project objective of fish passage improvements on the Des Plaines River and tributaries to mitigate potential losses in longitudinal connectivity from the GLMRIS-BR ecosystem restoration project. Longitudinal connectivity refers to the aquatic pathway that enables the unconstrained movement of biota, sediment, and nutrients from headwaters to the mouth of rivers. Connectivity is a central factor in shaping aquatic biological communities, particularly fish and mussel species, and is negatively affected by dams and aquatic nuisance species barriers.

The GLMRIS-Brandon Road ecosystem restoration project involves the construction of barriers and implementation of management actions to prevent the upstream transfer of aquatic nuisance species from the Mississippi River Basin to the Great Lakes Basin through the CAWS in the vicinity of the Brandon Road Lock and Dam. The obstruction of upstream movement of native fish and mussels is an unintended consequence of this project and is the focus of this mitigation plan.

Six alternatives were evaluated using the Fish Passage Connectivity Index (FPCI) model and the IWR Planning Suite decision support software to compare alternatives based upon habitat benefits and costs. The selected mitigation alternative was Alternative B - Trap and Transport. This mitigation alternative involves the manual capture of fish below the Brandon Road Dam; sorting of target species and transfer to a location upstream of the Brandon Road Dam for release. Wild caught fish have the potential to carry early life stages (i.e., glochidia) of mussels, which would also enhance upstream mussel populations.

USACE identified the least cost mitigation plan that provides full mitigation of losses specified in the mitigation planning objective as required in policy (USACE 2000). The mitigation objective for this project is 110 habitat units with the restoration of 127 habitat units.

f. Proposed Disposal/Discharge Site Determinations

1) Mixing Zone Determination

A mixing zone is not applicable because a violation of applicable water quality standards is not expected. Sediment will be placed upland with no direct return of untreated water (See Attachment A).

2) Determination of Compliance with Applicable Water Quality Standards

Rock removed during controlled blasting on the downstream approach channel will be reused as fill material behind the engineered channel walls as well as for widening the peninsula on the left descending bank of the downstream approach channel. Short-term effects on the water quality are expected because of temporary increases in the concentration of suspended solids and turbidity during dredging operations. The temporary increase of suspended solids is expected to cause short-term decreases in water clarity and minor changes to the color of the water. The placement of rock for the construction of the boat ramps and widening of the peninsula is also expected to have only short-term effects on water quality due to temporary increases in the concentration of suspended solids and turbidity during dredging operations. The temporary increase of suspended solids is expected to cause short-term decreases in water clarity. However, overall, the project is expected to comply with all applicable water quality standards and no violations are anticipated.

(3) Potential Effects on Human Use Characteristic

(a) Municipal and Private Water Supply

There are no drinking water intakes located in the Des Plaines River near the project area or within 20 miles (32.1 kilometers) downstream. The project will not impact the deep aquifers used for drinking water in Joliet and nearby communities.

(b) Recreational and Commercial Fisheries

No effects on commercial fisheries within the GLMRIS-BR Site-Specific Study Area will occur in regards to the proposed project since commercial fishing does not occur within the vicinity of

Brandon Road Lock and Dam. The proposed actions would cause only minor, temporary, and localized disruptions to sport fishing access since access to the lock will be restricted during the approach channel. The construction of the two boat launches and widening of the peninsula are not expected to have any temporary disruptions to sport fishing access.

(c) Water Related Recreation

As discussed earlier, the temporary increase of suspended solids is expected to cause a short-term decrease of water clarity and minor changes to the color of the water, and these effects are primarily expected to cause short-term, minor, and aesthetic impacts. In addition, for non-cargo navigation in the vicinity of BRLD there may be loud noises associated with approach channel construction activities, and the visual presence of the barges and marine construction vessels and equipment will have a temporary and minor adverse impact to the aesthetics near the BRLD.

Construction of the engineered channel and the various technology components of the alternative may impact noncargo vessels transiting through Brandon Road Lock due to temporary lock closure events to allow for construction activities. However, these impacts are expected to be short-term, lasting only as long as it takes to complete construction. Long-term impacts on non-cargo vessels would primarily be due to the continuous operation of the electric barrier. For example, the Chicago Sanitary and Ship Canal Electric Dispersal Barriers (CSSC-EB) have a restricted navigation area (RNA), which does not permit the transit of vessels less than 20 feet (6.1 meters) through the CSSC-EB nor the transit of personal watercraft such as kayaks, canoes, or jet skis. Federal vessels and nonfederal vessels would likely not be able to transit the electric barrier in the case of an emergency near the BRLD if this type of RNA were to be implemented at BRLD. Consistent with existing operating procedures at the CSSC-EB located in Romeoville, Illinois, the USACE personnel would alert the Fire Department in the case of an emergency. While it is uncertain what restrictions would be included in an RNA implemented at the BRLD electric barrier, it is likely that non-cargo navigation, especially smaller vessels, would be impacted to some degree by such restrictions. In addition, the actual extent of the elevated electric field at the BRLD is currently unknown and would be unknown until the electric barrier was constructed and in operation, and testing could be conducted. It is possible that the elevated electric field could extend to the tailwaters of the dam, which could impact recreational boaters that may fish in this area. The air bubble curtain and flushing lock are not expected to have any long-term impacts to recreational navigation.

(d) Aesthetics

The proposed project activities will result in various temporary adverse effects on the aesthetic quality in the area close to the project site. There may be minor and temporary effects on the aesthetic quality of the air, water, and visual quality. Increases in noise levels due to the operations will also occur, but they are expected to be relatively minor and short term. The aesthetic effects will be temporary and will only impact those people in the immediate vicinity. Since the area downstream of BRLD is primarily industrial and there are few, if any, private residences in the area, the adverse aesthetic impacts are anticipated to be minimal.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves

No Parks, National and historical monuments, national seashores, wilderness areas, research sites, and similar preserves are present within the GLMRIS-BR Site-Specific Study Area, so this topic is not applicable.

g. Determination of Cumulative Effects on the Aquatic Ecosystem

Upland placement of dredged material is anticipated to produce minor effects on the aquatic ecosystem. Impacts with the construction of the approach channel are negligible since the structure is manmade. Minor and temporary impacts are only expected with construction of the two boat launches and widening of the peninsula. Overall, the primary impact from the Recommended Plan would be the long-term impact to connectivity between the lower and upper Des Plaines River with continuous operation of the electric barrier.

h. Determination of Secondary Effects on the Aquatic Ecosystem

No secondary effects are anticipated as a result the proposed project activities.

III. Findings of Compliance or Non-Compliance with the Restrictions on Discharge

a. Adaptation of the Section 404(b)(l) Guidelines to this Evaluation

There were no adaptations of the Section 404(b)(l) guidelines for this evaluation.

b Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem

The GLMRIS-BR Report discusses the practicable alternatives that were evaluated. It is expected that all of the alternatives considered, besides the “no action” alternative, would have similar minor impacts on the aquatic ecosystem.

c. Compliance with Applicable State Water Quality Standards

The proposed construction materials for the engineered channel, control technologies, and boat launches will be clean, new materials that are not expected to be a source of contamination. None of the proposed activities are anticipated to cause any considerable long-term effects on, or changes to, the water chemistry or quality. Short-term effects on the water quality are expected because of temporary increases in the concentration of suspended solids and turbidity due to construction and dredging activities. The temporary increase of suspended solids is expected to cause short-term decreases in water clarity and minor changes to the color of the water. However, overall, the project is expected to comply with all applicable water quality standards and no violations are anticipated.

d. Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act

The project is in compliance with applicable Toxic Effluent Standards under Section 307 of the Clean Water Act.

e. Compliance with Endangered Species Act of 1973

Due to the industrial environment of the proposed project location and the absence of federally listed species, USACE determined “No Effect” on listed species or on proposed or designated critical habitat. USFWS has concurred with this determination, refer to Appendix K, Coordination for a response letter from USFWS dated November 23, 2016.

f. Compliance with the National Historic Preservation Act of 1966

USACE has acknowledged that with the implementation of the Recommended Plan the additions or modifications to the original fabric of the dam and the new construction within the BRLD Historic District boundaries may be considered to have adverse and visual effects. However, any new structures and alterations would, in part, retain the existing navigable lock profile and use concrete coloration that adheres to the Secretary of the Interior’s Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings. It is, therefore, the opinion of USACE that the modifications to the BR Lock would retain the overall historical nature or engineering attributes and characteristics under 36 CFR § 60.4, Criteria A and C. The major constituents and attributes of the Brandon Road Lock and esplanade would remain as a significant contribution to the BRLD Historic District. Formal concurrence with the finding or the “conditional no adverse effect” for the Recommended Plan was requested by the USACE in a letter dated March 8, 2016 (Appendix K, Coordination; letter dated March 8, 2016). The USACE received concurrence with the Illinois State Historic Preservation Office for a conditional no adverse effect (Appendix K, Coordination; letter dated March 25, 2016, Illinois Historic Preservation Agency Log# 002021015).

g. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972

The proposed project is for the Illinois River which is not included in the Marine Protection, Research, and Sanctuaries Act of 1972.

h. Evaluation of Extent of Degradation of the Waters of the United States

1) Significant Adverse Effects on Human Health and Welfare

The proposed fill (i.e., construction of the engineered channel, installation of control technologies, and construction of boat launches) activity is not expected to have any long-term adverse impacts on human health or welfare, including:

- Municipal and private water supplies,
- Recreational and commercial fisheries,
- Plankton,
- Fish,
- Shellfish,
- Wildlife communities (including community diversity, productivity, and stability), or
- Special aquatic sites

2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems

There are long-term impacts to the connectivity between the lower and upper Des Plaines River, which in-kind mitigation is continuing to be coordinated between USACE, USFWS, and ILDNR.

3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity and Stability

There are long-term impacts to the connectivity between the lower and upper DPR, which in-kind mitigation is continuing to be coordinated between USACE, USFWS, and ILDNR.

4) Significant Adverse Effects on Recreational, Aesthetic, and Economic Values

As described earlier, the project will have some minor and temporary effects on recreational, aesthetic, and economic values. In regards to recreation, there will be minor and temporary adverse impacts for sport fishing as well as for recreational boat users, because Brandon Road Lock will be temporarily closed and dredging operations will prevent access to a portion of the river bank downstream of the Lock. The project will also cause minor and temporary effects on the aesthetic quality of the air, water, and visual quality within the GLMRIS-BR Site-Specific Study Area. Increases in noise levels due to the operations will also occur, but they are expected to be minor and temporary. The aesthetic effects will be temporary and will only impact those people in the immediate vicinity. No adverse effects on economic values are anticipated, but the long-term control of ANS is expected to be a long-term beneficial impact for the Great Lakes Basin, and the new approach channel is expected have a beneficial impact on lock operations so commercial vessels will have adequate depths to navigate safely and transport cargo efficiently despite the ANS control technologies.

i. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem

Rock excavated during controlled blasting of the downstream approach channel will also be disposed of upland. This will prevent the release of any anthropogenic compounds associated with the sediment. Best management practices will be used for all construction activities to minimize localized impacts to the lower Des Plaines River

On the basis of the guidelines, the proposed disposal site for the discharge of the dredged material is specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize adverse impacts to the aquatic ecosystem.

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Attachment 2:
GLMRIS-BR Lock Treatment
Overview and Evaluation

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The Nature Conservancy

Midwest Division | North America Region
P.O. Box 440400, St. Louis, MO 63144

nature.org

JAN 05 2017

December 29, 2016

Major General Michael Wehr
Division Commander
U. S. Army Corps of Engineers
Mississippi Valley Division
Vicksburg, MS 39181-0080

Subject: Unsolicited proposal for consideration of a report and inclusion of an AIS Lock Treatment System in the Brandon Road Lock final implementation plan.

Dear Major General Wehr:

This letter is an unsolicited proposal to the U. S. Army Corps of Engineers (USACE) requesting consideration of the attached report: "Conceptual Aquatic Invasive Species Treatment System for the Chicago Area Waterways," and inclusion of an AIS Lock Treatment System in the Brandon Road Lock final implementation plan.

The Nature Conservancy (TNC) has been actively involved in the Chicago Area Waterways (CASW) Aquatic Invasive Species (AIS) discussions with stakeholders for many years. TNC has taken an active role in convening discussions on AIS control topics and sponsoring research on AIS control innovation, with much of this work engaging with USACE. Our AIS control interest led TNC to commission the attached report, "Conceptual Aquatic Invasive Species Treatment System for the Chicago Area Waterways" to further develop information on AIS chemical treatment in a lock approach channel. The report draws upon engineering expertise for water treatment chemical facilities to better understand what a chemical treatment facility would entail and cost. While we understand USACE has screened out chemical treatment as an approach to prevent AIS passage, TNC is convinced based upon the report findings that chemical control is an essential component of the technological solution and warrants further consideration and inclusion in the final implementation plan.

To promote understanding of our perspective on the importance of this AIS control technology, TNC welcomes meeting with USACE to discuss the report and answer questions that come up during USACE review. We would like to brief USACE at both the Division and District level. TNC requests that once USACE completes review of the report, that we receive a written response to this unsolicited proposal.

David Hamilton is the TNC AIS policy lead in the Great Lakes, and he will be the TNC point of contact on this topic. David is available at 517-316-2222 and via email dhamilton@tnc.org. We look forward to continuing to work with you on this important topic.

Sincerely,

Michael A. Reuter, Director
Great Lakes/Midwest Division

Cc: Lieutenant General Todd T. Semonite, Commanding General & Chief of Engineers
Colonel Craig S. Baumgartner, District Commander, Rock Island District
Major General Donald E. Jackson, Jr., Deputy Commanding General for Civil & Emergency Operations
Colonel Christopher T. Drew, Commander & District Engineer
James Dalton, Director of Civil Works
Dennis McGrath, Great Lakes Project Director, The Nature Conservancy
Robert Sinkler, Director of Water Resources Infrastructure, The Nature Conservancy
David Hamilton, Senior Policy Director, Great Lakes Project, The Nature Conservancy

Conceptual Aquatic Invasive Species Treatment System for the Chicago Area Waterways

Prepared for

The Nature Conservancy

November 2016

ch2m

135 South 84th St, Suite 400
Milwaukee, Wisconsin
United States. 53214

Contents

Figures

Acronyms and Abbreviations

AACE	Association for Advancement of Cost Engineering
AIS	aquatic invasive species
CAWS	Chicago Area Waterways
CFD	computational fluid dynamics
CPES	CH2M Parametric Cost Estimating System
GLMRIS	Great Lakes Mississippi River Interbasin Study
HP	horsepower
IEPA	Illinois Environmental Protection Agency
mg	milligrams
mg/L	milligrams per liter
TNC	The Nature Conservancy
TRC	total residual chlorine
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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Executive Summary

The Nature Conservancy (TNC), together with stakeholders in the Chicago Area Waterways (CAWS), is interested in an aquatic organism control alternative that would use a chemical to treat aquatic invasive species (AIS) that are in the water to prevent their movement with boat traffic through key locks. The treatment system would control the only continuously open pathway for AIS from crossing between the Mississippi River basin and the Great Lakes basin. This report provides an additional level of detail for the concept of AIS chemical control in or near a lock to further inform the discussion of such an alternative.

TNC envisions an approach channel or lock treatment systems that prevents AIS movement in one direction. The treatment system would have to be constructed in up to three locations in order to stop species in both directions through the CAWS. For conceptual design purposes, this report considers one location at the Brandon Road Lock.

The U.S. Geological Survey (USGS) has reviewed several chemicals that could be used to treat water for invasive species (USGS 2015). One chemical that showed promise for AIS control is chlorine (USGS 2015). This report summarizes the conceptual design and cost estimate to treat aquatic organisms in an approach channel with sodium hypochlorite solution, which is chlorine in a form that still provides disinfection control benefits, while being safer than chlorine gas to transport, store, and use.

The United States Army Corps of Engineers (USACE), as a follow up to their Great Lakes and Mississippi River Interbasin Study (GLMRIS), is currently working on a Brandon Road Study to assess the viability of establishing a single point to control for the one-way, upstream transfer of AIS from the Mississippi River Basin to the Great Lakes. USACE is considering a number of potential AIS control measures, and is designing an approach channel to the lock that could be used to try different measures. The Tentatively Selected Plan is due for public release in February 2017.

USACE has indicated that chemical treatment was screened out as an approach to prevent AIS passage. This report provides engineering information on the chemical treatment approach that was not further evaluated by USACE, including the engineering evaluation for chemical treatment sizing, dosing techniques, and chemical mixing. The report examines the conceptual design cost and issues of using chlorine for AIS control. As the USACE proceeds in their current process, their approach channel design could be adapted to incorporate a treatment chamber. The conceptual design findings in this report could be used to inform the planning and design of an AIS Lock Treatment System and necessary review under the National Environmental Policy Act (NEPA).

The use of sodium hypochlorite solution for AIS control appears technically feasible. Based upon available information, the chemical volume required is similar to volumes used at large drinking water or wastewater treatment plants, which have chemical facilities of similar size. Solutions exist for rapid mixing to quickly inject the chemical into the treatment chamber and thereby minimize delays for barge traffic traveling on the CAWS.

The capital cost opinion of the chemical and mixing system is $41.4 million with the annual operating costs range between $6.0 million and $8.9 million. These costs do not consider the approach channel construction or other supporting infrastructure but focus upon the chemical and mixing systems. While the capital and operational costs are not insignificant, the alternative offers cost savings compared to some of the GLMRIS report alternatives since a physical separation between the Lake Michigan and Mississippi River basins is not envisioned with this alternative.

The cost of chemicals would make up the majority of the annual operational costs. This report can inform potential variations in chemical use, treatment volume needed, and other measures to compare similar alternatives if variations to this concept develop.

Recommendations for future work necessary to complete a final design are included in the report.

Introduction

The Nature Conservancy (TNC), together with stakeholders in the Chicago Area Waterways (CAWS), is interested in an aquatic organism control alternative that would use a chemical to treat aquatic invasive species (AIS) that are in the water to prevent their movement with boat traffic through key locks. The treatment system would control the only continuously open pathway for AIS from crossing between the Mississippi River basin and the Great Lakes basin. Extensive prior study has been done on alternatives to control AIS between the Mississippi River basin and the Great Lakes basin by the U.S. Army Corps of Engineers (USACE) in their Great Lakes and Mississippi River Interbasin Study (GLMRIS) (USACE 2014). This report provides an additional level of detail for the concept of AIS chemical control in or near a lock to further inform the discussion of such an alternative.

The U.S. Geological Survey (USGS) has reviewed several chemicals that could be used to treat water for invasive species (USGS 2015). While much concern has been on Asian Carp AIS, the USGS considered chemicals that would be rapidly lethal to the full range of AIS taxa and life stages. One chemical that showed promise for AIS control is chlorine (USGS 2015).

This report summarizes the conceptual design and cost estimate to treat aquatic organisms in an approach channel to a lock with sodium hypochlorite solution, which is chlorine in a form that still provides disinfection control benefits, while being safer than chlorine gas to transport, store, and use. The USGS report noted other potential chemicals that could be considered further in a future evaluation task. The analysis presented in this report considers sodium hypochlorite solution for the conceptual chemical storage and mixing design that would be common for any chemical treatment approach. Treating water with sodium hypochlorite solution is a proven technology, its' ability to kill a wide range of organisms is well known, and dosing the chemical in water is well understood.

TNC envisions an approach channel or lock treatment systems that prevents AIS movement in one direction. The treatment system would have to be constructed in up to three locations in order to stop species in both directions through the CAWS. For conceptual design purposes, this report considers one location at the Brandon Road Lock.

For simplicity, this report summarizes a gated approach channel system that includes a treatment chamber, chemical addition, mixing, assumptions for contact time, and chlorine neutralization before discharge out of the treatment zone. The report's focus upon the chemical treatment facility is intended to illustrate how a chemical treatment facility could fit within planning improvements already occurring for the lock approach channel. Other improvements are required, such as the construction of a treatment chamber in the lock approach channel, which are beyond the focus of this report. While future additional evaluation and analysis would be required for detailed design and implementation, this analysis provides important conceptual infrastructure sizing and cost information for CAWS stakeholders to consider.

Treatment Concept

The following represents a conceptual design and cost opinion of an AIS treatment system at the Brandon Road Lock near Joliet, IL. The conceptual treatment sequence, shown in Figure 1, and a site plan at the Brandon Rock Lock shown in Figure 2, are premised on a constructed approach channel on the downstream end of Brandon Road Lock. Lock discharge water would be routed around the approach channel. Fish control measures, such as acoustic deterrents, could be incorporated both prior to the approach channel and upstream of the lock. The goal of deterrents would be to reduce the number of fish entering the approach channel, especially larger fish, and, as a result, reduce the potential for fish kills.

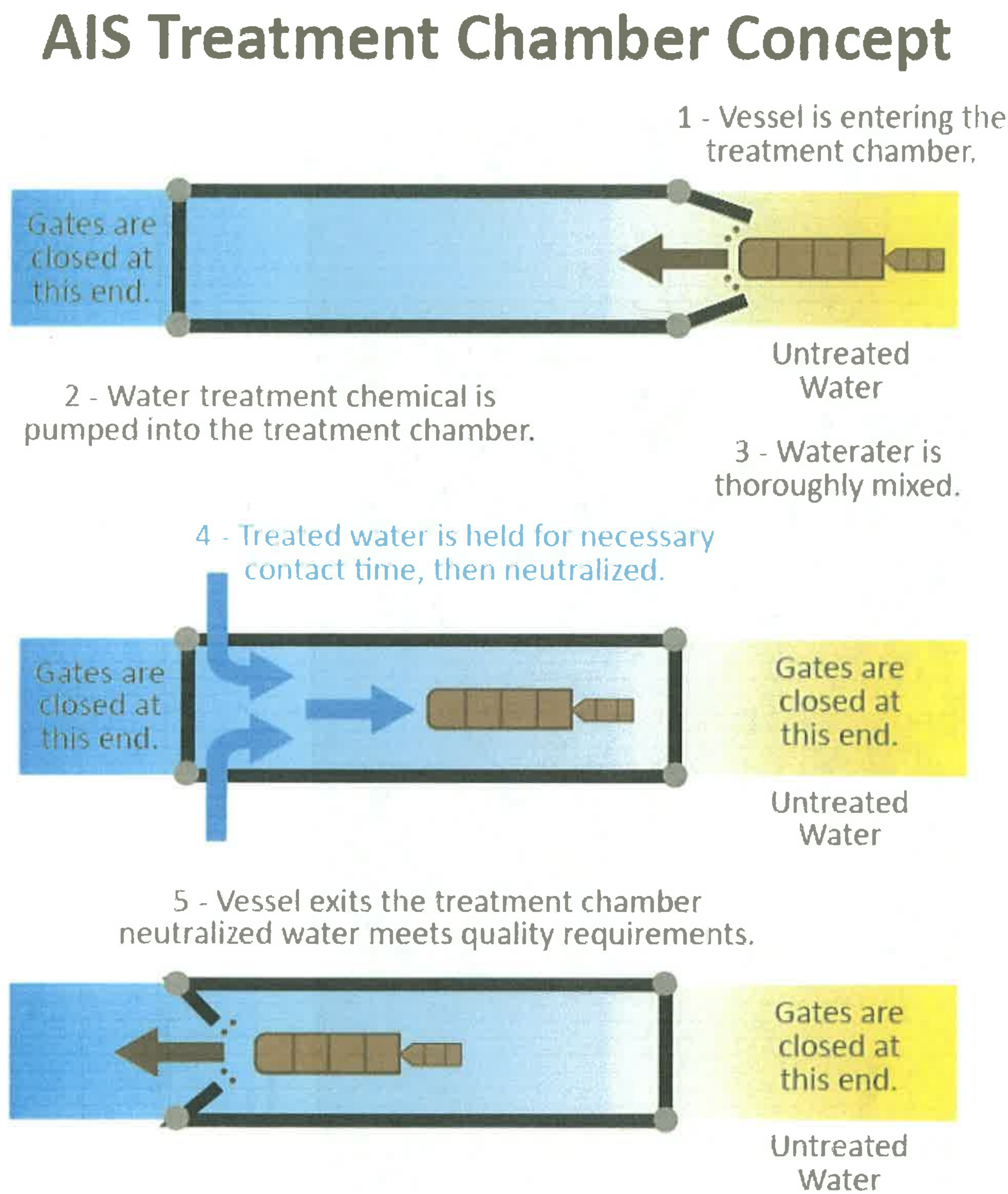

Figure 1. Conceptual Treatment Sequence

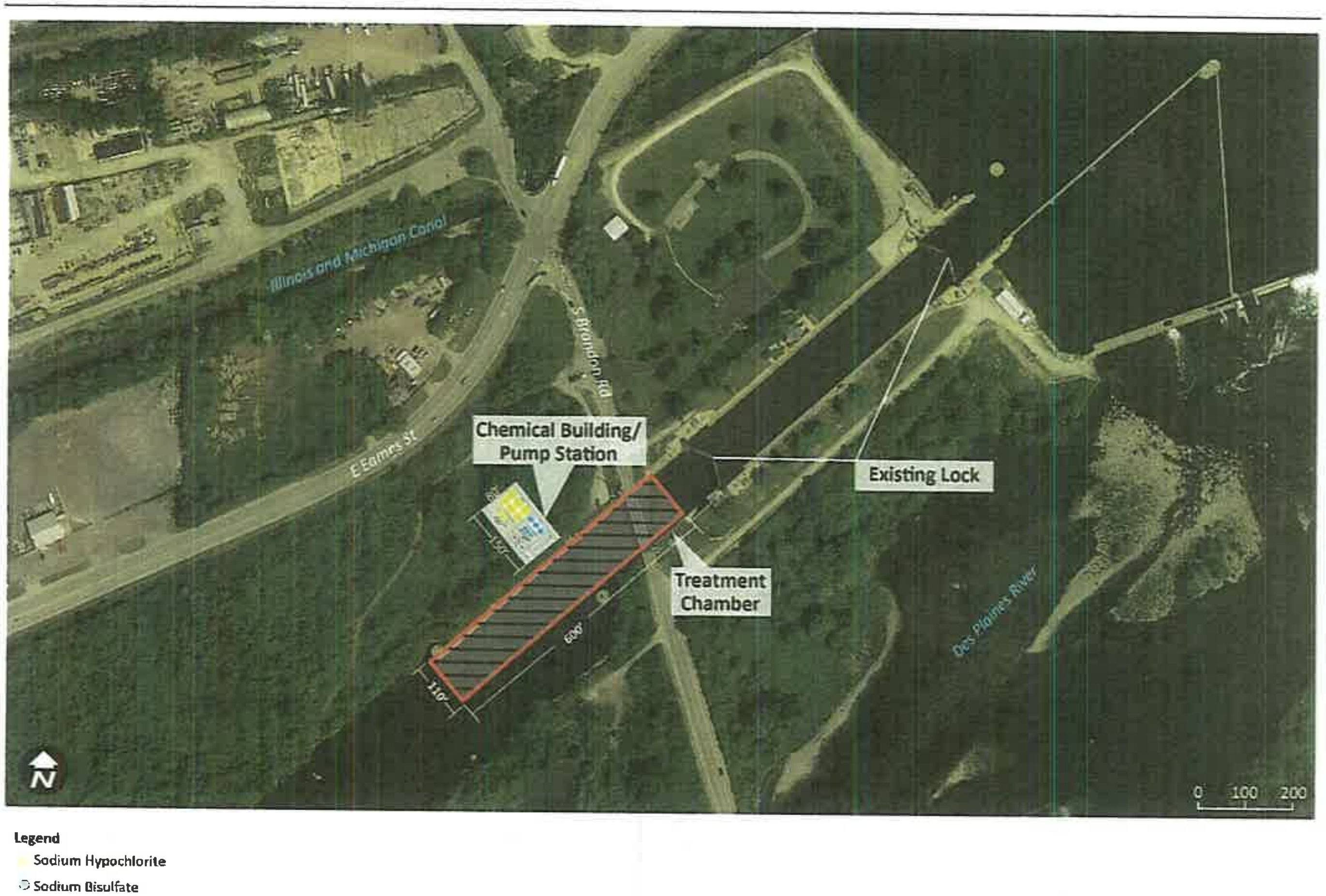

Figure 2. Conceptual Site Plan

The second premise is that gates in the approach channel would create an isolated treatment chamber from the rest of the river. The treatment chamber would include chemical feed and pumped mixing systems. The treatment chamber is assumed to be of the same size and orientation as the Brandon Road Lock, although other configurations could be used. It is intended that the conceptual design could be applied within the treatment chamber. As an alternative, the treatment system could be applied to the lock itself with modifications.

The conceptual design assumes the use of chlorine as a toxicant for AIS, based upon prior technology screenings (USGS 2015). The USGS identified chlorine in part because of its' ability to be a toxicant for the full range of AIS taxa and life stages. Chlorine is also commonly used for water treatment and is readily neutralized with sodium bisulfite to meet toxicity restrictions prior to release to a waterway. While the use of chlorine gas is advantageous from a unit cost perspective, chlorine gas poses significant storage and exposure risks. For these reasons, the chlorine dose is assumed to be from sodium hypochlorite solution rather than chlorine gas. Chlorine in the form of sodium hypochlorite solution offers the benefit of being a commonly used chemical for water treatment making both the design and regulation of the chemical commonplace. For example, sodium hypochlorite is used for wastewater disinfection at the Metropolitan Water Reclamation District of Greater Chicago's Calumet Water Reclamation Plant (WRP) located upstream of the Brandon Road Lock on the CAWS. The analysis in this report indicates the sodium hypochlorite chemical facility at the Calumet WRP is comparable in size to that envisioned in this report. The use of sodium hypochlorite solution for AIS control is a modified use to this commonly used water industry chemical.

The sodium hypochlorite solution would be dosed into feed pipes and then mixed in the treatment chamber. After achieving the required chlorine contact time, residual chlorine would be neutralized with sodium bisulfite. Figure 3 shows the process flow diagram for the treatment techniques envisioned.

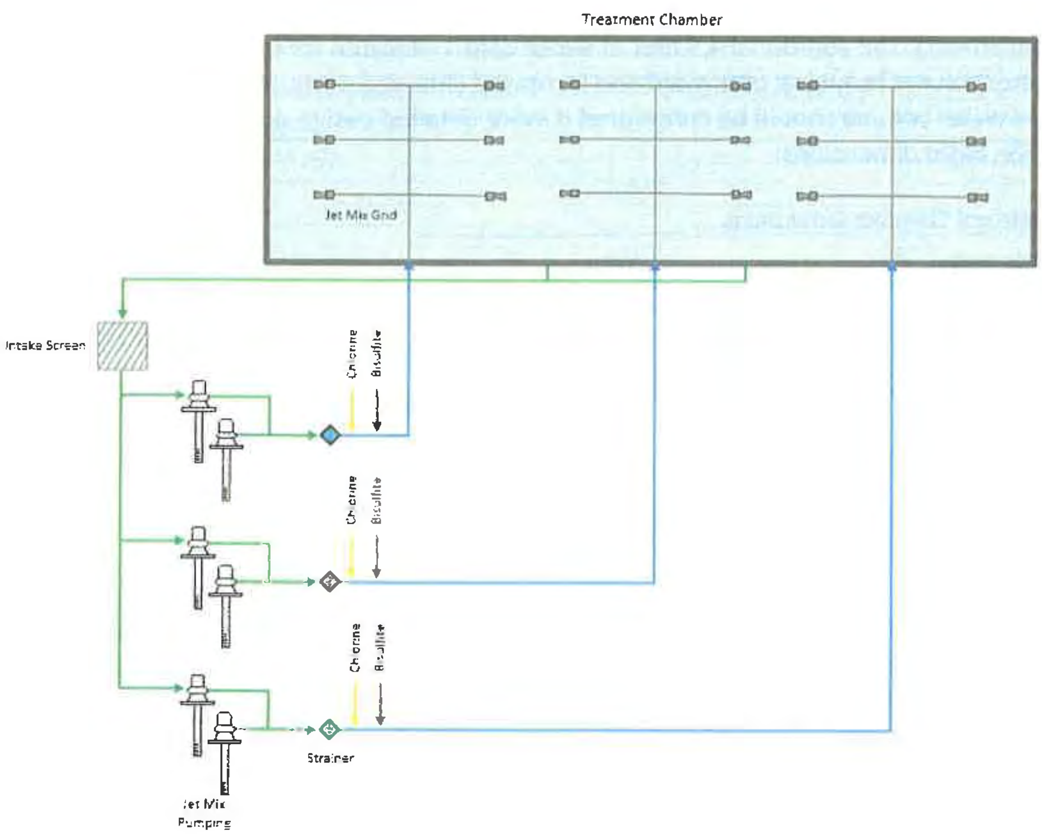

Figure 3. Process Flow Diagram

The assumptions utilized to develop the conceptual design are as follows:

1. The conceptual design focuses solely on the chemical feed systems, mixing systems, and ancillary equipment. The treatment chamber and fish deterrent methods were not included in the conceptual design.
2. The approach channel was sized to provide a navigational channel of the same dimensions as the existing lock system. The required navigational dimensions are assumed to be a depth of 9 feet, a width of 110 feet, and a length of 600 feet. Actual channel depth for mixing equipment is deeper, as later described.
3. A final free chlorine concentration of 10 milligrams per liter (mg/L) is consistent with the range of doses found to be effective with a contact time of 30 minutes or less (USGS 2015). This report recommends verifying chlorine concentration for AIS control as further described below (see section Areas for Evaluation to Support Detailed Design).

Treatment Chamber

The treatment chamber is assumed to be a similar configuration as the existing lock, with gates on the upstream and downstream side of the chamber to create an isolated treatment chamber. Upon completion of the treatment process, the upstream gates would open and the watercraft would leave the treated water to proceed to the lock. Discharge from the lock would bypass the treatment chamber and would need to be designed to prevent AIS from moving upstream through the lock discharge pipe.

The surface dimensions of the treatment system are assumed to be the same as the lock (110 by 600 feet). The depth of the treatment chamber will be greater than the required navigational depth to account for the vertical spacing requirements of the proposed mixing system (discussed later). The overall depth of the treatment chamber was assumed to be 13.5 feet (9-foot navigation depth + 4.5 feet for mixing equipment). The additional 4.5 feet of water depth allocated for equipment results in additional water volume requiring treatment and increased chemical costs. Approaches to minimizing this additional water volume should be considered if more detailed design occurs in the future. Table 1 summarizes the basin dimensions.

Table 1. Treatment Chamber Dimensions

Dimension	Value
Length (feet)	600
Width (feet)	110
Navigable Depth (feet)	9
Total Depth (feet)	13.5
Volume, cubic feet (million gallons)	891,000 (6.67)

In 2014, commercial lockages at the Brandon Road Lock accounted for 91 percent (3,080 out of 3,384) of the total lockages (USACE 2015). The remaining 9 percent of the lockages accounted for non-commercial and recreational users. For the 9 percent, treatment of the entire treatment chamber volume will generally be unnecessary. If full scale implementation occurs, evaluation of a smaller side stream treatment process or isolation of a portion of the treatment chamber should be evaluated, which, for smaller watercraft, could reduce the cost of chemicals required for each treatment. Being able to isolate a portion of the treatment chamber with a third gate to treat a smaller volume for smaller watercraft would result in chemical cost savings.

Chemical Dosage

Previous studies by the USGS and TNC examined a variety of biocides on the effectiveness and practicality of implementation. Utilization of chlorination and dechlorination was identified as an effective and acceptable solution to be further evaluated for practicality.

The use of sodium hypochlorite solution is common throughout the water and wastewater industry as a disinfectant. This analysis assumes sodium hypochlorite solution stored as a typical 12.5 percent solution. Advantages and disadvantages of the use of sodium hypochlorite solution can be seen in Table 2.

Table 2. Advantages and Disadvantages of Sodium Hypochlorite Solution

Advantages	Disadvantages
• Low operational complexity • Sodium hypochlorite solution is widely used because of its availability, reliability, ease of handling, safety, and cost • Most typical choice for the application of chlorine use in water	• Sodium hypochlorite solution's degradation during storage, which requires higher dosing with age and potential need to replace the inventory every few months if unused • Building with heating in the winter and air conditioning in the summer recommended to minimize degradation rate of sodium hypochlorite solution and to prevent sodium bisulfite from freezing • Contributes to creation of disinfection byproducts particularly if free chlorine is used • Second chemical needed to control chlorine residual

Based on previous TNC and USGS studies, a final free chlorine residual of 10 mg/L dose was assumed for AIS treatment. In order to achieve a free chlorine concentration of 10 mg/L, additional dosing is required to overcome the natural chlorine demand from the waterway. Chlorine demand includes the chlorine that is used in the oxidation of organic matter and the chlorine that forms compounds (organic- or ammonia-based). Chlorine demand can vary seasonally with changes in organic matter present in the water. The chlorine added in excess of the natural demand is known as free chlorine, which is assumed to be the free chlorine required for AIS control in this analysis. Figure 4 is a graphical representation of the typical partitioning that occurs from an applied chlorine dose.

When chlorine is added, it will first react with reducing compounds such as NO_2^-, Fe^{2+}, Mn^{2+}, H_2S, and organic matter. After this initial demand is satisfied, chlorine will react with ammonia to form monochloramine (combined chlorine). As chlorine addition continues, monochloramine is destroyed forming dichloramine and eventually trichloramine. Continued addition of chlorine will result in the destruction of all of the chloramines, a condition called "breakpoint chlorination". Further addition of chlorine beyond the breakpoint will lead to free chlorine residual. Simultaneously, chlorine will also react with organic nitrogen forming orgnochloramine. Monochloramine has some disinfection properties, although it is not as effective as free chlorine for typical water disinfection uses.

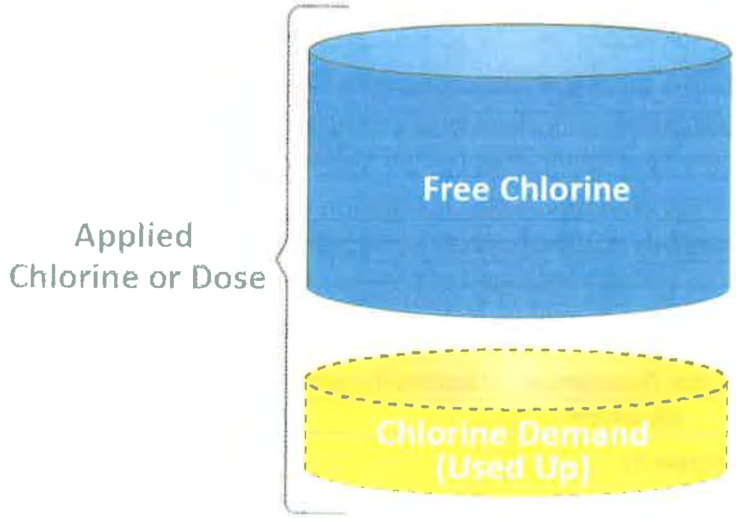

Figure 4. Chlorine Fate

Chlorine demand testing of the CAWS water was not part of this evaluation, but is recommended as further described below (see section Areas for Evaluation to Support Detailed Design). To estimate the chlorine demand, the internal database kept by CH2M's Applied Sciences Lab was referenced. Based on this database, a chlorine demand of 20 mg/L was identified as an initial estimate of the waterway's potential chlorine demand. As such, the final dose to achieve a residual chlorine concentration of 10 mg/L was estimated to be 30 mg/L. The treatment chamber would include real-time chlorine concentration sensors to test that the chlorine concentration has been met for the intended AIS exposure duration. If the chemical treatment concept moves into a more detailed design phase, it is recommended chlorine demand testing be done to understand the actual chlorine demand and how it varies during the year.

Following the required contact time, chlorine residuals must be reduced in adherence to Illinois Environmental Protection Agency (IEPA) guidelines for chlorine discharge into waterways. The level of total residual chlorine (TRC) that can be discharged into waterways is governed by Part 304 of Title 35 in the IEPA regulations. As identified in Section 304.222 "Intermittent Discharge of TRC," the TRC shall not exceed an average of 0.2 mg/L throughout the period, or a onetime exceedance of on 0.5 mg/L. To meet the chlorine neutralization goal and IEPA discharge requirement, sodium bisulfite is used to neutralize chlorine. The sodium bisulfite system was sized assuming neutralization of 10 mg/L residual chlorine to meet IEPA chlorine discharge requirements. The required sodium bisulfite dose to neutralize residual free chlorine typically falls between 1.5 to 1.7 milligrams (mg) sodium bisulfite per mg of free chlorine. Without bench testing, a ratio 1.7 was assumed as a conservative approach for the conceptual design. This number should be verified through testing of the CAWS water should more detailed design proceed. The real-time chlorine concentration sensors would also be used to verify chlorine neutralization had occurred. Table 3 summarizes the chemical dosing requirements.

~WAYS

'able 3. Chemical Feed Summary

Parameter	Sodium Hypochlorite Solution	Sodium Bisulfite Solution
mical Dose (mg/L)	30 (20 chloride demand, 10 residual)	17
Concentration	12.5 percent	40 percent
Lock Volume (million gallons)	6.67	6.67
Required Chemical (Gallons per Lockage)	1,600	300

Chemicals would be dosed into the mixing system at multiple points throughout the mixing chamber to promote even distribution of chemicals and to reduce initial mixing requirements.

Chemical Volume

In 2014, the Brandon Road Lock averaged approximately 9.3 locks per day (USACE 2015). To account for increased traffic and provide a factor of safety, the chemical systems were assumed to require 11 lockages per day. 11 lockages per day assumes that vessels traveling both upstream and downstream will require treatment. Under the right conditions fewer treatments may be needed, for example, if a vessel headed downstream uses the lock after a vessel has moved through heading upstream, the treatment chamber could continue to hold water that has been treated. These assumptions result in a conservative estimate of the number of treatments that may occur and the resulting chemical volume requirements.

Applying the proposed treatment chamber volume of 6.67 million gallons and required chemical dosing, the chemical use per lock fill can be estimated. In the water and wastewater industry, which regularly uses these chemicals, storage volumes range from 10 to 30 days, depending on chemical and application. For this application, a minimum 10-day storage volume was assumed to provide sufficient storage of chemicals, without providing excessive storage for low use periods. Table 4 summarizes the estimated chemical use and storage requirements for the treatment system.

Table 4. Chemical Volume Sizing

Parameter	Sodium Hypochlorite Solution	Sodium Bisulfite Solution
Chemical Dose (mg/L)	30 (20 chlorine demand, 10 residual)	17
Concentration (Delivered)	12.5 percent	40 percent
Lock Volume (million gallons)	6.67	6.67
Required Chemical (gallons per lockage)	1,600	300
Design Lockages per Day	11	11
Required Chemical (gallons per day)	17,600	2,500
10 Day Storage Minimum Provided (gallons)	200,000	30,000

Under flood or high water conditions, if barge traffic still occurs, the tailwater depth at the Brandon Road Lock would be deeper and could result in additional treatment volume. The chemical dosage would need to be modified for the larger treatment volume during a flood. Addressing flood conditions should be considered in more detailed design, but would result in proportionally larger chemical volumes for each treatment compared to the volume assumed in this conceptual design.

Chemical Storage and Delivery

Storage of bulk sodium hypochlorite solution and sodium bisulfite in Midwestern climates is typically accomplished through an enclosed building envelope to prevent freezing of bulk solution. Additionally, sodium hypochlorite solution can break down over time, with the active concentration decreasing over time. During warmer temperatures, the rate of chemical breakdown is substantially increased. In this conceptual design, the chemical storage facilities assume a climate-controlled building envelope to control temperature and increase storage life. The building envelop has the added benefit of increasing security of the bulk chemicals by providing a physical barrier from the public. Moreover, the chemical building will help to mitigate risks associated with a chemical tank leak.

A bulk delivery of 12.5 percent sodium hypochlorite solution by weight using a semi-truck is estimated to be between 4,165 and 4,459 gallons. Similarly, a sodium bisulfite solution bulk delivery of 38 to 40 percent sodium bisulfite using a semi-truck is estimated to be between 3,980 and 4,150 gallons. Given the large volume of anticipated use, bulk delivery is anticipated to be the most suitable delivery method.

Assuming average chemical use, it is anticipated the treatment system would require between 28 and 30 deliveries of sodium hypochlorite solution and between 4 to 5 deliveries of sodium bisulfite solution per week (average of 9 lockages per day for a week). The number of weekly deliveries of sodium bisulfite solution falls within the normal range experienced by larger water and wastewater treatment facilities that often use these chemicals. Conversely, the anticipated deliveries of chlorine are more frequent than what most facilities choose to receive. With chlorine use of this magnitude, implementation of onsite generation or the use of chlorine gas is often employed because it usually results in cost savings. However, for analysis purposes, it is assumed sodium hypochlorite solution will be delivered by semi-truck to the facility. An evaluation to determine if onsite sodium hypochlorite generation is cost effective is recommended as further described below (see section Areas for Evaluation to Support Detailed Design).

Mixing

Attaining a completely mixed treatment basin is an essential step to realize the target free chlorine concentration throughout the treatment chamber. Bringing a volume of this size to a completely mixed condition requires an efficient dissemination and mixing system. The evaluation considered mixing times of 5 minutes and 15 minutes. As part of this conceptual design, two competing mixing technologies were evaluated. The technologies evaluated include mechanical mixing and jet mixing.

Mechanical Mixers

The mechanical mixers analyzed for this application were manufactured by PAX Water Technologies Active Tank Mixer. Figure 5 includes a photograph of the mixer. The PAX mixer was chosen because of its compact design and perceived increased resiliency to interruption by debris. Conventional submerged mixers utilize large propellers that force water through a propeller to induce mixing. Conventional submerged mixers would have the propensity to be impacted by debris in the water if large enough debris were to be pulled into the mixer.

Figure 5. PAX Active Tank Mixer

PAX mixers are typically utilized in drinking water storage tanks because the compact design provides efficient mixing while occupying limited space. The compact mixing head spins at a sufficiently high velocity to create turbulence in the water. In large tanks attempting to achieve rapid complete mix, it is desired that the vortexes created by each mixer overlap. In a typical drinking water storage tank, one to two mixers would be used. In the conceptual design, the use of six mixers was considered. Chemical feed occurs at the propeller to promote rapid diffusion of feed chemicals. Table 5 lists advantages and disadvantages associated with PAX mixers.

Table 5. Advantages and Disadvantages of PAX Mixers

Advantages	Disadvantages
• Compact design • Easily maintained • No pumping requirements • Minimal impact of debris • Complete mix of tank including below mixer	• No applications in untreated water with potential debris • Unproven rapid mix performance • Submerged moving parts

Jet Mixing System

The second type of mixing system evaluated was a jet mix system. Jet mix systems involve internal recycle pumping of the treatment chamber contents to create a completely mixed system. Flow is dispersed through small-diameter nozzles that discharge high-velocity water. The high-velocity discharge creates turbulence and promotes mixing. The jet mixing nozzle is estimated to require 4.5 feet of water depth. As a result, total water depth is estimated as 9 feet for navigational depth plus 4.5 feet for equipment for a total treatment chamber depth of 13.5 feet. This additional depth results in more water volume requiring treatment and increased chemical costs. Approaches to minimizing this additional water volume should be considered if more detailed design occurs in the future. Figure 6 shows a diagram of the jet mix nozzles.

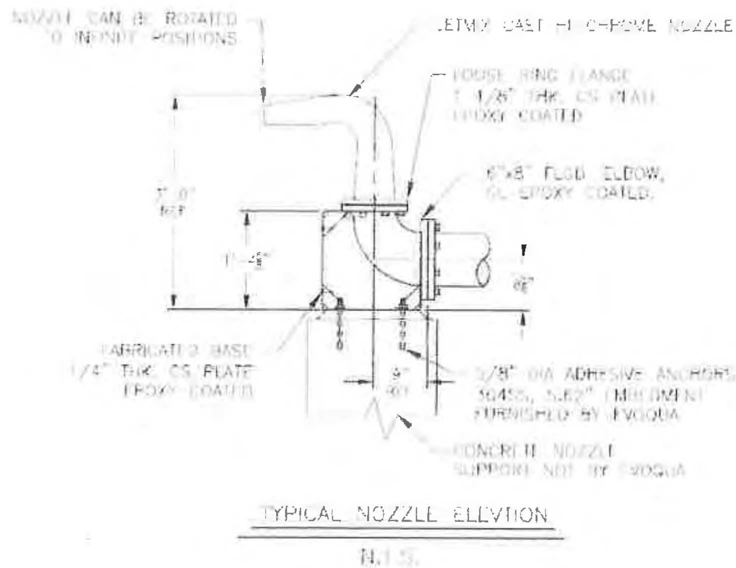

Figure 6. Jet Mixing Nozzle by Evoqua Technologies

A jet mix system includes high flow pumps (submersible or dry pit), piping, pump intake protection, jet mix nozzles, and ancillary equipment. In a jet mix system, chemicals are fed into the piping following the pump to increase the mixing efficiency. Due to the high concentrations of chemicals proposed in this conceptual design, the piping, pumps, and related appurtenances in contact with the process water will need to be constructed of chemically-resistant materials.

Two jet mixing system layouts were evaluated. Figure 7 presents a base grid layout with a jet mixing grid placed on the base of the chamber. This option utilizes 18 jet mixing nozzles and 3, 125-horsepower (HP) pumps. Figure 8 presents a perimeter option with all piping and nozzles located around the perimeter of the basin. This option utilizes 4, 125-HP pumps and 16 jet mix nozzles. The requirement of 125-HP pumps is based on achieving mixing in 15 minutes. If 5 minute mixing is desired; the preliminary size of the respective pumps would be increased to 175 HP. It is important to note that for the overall treatment time needed, chemical contact time starts after mixing has been completed.

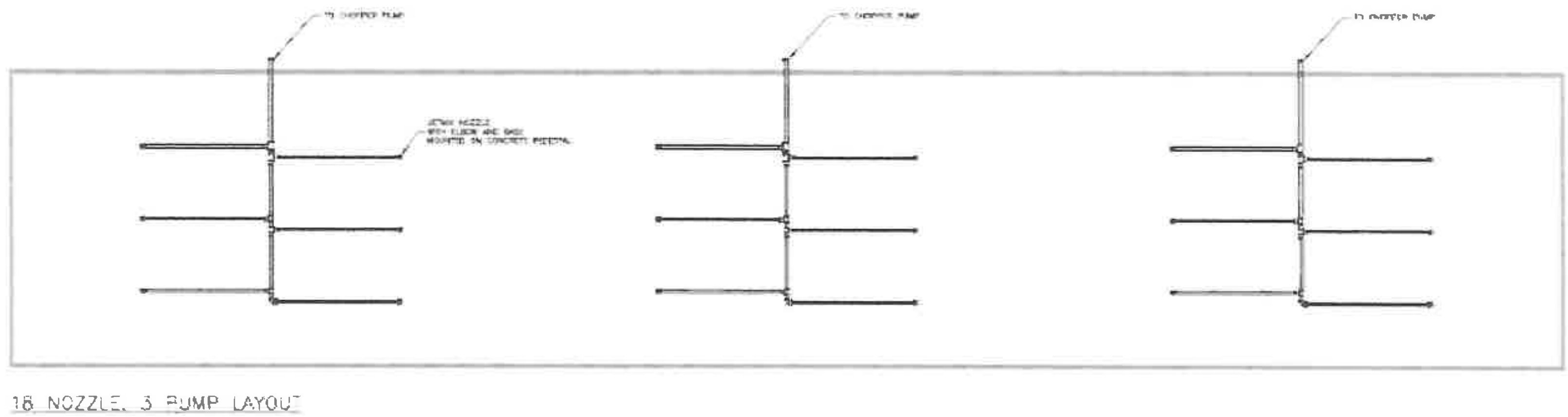

Figure 7. Jet Mix System Base Grid Layout

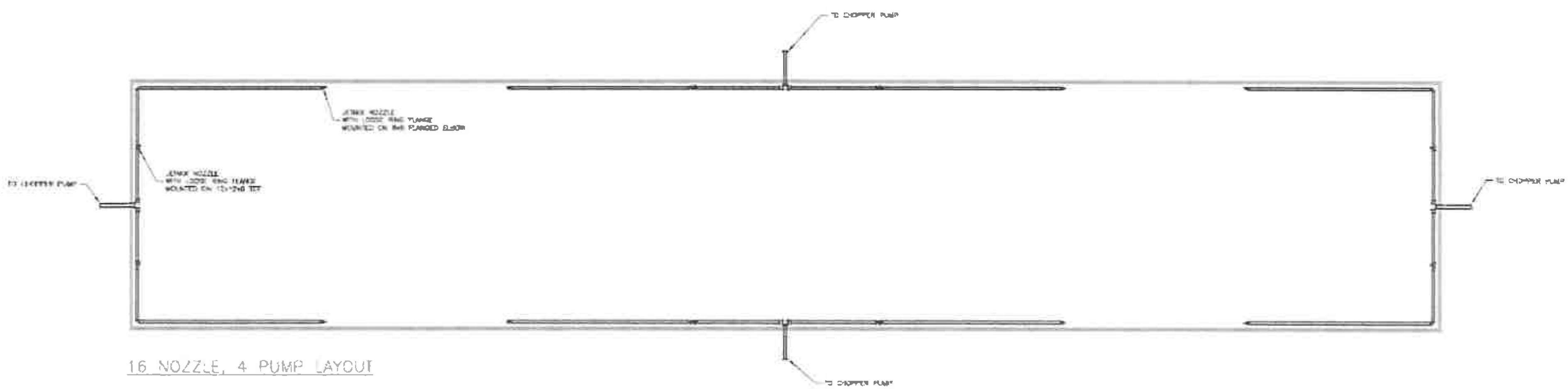

Figure 8. Jet Mix System Perimeter Layout

While the perimeter layout presented in Figure 8 restrains the piping to the exterior of the basin, it requires piping and mixing nozzles to be located at the entrance and exit of the treatment chamber, which could potentially interfere with isolation gate operation. Additionally, preliminary analysis by the manufacturer suggests that the base grid layout presented in Figure 7 provides the most efficient mixing of the two options, while representing a lower cost alternative. Table 6 provides advantages and disadvantages of a jet mix system.

Table 6. Jet Mixing Advantages and Disadvantages

Advantages	Disadvantages
• Efficient mixing • No submerged moving parts • Proven technology	• Energy intensive • Pump screens require maintenance to remove debris

The conceptual design assumes the jet mix grid layout. The system requires pumps which will have an intake screen and traveling band to remove debris accumulation on the intake screen. With fish deterrents upstream and downstream of the treatment chamber, this will help to minimize the need for dead fish removal. Should other debris enter the treatment chamber and need to be removed, it could be removed with similar techniques to those used to manage debris in the lock.

Cycle Time

To minimize impact on lock operations, the overall additional cycle time was evaluated. The overall cycle time is a function of the time to create a completely mixed system, the contact time required for AIS control, and the chlorine neutralization time. There will also be additional time to maneuver a barge tow before and after the chemical treatment that is not included in the durations listed below. Rapid mixing times can be achieved, but are limited by the practicality of the equipment required to achieve such mixing times. In this evaluation, mixing times of 5 and 15 minutes were assumed. These are high flow rates and should be analyzed with hydraulic modeling to verify the flow rate and mixing configuration does not create unwanted waves or jets within the treatment chamber.

Chlorine contact times and dechlorination times are typically determined through bench testing. With bench testing information unavailable for this evaluation, it was assumed that the required chlorine contact time was 15 to 30 minutes (USGS 2015) and dechlorination was assumed to be the same as the mixing time (5 or 15 minutes). Testing is required to determine the durations and the chemical concentrations needed to achieve these times before proceeding with additional detailed design. Table 7 represents the range of anticipated cycle times and associated modifications to the jet mixing system.

Note that mixing must occur before chemical contact time begins for sodium hypochlorite solution, however the sodium bisulfite solution reaction to neutralize residual chlorine occurs quickly such that additional contact time may not be required. This assumption should be verified through testing prior to implementing a detailed design. This and other mixing recommendations are further described below (see section Areas for Evaluation to Support Detailed Design).

While chemical contact time requirements are fixed and covered by chemistry and AIS response, other measures could be implemented to promote travel efficiency by reducing the overall time it takes to enter the treatment chamber, complete the treatment process, and then depart the treatment chamber. Such measures could include: larger pumps to reduce mixing time, a longer treatment chamber to reduce breaking up tows, parallel chambers to accommodate more traffic, or treatment in the lock itself to reduce time to tie up, release, and move vessels. It should be noted that the AIS treatment chamber concept would not impact all vessels. Vessels moving from downstream to upstream would require treatment. However, vessels moving from upstream to downstream would not require treatment if the prior lockage was from downstream to upstream. While the overall sequencing and durations of all these procedures are beyond the scope of this conceptual design, they will be important to quantify and understand the overall time impacts to vessels.

Table 7. Cycle Times

Mixing Time	15 minutes	5 minutes	15 minutes	5 minutes
Contact Time	**30 minutes**	**30 minutes**	**15 minutes**	**15 minutes**
Mixing Time (minutes)	15	5	15	5
Pump Size (HP)	125	175	125	175
Chlorine Contact Time (minutes)	30	30	15	15
Mixing and Dechlorination Time (minutes)	15	5	15	5
Total Treatment Time (minutes)	**60**	**40**	**45**	**25**

Opinion of Probable Cost

The CH2M Parametric Cost Estimating System (CPES) was used for estimating the costs of the improvements associated with the conceptual chemical facility design. The focus of this report is on the chemical facility conceptual sizing and configuration. Consequently, the cost opinion does not include the treatment chamber or supporting road improvements to access the chemical facility. Other key cost assumptions are listed below.

CPES is a proprietary conceptual design and cost estimating tool that generates quick, accurate, and detailed cost estimates at the conceptual stage of water treatment projects. CPES is based on general arrangement drawings derived from real projects. Using project-specific design criteria and selected performance parameters, CPES will generate facility layouts and quantities. These quantities are used to prepare a detailed construction cost estimate. Compared with traditional conceptual estimating techniques, CPES yields an accurate definition of facility layout and cost during the conceptual and preliminary design stages of a project. Opinions of probable cost generated from CPES are considered to be consistent with Class 5 estimates as defined by the Association for Advancement of Cost Engineering (AACE).

The opinion of probable cost was prepared on the basis of information available at the time of the project to guide in comparing alternatives. As detailed engineering design has not been done, the final opinion of probable cost of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs will vary from the estimates presented here. In agreement with AACE Class 5, conceptual level opinions of probable cost can vary by as much as +100/-50 percent. The components included in the opinion of probable cost for the conceptual treatment building and process included the following:

1. Sodium hypochlorite solution and sodium bisulfite solution feed systems
2. Jet mixing system
3. Pumping station, including traveling band screens
4. Strainers to protect jet mix nozzles on pump discharges
5. Operations room
6. Onsite generator

The assumptions used to guide the opinion of probable cost for the conceptual design were as follows:

1. The opinion of probable cost was completed in 2016 dollars.
2. The opinion of probable cost includes construction cost, contractor mobilization, insurance, and overhead (further described in the following subsections).
3. Sodium hypochlorite solution and sodium bisulfite solution were contained in a common climate-controlled chemical building.
4. Chemical tank sizing and mixing design corresponded to the previously described conceptual design.
5. The chemical building was constructed of masonry with a standard foundation that does not require piles.
6. Chemical containment for each chemical was accomplished in depressed below grade concrete chemical containment tanks to support spill prevention control and countermeasure (SPCC) requirements.
7. Mixing pumps draw water from a wet well adjacent to the treatment chamber.
8. Power to the mixing system is fed from the proposed chemical building.
9. Backup power is provided to operate chemical feed systems and mixing equipment, along with required building components.
10. Land cost was not included in this evaluation.
11. Road access, driveway, parking areas, and other site preparation are not included in this evaluation.

In addition to the previously stated assumptions, additional markups are applied to cover assorted project-related costs that are not directly accounted for in conceptual estimates. Such costs include contractor overhead costs, additional construction costs, and non-construction related costs. The specific adjustments for each category are described in more detail in the following tables. The markups applied to the facilities in the CPES cost estimates are presented in Table 8.

Table 8. Markups in CPES Cost Estimates

Item	Value (percent)
Overhead	10
Profit	5
Mobilization/Bond/Insurance	5
Contingency	30

The additional project costs applied to the facilities in the CPES cost estimates are presented in Table 9.

Table 9. Additional Project Costs in CPES Cost Estimates

Item	Value (percent)
Overall Site Work	10
Plant Computer System	10
Yard Electrical	10
Yard Piping	5

The non-construction cost markups applied to the facilities in the CPES cost estimates are presented in Table 10.

Table 10. Non-Construction Cost Markups in CPES Cost Estimates

Item	Value (percent)
Permitting	5
Engineering	12
Services During Construction/CM/Inspection/Startup	8
Legal/Admin	7.5

A conceptual design of the chemical building layout can be seen in Figure 9. Security and isolation of the chemicals is provided by having the chemical tanks within the building. The chemical building includes a designated sodium hypochlorite solution room; designated sodium bisulfite solution room; control room; electrical/heating, ventilation, and air conditioning room; and a restroom. The need for other rooms within the building should consider how staffing of the overall chemical facility and lock might occur. For example, if jointly staffed with other lock operations, then no additional facilities may be required. If staffed separately, a break room could be added to the chemical building at nominal cost. Overhead door access was provided to each chemical area. The chemical feed systems consist of the equipment presented in Table 11.

Table 11. Chemical System Sizing

Equipment	Sodium Hypochlorite Solution	Sodium Bisulfite Solution
Chemical Tank Material	Plastic-lined steel	Plastic-lined steel
Bulk Tank Quantity	6	3
Bulk Tank Size (gallons)	42,000	12,700
Day Tank Quantity	3	3
Day Tank Size (gallons)	6,000	1,300
Chemical Transfer Pumps Quantity	3	3
Chemical Metering Pumps Quantity	6 total (3 standby)	6 total (3 standby)

Design details of the jet mix system and intake pumping system used in the opinion of probable cost can be seen in Table 12.

Table 12. Mixing System Sizing

Equipment	Value
Mixing Time (minutes)	15
Pump Type	Vertical turbine
Pump Quantity	6 total (3 standby)
Pump Size (HP)	125
Pump Flow (gallons per minute)	5,500
Pump Strainers Quantity	3
Jet-Mix Nozzles Quantity	18
Intake Screen Style	Traveling band screen
Intake Screen Width (feet)	2

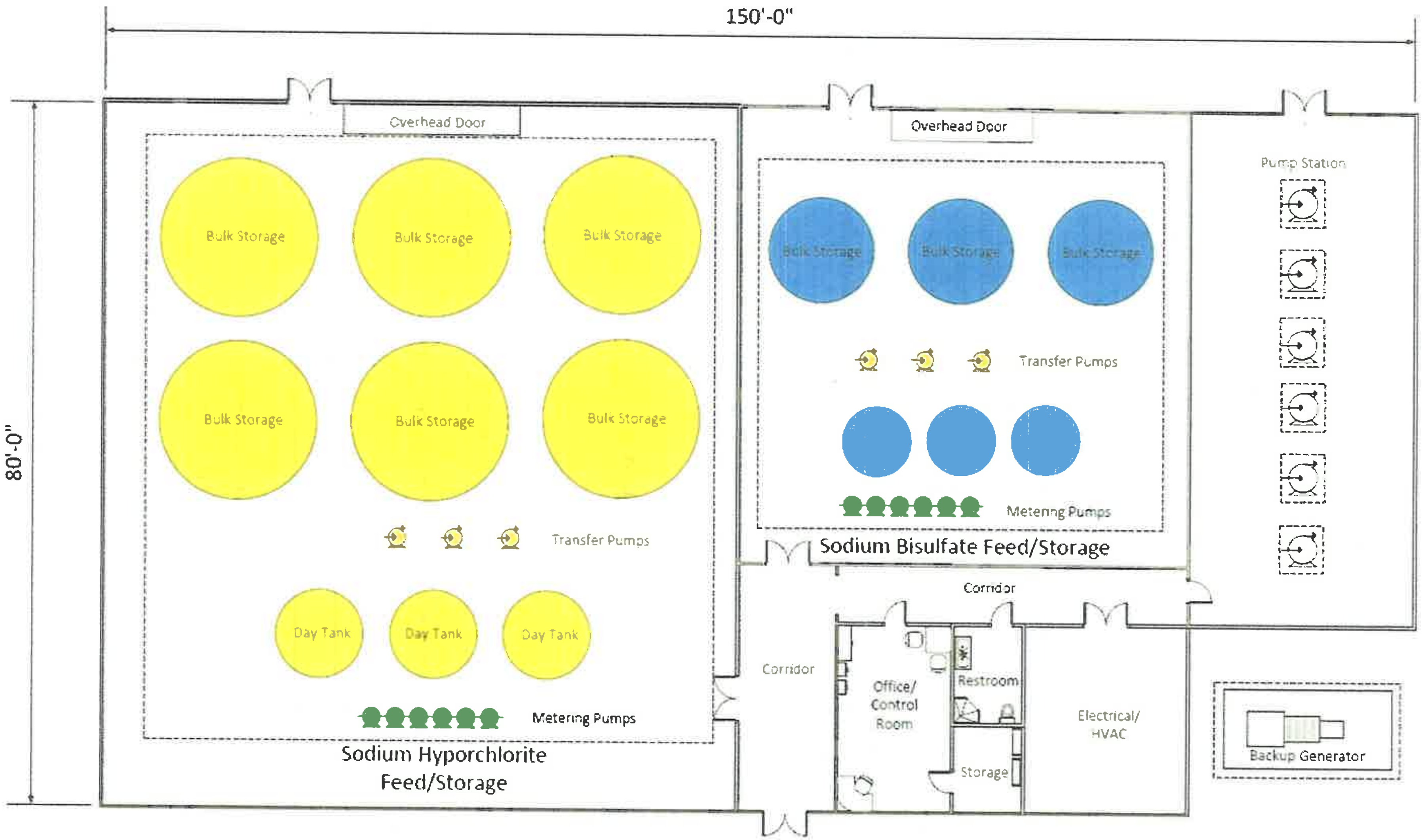

Figure 9. Conceptual Chemical Building Layout

Table 13 represents the opinions of probable cost for the conceptual design conditions and additional project costs previously described.

Table 13. Opinions of Probable Cost

Component	Construction Costs	Non-construction Costs	Total
General Building Components	$3,700,000	$1,200,000	$4,900,000
Sodium Hypochlorite Solution Facility	$10,000,000	$3,300,000	$13,300,000
Sodium Bisulfite Solution Facility	$3,200,000	$1,000,000	$4,200,000
Jet Mix System and Intake Screening	$12,900,000	$4,200,000	$17,100,000
Emergency Generator	$1,400,000	$500,000	$1,900,000
Total	**$31,200,000**	**$10,200,000**	**$41,400,000**

Note: Non-construction costs include items such as permitting, engineering, legal, administrative, construction inspection, and other related costs.

Recognizing that uncertainty exists in the mixing system sizing and chemical demand requirements, it is important to understand cost sensitivity of the two major components (mixing systems and chemical feed systems). Table 14 represents an opinion of the additional chemical system cost if the chlorine demand were increased from 20 mg/L to 30 mg/L (total dose 40 mg/L) and the additional mixing system cost to speed up mixing time to 5 minutes from 15 minutes. It is important to note that, while 5 minutes of mixing time appears technically feasible, the logistics of moving water at a velocity sufficient enough to provide the desired mixing with barges present in the treatment chamber requires further evaluation using a hydrodynamic model to verify mixing occurs without unintended consequences.

Table 14. Project Cost Adjustments

Item	Additional Total Cost
Increased Chlorine Demand (10 mg/L) for a Total Chlorine Dose of 40 mg/L	$4,100,000
Speed Up Mixing Time from 15 to 5 Minutes	$2,100,000

Operational Cost

The annual operating costs for the facility were estimated based on the number of lockages experienced in 2014 (USACE 2015). The expenditure per lockage was estimate in two scenarios. Scenario one assumes no displacement of water with vessels in the lock and is an estimate of high chemical usage. This type of lockage would be typical of a small vessel or if treatment were to occur without a vessel in the treatment chamber. Scenario two assumes displacement of water associated with six full barges and is an estimate of low chemical usage.

Table 15 shows the annual treatment operating costs. The cost of chemicals is assumed from historical data contained within CPES. Table 15 assumes that all lockages require treatment. Under the right circumstances, not all lockages may require treatment, such as when a vessel headed downstream goes through the lock after a vessel that was headed downstream when the treatment chamber continues to hold treated water. When fewer treatments are necessary, operational costs for chemical and energy usage would decrease.

Table 15. Treatment Costs, Consumables

Item	Scenario One: High Chemical Usage Estimate	Scenario Two: Low Chemical Usage Estimate
Number of Full Barges in Treatment Chamber	0	6
Volume Displaced by Barges (million gallons)	0	2.79
Volume to Treat/Mix	6.67	3.88
Chemical Costs		
Gallons Sodium Hypochlorite Solution per Lock	1,600	1,000
Gallons Sodium Bisulfite Solution per Lock	300	200
Sodium Hypochlorite Solution Cost ($/gallon)	$1.08	$1.08
Sodium Bisulfite Solution Cost ($/gallon)	$2.10	$2.10
Energy Costs		
Total Mixing Time (hours)	0.50	0.50
Mixing Energy (kilowatt hours/lock)	251	251
Electricity Cost ($/kilowatt hours[1])	$0.12	$0.12
Operating Costs		
Chemical Cost ($/lock)	$2,358	$1,500
Electricity Cost ($/lock)	$30	$30
Total Cost ($/lock)	$2,388	$1,530
Average Number of Lockages per Day (Year 2014)	9.3	9.3
Number of Lockages per Year (2014)	3,384	3,384
Annual Cost	**$8,100,000**	**$5,200,000**

[1]Does not include demand charges for high energy users.

Note: Chemical volumes are rounded to the nearest 100 gallons; annual cost rounded to the nearest $100,000.

In addition to the treatment operating costs, the facility will also have fixed annual costs associated with operations staff, maintenance, and building related costs (electricity and natural gas). Staffing assumes four personnel, the approximate equivalent of a staff person onsite 24/7/365. Staffing above these levels should first evaluate responsibilities and how normal work that is occurring at the lock system may integrate with the chemical facility operation. While staffing costs are not insignificant, they are a small percentage of the overall operating cost which is dominated by the cost of chemicals. These additional costs are identified in Table 16. Equipment maintenance was assumed to be 3 percent of capital costs annually and miscellaneous additional costs were assumed to be approximately another 1.5 percent of capital costs.

Table 16. Additional Annual Operational Costs

Item	Annual Cost
Annual Operations Staff[1]	\$400,000
Annual Building Cost, Energy[2]	\$40,000
Equipment Maintenance	\$220,000
Misc. Additional Costs	\$110,000
Total Additional Annual Operating Costs	**\$770,000**

[1]Assumes four full time equivalents at \$100,000 each.

[2]Does not include demand charges for high energy users.

Considering operating costs from Tables 15 and 16, this analysis shows a range of total operating costs of \$6,000,000 to \$8,900,000 per year, depending upon the amount of chemical needed for treatment.

Areas for Evaluation to Support Detailed Design

As part of further developing the conceptual design, several of the required assumptions about the treatment processes should be verified through bench scale or pilot scale testing to inform more detailed design or to answer additional questions raised by stakeholders as this AIS control concept is further developed. Evaluating the assumptions around chemical dosing and mixing are logical next steps for the design of a chemical facility of this size.

AIS Chemical Exposure Testing

The conceptual design assumed 10 mg/l chlorine dosage and 15 to 30 minute exposure times in the analysis (USGS 2015). Prior to more detailed design, testing is recommended to identify a relationship between chemical concentration and exposure time that focuses upon the short duration contact times needed to reduce time delay impacts to the shipping industry. Adult and juvenile testing should be considered with additional literature review for other potential species that may be of concern in the future. Because respiration levels can have a direct affect upon chemical toxicity, the testing should consider temperature variations to reflect seasonal fluctuations and AIS respiration differences between summer and winter temperatures.

Chemical Demand Testing

The CAWS water will consume chlorine before achieving the chlorine residual concentration that is lethal to AIS. This analysis assumed a range of potential chlorine demand. However, testing should be done prior to more detailed design to understand the chlorine demand of the actual waterway. A testing plan should consider known water quality data and include testing throughout the year to capture seasonal changes. During chlorine demand testing, byproduct formation could also be measured.

Chlorine is routinely used within the wastewater industry for the benefits of wastewater effluent and combined sewer overflow disinfection. While discharge of disinfection byproducts is not regulated for wastewater plants using chlorine for these disinfection purposes, questions have been raised regarding disinfection byproduct formation with the use of chlorine for AIS control. Regulation of disinfection byproducts exists within public drinking water systems. Since the application envisioned under this conceptual design is not a public drinking water system, and, like wastewater disinfection, would provide a protection of the environment, CH2M is not aware of a regulation governing disinfection byproduct formation for this application.

Chlorine treated water is currently discharged into the CAWS. There are large sodium hypochlorite facilities just upstream of the Brandon Road Lock on the CAWS, including for wastewater disinfection at the Metropolitan Water Reclamation District of Greater Chicago's Calumet Water Reclamation Plant (WRP). The analysis in this report indicates the sodium hypochlorite chemical facility at the Calumet WRP is comparable in size to that envisioned in this report at a Brandon Road Lock treatment chamber. Sodium hypochlorite use for wastewater disinfection protects the environment from undesirable bacteria and viruses in wastewater even though byproducts are generated. Similarly, sodium hypochlorite could protect the environment from AIS. None-the-less, there may be ways to reduce disinfection byproduct formation that could be evaluated further. The chemical demand testing could include evaluating disinfection byproduct formation under different doses in order to consider ways to minimize their formation, if required. The chemical dosage testing plan should be developed to gather information on how to reduce disinfection byproduct formation.

While work to further detailed design can continue to proceed using sodium hypochlorite as a known chemical, alternative chemicals could also be considered. Including alternative chemicals in the testing plan could evaluate their potential financial or environmental impact benefits.

Testing chlorine neutralization is also recommended to gather detailed information on how the sodium bisulfite solution performs in the CAWS water with the chlorine residual concentrations needed for AIS control. Gathering this information will provide the benefit of more accurately knowing the dosage required to realize the residual chlorine concentration needed.

Corrosion Control Strategy Development

The water in the treatment chamber will have increased potential for corrosion of metals as a result of the concentrations of chlorine and its reaction products. Thermal plastic materials, elastomers (natural and synthetic rubbers), and paint coatings are also likely to be oxidized at an increased rate by the chlorine. Sodium bisulfite solutions are expected to be less corrosive and oxidizing than chlorine solutions. Information on resistance to chlorine is generally available in the literature, but it may not be specific to the anticipated range of concentrations and exposure duration. If existing information is insufficient on this point, it is advisable to conduct tests to determine the increase in rate of corrosion or deterioration using ASTM standard methods.

Metals

Metallic materials of construction will likely include carbon steel lock gates and similar structural elements that require high strength and rigidity. Tug boats and barges are also made of carbon steel. With the exception of barges, most steel surfaces have protective coatings that are designed to protect against corrosion by water but not necessarily water with elevated concentrations of chlorine. Requirements for protective coatings with chloride resistance will need to be identified. Existing coatings on the USACE Brandon Road Lock gates will also need to be identified and reviewed for chlorine resistance to assess the potential effect of chorine concentrations and time of exposure. Considerations for ductile and gray cast iron are similar to those for carbon steel. Cathodic protection could be used in combination with coatings for optimal corrosion protection of exposed metals.

Certain metallic elements made of stainless steel and brass will also be at increased risk of corrosion due to chlorine. These metals may occur in proposed facilities, existing Corps facilities, and in tug boats and barges (e.g. shafts and propellers). Requirements will need to be identified for alloys to provide corrosion resistance to anticipated concentrations of chlorine.

The materials of construction for the chlorination and de-chlorination systems will also need to be reviewed for chemical resistance and requirements identified so that the intended design life can be achieved. Elements include pumps, piping, valves, controls, mixers, and similar items. Special pipe linings and more corrosion-resistant alloys for uncoated parts will probably be required to achieve the intended service life.

Nonmetals

Nonmetals include concrete, plastics, elastomers and protective coatings. Protective coatings are considered in the context of the metal surfaces to which they will be applied, as described above. Concrete is not considered subject to deterioration by chlorine or bisulfite except for the possible long-term risk to steel reinforcement to corrosion by accumulation of chloride ions in the concrete over time. It may be necessary or advisable to apply a protective coating on the concrete near the water surface in the treatment chamber for this reason.

Elastomers include flexible seals, membranes and similar items. Elastomers vary widely in resistance to chlorine. Although certain elastomers have better resistance to oxidation, they may not be available in the form required for the particular item, such as an O-ring. In such cases, it may be necessary to provide for frequent replacement of parts.

Chlorine Delivery versus Generation Onsite Evaluation

The chlorine required under the assumptions used in this conceptual design is substantial and requires multiple semi-truck loads to replenish the chemicals each day. The sodium hypochlorite solution used in the chemical analysis for this report is only 12.5 percent chlorine, meaning 87.5 percent of the chemical volume is water. This leads to expensive hauling costs for the chemical, the majority of which is water. For chemical usage at these quantities of sodium hypochlorite solution within the water and wastewater industry, it is not uncommon for this size of a facility to evaluate generating its own chlorine. A cost effectiveness evaluation study should be considered that would evaluate in greater detail the capital and operational costs of bulk chemical delivery compared to onsite chlorine generation. Other environmental considerations, including worker safety, should also be considered in such an evaluation.

Mixing System Performance

Key to reducing time delays in barge traffic with such an approach is mixing the chemicals within the treatment chamber and achieving a consistent concentration. Barge tows can tie-up in different configurations that will influence how effective the mixing is. To increase confidence that mixing will occur as intended under different configurations, a hydraulic model of the treatment chamber mixing should be considered as part of the detailed design process. One tool that is often used to understand complex hydraulic conditions is computational fluid dynamics (CFD) modeling. CFD modeling could evaluate varying geometry configurations and how mixing is influenced by these variations, such as full or empty barges, and different tie-up configurations. For these short mixing times of 5 to 15 minutes, CFD will also be important to understand how waves or jets could form within the treatment chamber and be considered in the design development. CFD analysis would be helpful particularly for maintaining a consistent chlorine concentration and also to achieve quick neutralization once disinfection is complete. Other considerations that should be considered in a mixing system performance evaluation include nozzle maintenance accessibility and redundancy should repairs be required.

Using mixers as fish deterrents could also be evaluated. Sequencing the start of mixing to drive out species or keep them from entering the treatment chamber could be considered. Mixing equipment will be required for any chemical solution and may be able to deter AIS from the entering the treatment chamber in the first place. Sequenced mixing would not take the place of chemical treatment, but could support its effectiveness.

Treatment Chamber Isolation Gate for Smaller Watercraft

The treatment chamber should be evaluated to see if a portion of the chamber can be isolated for smaller watercraft so that treatment of the entire chamber volume is not required. This would greatly reduce the chemical volume needed per treatment, and resulting chemical cost per treatment. To isolate a portion of the treatment chamber, a gate in a portion of the chamber that would only be used for smaller watercraft would be required. Depending upon the economics of the cost for an additional gate and the cost savings from reduced chemical usage, an isolation gate option could be beneficial.

Regulatory Pathway Evaluation

Moving forward with this approach to AIS control will trigger a number of regulations, but it is unclear what specific requirements there will be and what organizations would be involved. To have a clear understanding of organizations that would need to be involved and the information required to proceed with project implementation, a regulatory pathway evaluation should be considered. The evaluation could consider questions such as: would the environmental impacts of all three potential AIS control locations have to be considered to obtain regulatory approval for one location? What requirements would there be for using chemicals for AIS control and what would the timeframe likely be to obtain approval and complete the National Environmental Policy Act (NEPA) environmental review process? Such an effort would be a complex undertaking spanning multiple watersheds, local units of government, and potentially involve multiple states. Significant public interest in the project would be expected. As a result, having preliminary discussions on the regulatory pathways to operation could be beneficial to identify any significant items that should be considered in greater detail early on in the process.

Stakeholder Engagement Plan

With the significant public interest expected in such a project, communications with stakeholders and the public will be important. Developing a stakeholder engagement plan to keep interested parties informed and up-to-date on important project issues and evaluations will be important to inform project implementation. A stakeholder engagement plan that considers how to obtain public opinions of the project and that develops strategies to keep stakeholders informed should be developed if the project is considered in greater detail.

Other Considerations

CAWS stakeholders provided initial questions to TNC regarding this AIS control conceptual design approach. While the focus of the conceptual design was not to evaluate answers to these questions in-depth, initial opinions regarding the following questions are provided:

1. Are there any aspects of the design or operation of the gates that could affect the treatment process and should be considered in the final design?

   Discussion: The conceptual design approach has assumed a treatment chamber separate from the gate and locks (Figures 1 and 2). The treatment chamber would have gates to keep water within the treatment chamber during treatment. Gates would need to be designed of materials that can be in contact with the chemicals used in treatment and also be able to minimize leakage since the water would contain chlorine (or minimized leakage approved by IEPA). However, head differential between the CAWS and the treatment chamber is not expected to be significant, and, as a result, head differential that would drive leakage would be expected to be minimal. Should leakage occur, downstream areas could be monitored with sensors. Should leaks occur, they would be mixed with other water when the next barge tow moves through the system. Key to the gate operation concept will be allowing the barge traffic to move into or out of the lock system without introducing AIS into the lock (that is, not allowing untreated water to enter the lock). Configurations of the treatment chamber gate with the lock gate will have to consider these conditions in greater detail.

   The treatment chamber should also consider if a portion of the chamber can be isolated for smaller watercraft so that treatment of the entire chamber is not required. This would greatly reduce the chemical volume needed for treatment of smaller vessels. To isolate a portion of the treatment chamber, a gate in a portion of the chamber that would only be used for smaller watercraft would be required.

2. Are there configurations of the approach channel that could make the overall process more efficient or effective? One example: there is a tradeoff between the size of the channel and speed that a tow can move through it; however, a small chamber requires less chemical to treat, but also slows down vessels.

   Discussion: For conceptual design purposes, the treatment chamber has been assumed to be the same length and width as the Brandon Road Lock. The size of the channel is not anticipated to significantly influence the ability of mixing to occur or of chemicals to be added. There may be advantages of alternative treatment chamber geometries for barge movement purposes, which were not evaluated as part of this conceptual design for water treatment. If the water volume in the treatment chamber is greater than what has been assumed, larger tanks and chemical usage, as well as additional mixing, would be required.

3. The second premise assumes a "batch" process will be used. Is there a way to recycle the treated water to reduce the amount that needs to be dosed and detoxified?

   Discussion: Recycling the water when using chlorine appears unlikely due to the IEPA requirement for neutralizing chlorine before discharging to the environment. When the treatment chamber gates open, the chlorine neutralization requirements would need to be met. Pumping water out of the treatment chamber for later use does not appear practical, although ideas on this concept are welcomed. If other AIS control measures are considered within the treatment chamber, the potential to recycle the treated water should be reconsidered.

4. Would any efficiencies be achieved by using a continuously maintained "hot zone" that vessels would pass through for treatment? This would have to consider the difficulty of containing chemicals when vessels displace water as they enter and exit.

   Discussion: Maintaining a "hot zone" with chlorine appears unlikely due to the significant water movement and mixing that would occur from barge movement and propeller wash. The water movement would send water containing chemical outside of the treatment chamber. To meet IEPA chlorine discharge requirements, the chlorine would have to be first neutralized, making the ability to maintain a chemical "hot zone" unlikely.

   With the pumps and mixers that would be required in the treatment chamber, it may be possible to start the mixers before the gates are closed to encourage fish to seek calmer waters outside of the treatment chamber. Using mixing in part to support a "hot zone" could be evaluated further through testing to observe how fish or other AIS respond to rapid mixing and seek refuge to determine how this infrastructure already required for chemical mixing could be further utilized to deter AIS from the entering the treatment chamber. Mixing would not take the place of chemical treatment, but could support its effectiveness.

5. Are any measures available that would minimize the formation of disinfection byproducts?

   Discussion: Disinfection byproducts will form with the use of free chlorine. As stated earlier, chlorine is routinely used within the wastewater industry for the benefits of wastewater effluent and combined sewer overflow disinfection, and discharge of disinfection byproducts are not regulated for wastewater plants using chlorine for these disinfection purposes. Regulation of disinfection byproducts exists within public drinking water systems. Since the application envisioned under this conceptual design is not a public drinking water system, and, like wastewater disinfection, would provide a protection of the environment, CH2M is not aware of a regulation governing disinfection byproduct formation for this application.

None-the-less, there may be ways to reduce disinfection byproduct formation that could be evaluated further. The chemical demand testing could include evaluating disinfection byproduct formation under different doses in order to consider ways to minimize their formation, if required. For example, a common strategy to reduce disinfection byproduct formation is to utilize monochloramine as a disinfectant instead of free chlorine because free chlorine produces more disinfection byproducts than monochloramine. Monochloramine is a weaker disinfectant compared to free chlorine, so it is unclear how effective it would be upon AIS control. Determining the chlorine dose needed for AIS control in order to not add excessive amounts of chemical is a fundamental first step for testing. Testing could be used to better understand these and other potential strategies, their effectiveness upon AIS control, and relationship to disinfection byproduct formation.

Organics present in water lead to disinfection byproduct formation. A water treatment concept was considered using high flow rate treatment techniques for solids reduction as a way to consider removal potential for organics present in the water. Such treatment techniques use either filtration or settling. Treatment would likely only be able to treat a portion of the treatment chamber water within the mixing time and new water would be constantly entering the treatment chamber with barge movement and natural water flow. In addition, these treatment methods focus upon particulate removal and not dissolved organics removal. Consequently, while some solids reduction may be possible with a treatment process, removing dissolved organics appears unlikely to be practical or significant. As a result, significantly reducing disinfection byproduct formation through water treatment is not expected. The potential benefits of such a treatment approach were consequently not considered further.

As previously described, testing chlorine doses and alternative chemicals appears to be the most promising opportunity for reducing disinfection byproduct formation. Because this water is not in a public drinking water system and if disinfection byproducts in this setting are not regulated, extensive efforts to minimize disinfection byproduct formation may not be warranted in light of the risk posed by AIS.

6. Potential health and environmental impacts of chemical transport, storage, and use are a concern and should be evaluated. This includes the effects to barge crews as they traverse the locks and people that work at the lock, as well as to people and the environment in proximity to the lock. What are the health and environmental risks under normal operations, what is the risk of an uncontrolled or unplanned release of chlorine, and what type of safety features must be in place to prevent such releases of chlorine?

   Discussion: Choosing to use sodium hypochlorite solution instead of chlorine gas significantly reduces the potential risk to the environment and people. Sodium hypochlorite solution is envisioned to be delivered in semi-trucks to the site. There are standard procedures to minimize impacts for leaks and spills of liquid chemicals, including the use of secondary containment of the storage tanks, which has been included in this conceptual design. These and other industry standard procedures and practices reduce the risk of an uncontrolled or unplanned release of chlorine. Additional discussions on this topic are recommended to identify risks and mitigation measures should detailed design proceed. For all chemicals considered in greater detail, their regulatory requirements, storage regulations, reporting requirements, and training requirements should be documented and considered if detailed design progresses.

   By not using chlorine gas, the risk to people who work or are present in and around the treatment chamber is reduced. Evaluating the health and environmental impacts are beyond the scope of this Task Order. What to evaluate in order to more clearly understand the environmental and health risks, including potential downstream impacts, will need to be defined and evaluated in the future if this AIS control approach proceeds.

7. Are there likely to be impacts to vessels, the treatment chamber, or locks based on the concentrations and contact times used in this study? If higher concentrations had to be used, at what point would additional study be required to address possible impacts on vessels and the treatment chamber or locks?

   Discussion: It is considered very likely that the concentrations and contact times associated with chlorine and bisulfite will result in increased potential for corrosion of metals and oxidation of soft parts. Conditions can be expected to be more corrosive for any increased concentrations or durations of chemical exposure. The strategies and methods described in the Corrosion Control Strategy can be applied for alternative conditions that are investigated to identify impacts and mitigation methods.

8. The total impact on travel time of a vessel through the locking process should be evaluated.

   Discussion: The time needed for chemical mixing and chemical contact time has been evaluated and generally ranges from 30 to 60 minutes, as shown in Table 7. This does not include barge tow movement and positioning time in the treatment chamber. Additional evaluation is needed for the short mixing times to check that the hydraulics in the treatment chamber during mixing are acceptable and are considered in the treatment chamber design.

9. What other considerations are there, should this concept move forward towards implementation?

   Discussion: An important next step should this project concept move forward in greater detail, will be to identify the organizations and permits required to implement and to operate the project. The project envisioned in this conceptual design would involve many complexities, watersheds, and potentially multiple states. Future analysis would need to identify coordination requirements with the shipping industry, federal, state, and local agencies. These interests and requirements will be important for ultimately implementing a project.

   Another potential question that deserves additional investigation is understanding the water treatment operational requirements involved with the AIS control concept. That is, adding chemical and mixing, turning off chemical and mixing system, holding for the specified contact time, considering how to measure chemical residual during contact time to document that the target residual has been maintained, and understanding if intermittent chemical feed and mixing may be needed to maintain the target residual. Similarly for chemical neutralization, understanding when to initiate de-chlorination, checking that the target chlorine residual prior to discharge has been achieved, and other operational and testing processes to document that the system is functioning as intended. These water treatment operational details must also include the watercraft movement requirements as well as the watercraft coordination and communication practices that will be required with each lockage.

Summary and Conclusions

The use of sodium hypochlorite solution for AIS control within the assumptions used for this conceptual design appears technically feasible. Based upon available information, the chemical volume required is similar to volumes used at large drinking water or wastewater treatment plants, which have chemical facilities of similar size. Solutions exist for rapid mixing to quickly inject the chemical into the treatment chamber and thereby minimize delays for barge traffic traveling on the CAWS. Stakeholder feedback and additional testing can be used to understand questions and concerns that must be answered to verify the conceptual design acceptability with stakeholders and regulators before proceeding with detailed design.

The capital cost opinion of the chemical and mixing system is $41.4 million with the annual operating costs range between $6.0 million and $8.9 million. While the capital and operational costs are not insignificant and do not consider the approach channel cost, the alternative offers cost savings compared to some of the GLMRIS report alternatives since a physical separation between the Lake Michigan and Mississippi River basins is not envisioned with this alternative.

The cost of chemicals would make up the majority of the annual operational costs. If other alternative chemicals are considered, volume estimates of chemicals needed per lockage can be used to compare to the estimated capital and operational costs for the conceptual chlorine treatment approach listed in this report. This report can inform potential variations in chemical use, treatment volume needed, and other measures to compare similar alternatives if variations to this concept develop.

The chlorine addition will increase the corrosivity of the water in the treatment chamber. Potential corrosion impacts have been considered and recommendations for ways to further evaluate the potential impacts in greater detail are included. Recommendations for future evaluation, should this AIS control approach move forward in greater detail, include:

- AIS Chemical Exposure Testing
- Chemical Demand Testing
- Corrosion Control Strategy Development
- Chlorine Delivery versus Generation Onsite Evaluation
- Mixing System Performance Evaluation
- Treatment Chamber Isolation Gate Evaluation for Smaller Watercraft
- Regulatory Pathway Evaluation
- Stakeholder Engagement Plan Development

AIS control has garnered much public attention. This report provides additional information on a non-traditional AIS control approach. Consideration of this or similar alternatives could offer cost savings, while improving AIS control.

References

USACE. 2014. Great Lakes and Mississippi River Interbasin Study Report. January.

USACE. 2015. Brandon Road Lock & Dam. June.

USGS. 2015. Identify Potential Lock Treatment Options to Prevent Movement of Aquatic Invasive Species through the Chicago Areas Waterways System (CAWS). May.

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
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REPLY TO
ATTENTION OF:

Executive Office

21 JUN '17

Michael A. Reuter
Director, Nature Conservancy
P. O. Box 440400
St. Louis, Missouri 63144

Dear Director Reuter:

Thank you for the Aquatic Invasive Species (AIS) Lock Treatment System proposal that you submitted to the U.S. Army Corps of Engineers (USACE). We appreciate the hard work and efforts The Nature Conservancy (TNC) has put forth in research and development of AIS lock treatment technologies. Aquatic invasive species control is a shared responsibility and a continuing threat requiring an "all hands on deck" approach as the fight to prevent the transfer of AIS continues.

The Brandon Road Study team did consider AIS Lock Treatment as a measure in the current study but it was screened from consideration for immediate implementation. As the proposed AIS lock treatment process is conceptual, there is no working lock treatment process to demonstrate real world effectiveness. Information regarding real world effectiveness is vital, and would be necessary for further consideration and evaluation within the USACE planning process. Additional testing is also required to understand the impacts this proposed treatment process would have on the environment, water quality, lock and navigation infrastructure, and safety for lock personnel and mariners, among other things. Further, there is no demonstrated cost to operate and maintain a system as proposed, or what the potential navigation delays for treatment time and effectiveness would be. While continued research and development of a chemical lock treatment could result in a viable control method for AIS, substantial additional development, to include field testing and demonstration, would be needed in order to be considered for implementation. This work is beyond the scope, cost, and timeline of the Brandon Road Study.

It is essential that the collaborative partnership with TNC, federal and state partners continue, to include the research and development of control methods to prevent the transfer of AIS. We encourage the continuation of research and development of technologies to control the spread of AIS. Through the Water Operations Technical Support Program (WOTS) at the Engineer Research Development Center (ERDC), we requested technical review of your proposal. We will share their thoughts with you as soon as their results are available.

Thank you for your efforts to develop solutions to combat the spread of AIS. If you have any questions regarding the Brandon Road Study, please contact the Brandon Road Study Project Manager Andrew Leichty, (309) 794-6399 or via email at Andrew.l.leichty@usace.army.mil.

Sincerely,

Michael C. Wehr
Major General, U.S. Army
Division Engineer