LOWER MAUMEE RIVER RESTORATION DESIGN CONCEPTS

Table of Contents

PREPARED FOR:

MAAC

Ohio Environmental Protection Agency

PREPARED BY:

The University of Toledo

BGSU

HULL

FUNDED BY:

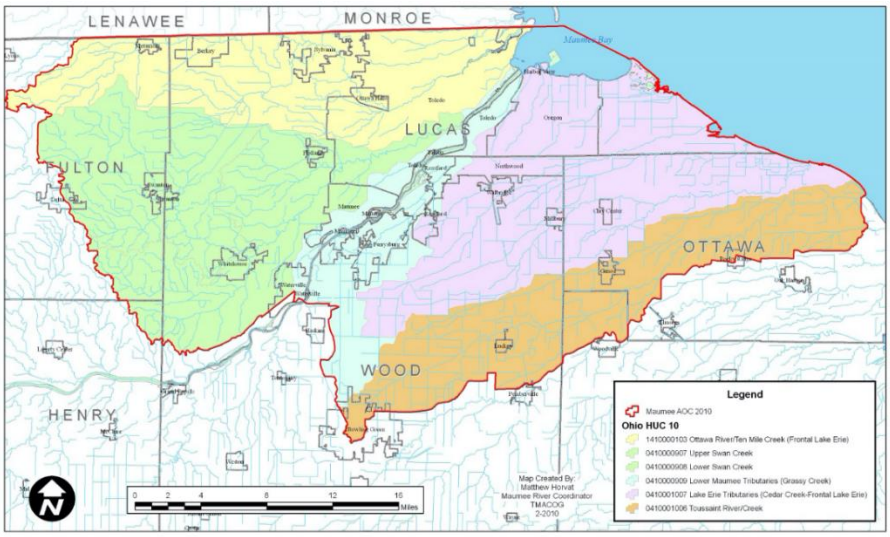
USGS science for a changing world

Great Lakes Restoration

March 2021

BACKGROUND

The Maumee River has the largest watershed of all the Laurentian Great Lakes tributaries and drains into western Lake Erie. The river is a vital resource for a variety of agricultural, industrial, and recreational uses in northwestern Ohio, and maintains biological value for a variety of aquatic organisms. Unfortunately, the lower Maumee River has undergone a variety of geologic, hydrologic, and biological changes since agricultural and industrial development began in the region in the 1800s. The region, which was once part of the "Great Black Swamp" on the western end of Lake Erie, has experienced extensive wetland habitat loss as a result of this development. The watershed is currently subject to excessive non-point source sediment and nutrient loads, among other anthropogenic forces that have led to aquatic habitat and biodiversity decline. As a result of these issues and other impairments, the downstream portion of the Maumee River and many surrounding waterways in the greater Toledo area were established as one of 43 Areas of Concern (AOC) in the U.S. and Canada in the 1987 Great Lakes Water Quality Agreement. Of the 14 beneficial use impairments (BUIs) defined for Great Lakes AOCs, the Maumee AOC, led by Ohio EPA and coordinated locally through the Maumee AOC Advisory Committee, is working through the process to restore water quality and habitat resources to delist nine BUIs.



Due to the extensive agricultural and urban development within and beyond the boundaries of the Maumee AOC, regeneration of the formerly expansive wetland network is prohibitive. Therefore, identifying main-channel fluvial habitats that support or could be enhanced to support river biota is essential to provide realistic and feasible recommendations for removing impairments to aquatic habitat and fish and invertebrate communities of the Maumee AOC. To accomplish this, during the summer of 2019, researchers from the University of Toledo (UT) and Bowling Green State University (BGSU) studied a stretch of the Lower Maumee River from Perrysburg (~river mile [RM] 15) downstream to I-75 (~RM 7) to identify potential in-channel projects to implement and address the BUIs in the Maumee AOC. This study reach contained several river island complexes that were thought to have high restoration potential (Hintz, et al., 2019). The BUIs to be targeted by this sampling and the resulting recommendations are 3a.) Degradation of fish populations, 6.) Degradation of benthos, and 14a.) Loss of fish habitat.

To identify the project sites where the most benefit may be achieved through restoration efforts, UT and BGSU performed sampling activities that included fish sampling with electrofishing and bottom trawling and invertebrate sampling with Ponar grab samples and Hester Dendy samplers (Hintz et al., 2019). The fish sampling was used to evaluate fish populations at the sampling sites through fish species richness, fish abundance, and Index of Biological Integrity (IBI). The invertebrate sampling was used to evaluate the benthos in these areas through taxa richness; total abundance; and percent Ephemeroptera, Plecoptera, and Trichoptera taxa abundance (%EPT).

This report summarizes the general restoration activities proposed to address the BUIs in this stretch of the Maumee River, the specific project locations identified to implement restoration activities, and challenges, preliminary costs, and preliminary ranking of the proposed project sites. Please note that the restoration concept plans and their rankings do not yet incorporate anticipated feedback regarding tribal interests and/or cultural resources at or near these project sites. We recommend ongoing consultation with federally recognized tribes who may have a cultural or historical interest in the area and surveys of the area to identify any potential conflicts between these habitat enhancement projects and pre-contact and historical cultural resources

RESTORATION ACTIVITIES

Six main restoration activities are proposed to help address the BUIs in this stretch of the Maumee River:

1. Plantings
2. Invasive Species Removal
3. Installation of Root Wads and Submerged Trees
4. Dredging Coves
5. Installation of Wing Dikes
6. Installation of Chevron Dikes

Plantings

Plantings may help stabilize stretches of shoreline with sparse vegetation and provide habitat for a variety of species. Flood-resistant herbaceous emergent aquatic plants (e.g., swamp milkweed, arrowhead, water willow, or others) are recommended to be planted in the "splash zone," which is the portion of the riverbank that is between the normal high- and low-water stages. Herbaceous and woody plants (e.g., black willow, river birch, silky dogwood, or others) that can tolerate several weeks of partial to complete submergence should be planted in the "bank zone," which is above the normal high-water level, but may still be exposed to waves, erosive flows, and ice and debris movement (**Figure 1**) [U.S. Army Corps of Engineers (USACE), 2012].

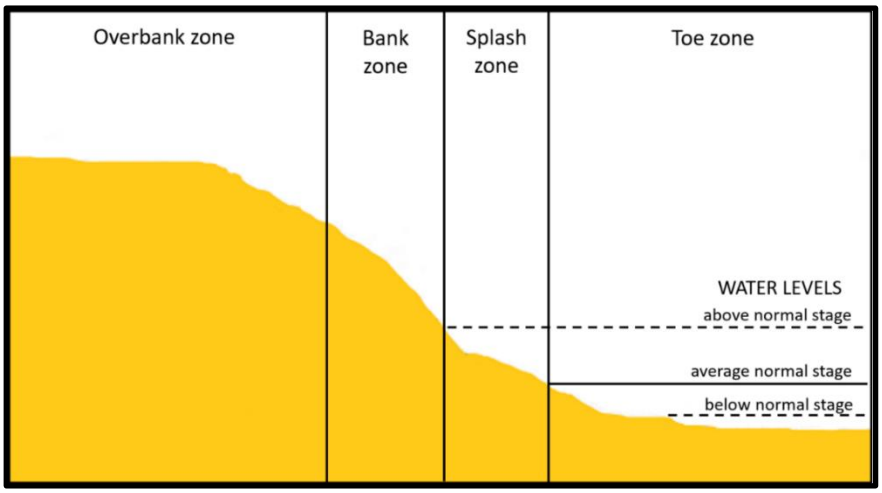


Figure 1. *Bank zones defined for slope protection (adapted from USACE, 2012).*

Invasive Plant Removal

Invasive plants, such as common reed (*Phragmites Australis*) (**Figure 2**), are recommended to be removed from the vicinity where native plantings are being installed. These invasive plants may prevent the native plantings from becoming established and do not provide the same quality of habitat for the area. The plants may be removed through either chemical or mechanical means.

Figure 2. *A stand of common reed (Phragmites Australis) (photo credit: UT and BGSU).*

Installation of Root Wads and Submerged Trees

Installing root wads (**Figure 3**) and submerged trees along the shoreline may provide habitat improvements for fish by providing areas with shelter and slower river flows, improve macroinvertebrate populations by providing a food source, and may protect the shoreline from erosion by deflecting the river flow away from the bank. Spacing of root wads and submerged trees is dependent on whether they are being used solely for habitat improvements or also for erosion protection. Erosion protection requires individual root wads and submerged trees to be placed closer together, and the USDA Natural Resources Conservation Service (NRCS) recommends 1 foot of overlap between individual root wads and overlapping submerged trees based on the conceptual plans provided on their Stream Corridor Restoration webpage.

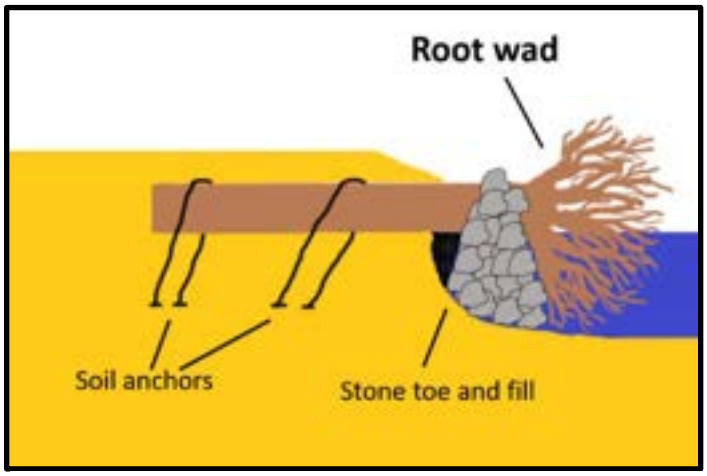


Figure 3: *Root wad example (adapted from NRCS, 2008).*

Dredging Coves

Mechanical or hydraulic dredging (**Figure 4**) may be used to create/enhance shallow water habitat in existing coves of islands by dredging these coves to appropriate water depths to promote submerged aquatic vegetation (SAV) growth. SAV may provide nursery habitat for juvenile fish and a food source for macroinvertebrates (Hintz et al., 2019). However, SAV need to be protected from high flows and waves. To accomplish this, woody palisades or other structures may be placed across the cove entrances as protection against high flows and waves. These woody palisades or other structures may also limit unwanted watercraft access to minimize disturbance to these areas.

Figure 4: *Mechanical dredging in the Maumee River.*

Wing Dikes

Wing dikes, also known as wing dams, are constructed perpendicular to the flow of the river and may be built from a variety of materials, including rock (**Figure 5**). These structures function as deflectors to direct the current away from the shoreline and create areas of slack water near the shoreline (ODNR). The areas of slack water may provide protected habitat for fish and the rock of the wing dikes may be used for fish spawning or a food source for macroinvertebrates. In addition, notches may be added to create additional habitat diversity, according to the Upper Mississippi River Restoration (UMRR) Environmental Management Program (EMP) Environmental Design Handbook (USACE, 2012).

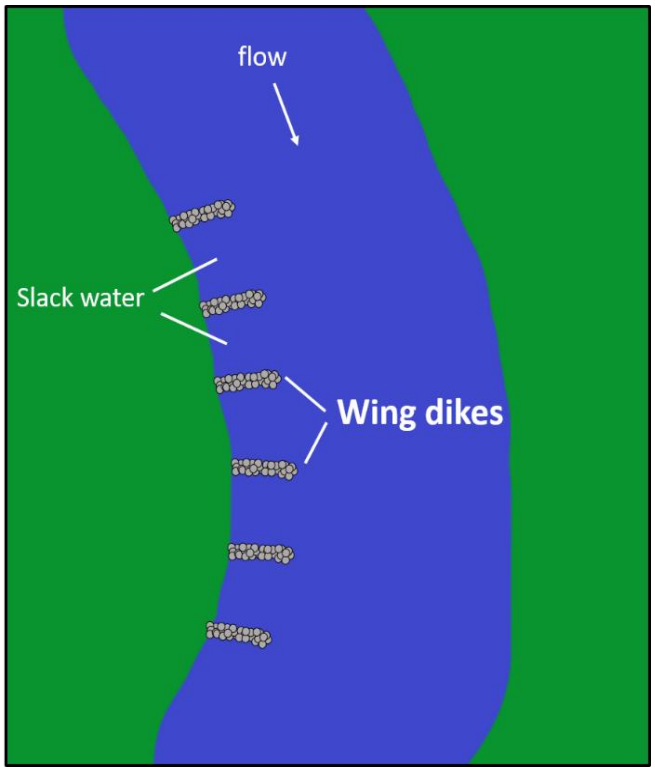


Figure 5. *Wing dike example (adapted from USACE, 2012).*

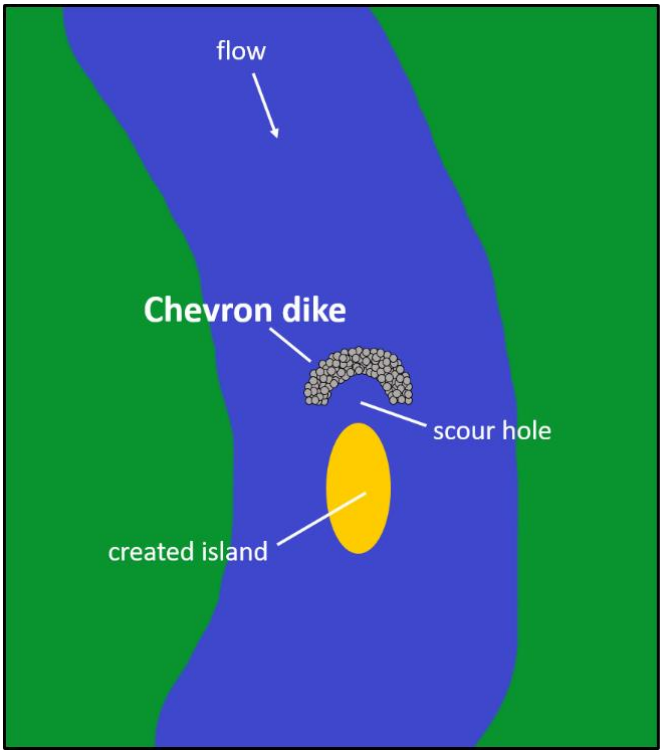


Figure 6. *U-Shaped chevron above an island (adapted from USACE, 2012).*

Chevron Dikes

Chevron dikes are a V- or U-shaped rock structure constructed parallel to the flow of the river, typically to the 2-year flood elevation. The rock dike material may provide habitat for macroinvertebrates, thereby providing a food source for fish. Chevron dikes also increase habitat diversity by redistributing flow and sediment in the river. According to the UMRR EMP Environmental Design Handbook, periods of high water may cause scour downstream of the dike's apex and the sediment suspended by this is expected to be deposited immediately downstream where it may eventually form a new island or build on existing islands. The hole formed during scour events also provides an area of slack water during low flows, which provides beneficial fish habitat (**Figure 6**) (UASCE, 2012).

RESTORATION SITES

Within this stretch of the Maumee River, 12 project sites were identified and are generally grouped into four focus areas for ease of presentation:

1. Audubon Islands
2. Main Channel (covering the stretch of the river from Audubon Islands to Grassy Island)
3. Grassy Island
4. Delaware/Horseshoe Complex

Note that it is not necessary to implement all project sites identified within a focus area concurrently, though it may be cost-effective to do so. **Exhibit 1** provides an overview of this stretch of the Maumee River and identifies the location of each of the 12 project sites.

WALBRIDGE PARK BOAT LAUNCH

ROSSFORD MARINA

DELAWARE CREEK

DELAWARE/HORSESHOE COMPLEX (SEE EXHIBIT 5)

TOLEDO COUNTRY CLUB

GRASSY ISLAND (SEE EXHIBIT 4)

MAIN CHANNEL (SEE EXHIBIT 3)

COREY STREET BOAT LAUNCH

SENTINEL POINT

AUDUBON ISLANDS (SEE EXHIBIT 2)

ORLEANS PARK BOAT LAUNCH

MAPLE STREET BOAT LAUNCH

12 11 8 9 7 10 6 5 3 2 4 1

Horseshore Island

Grassy Island

Audubon Islands State Nature Preserve

Audubon Island

0 1250 2500
SCALE IN FEET

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EXHIBIT 1
PROJECT AREA OVERVIEW

LOWER MAUMEE RIVER
AQUATIC MANAGEMENT
ACTION PROJECT
UNIVERSITY OF TOLEDO

LAYOUT BY: JMC/SAH
CHECKED BY: JMC/PAH
DRAWN BY: SAH
DATE: 3/18/2021
PROJECT NO. UOT030
EXHIBIT NO. 1

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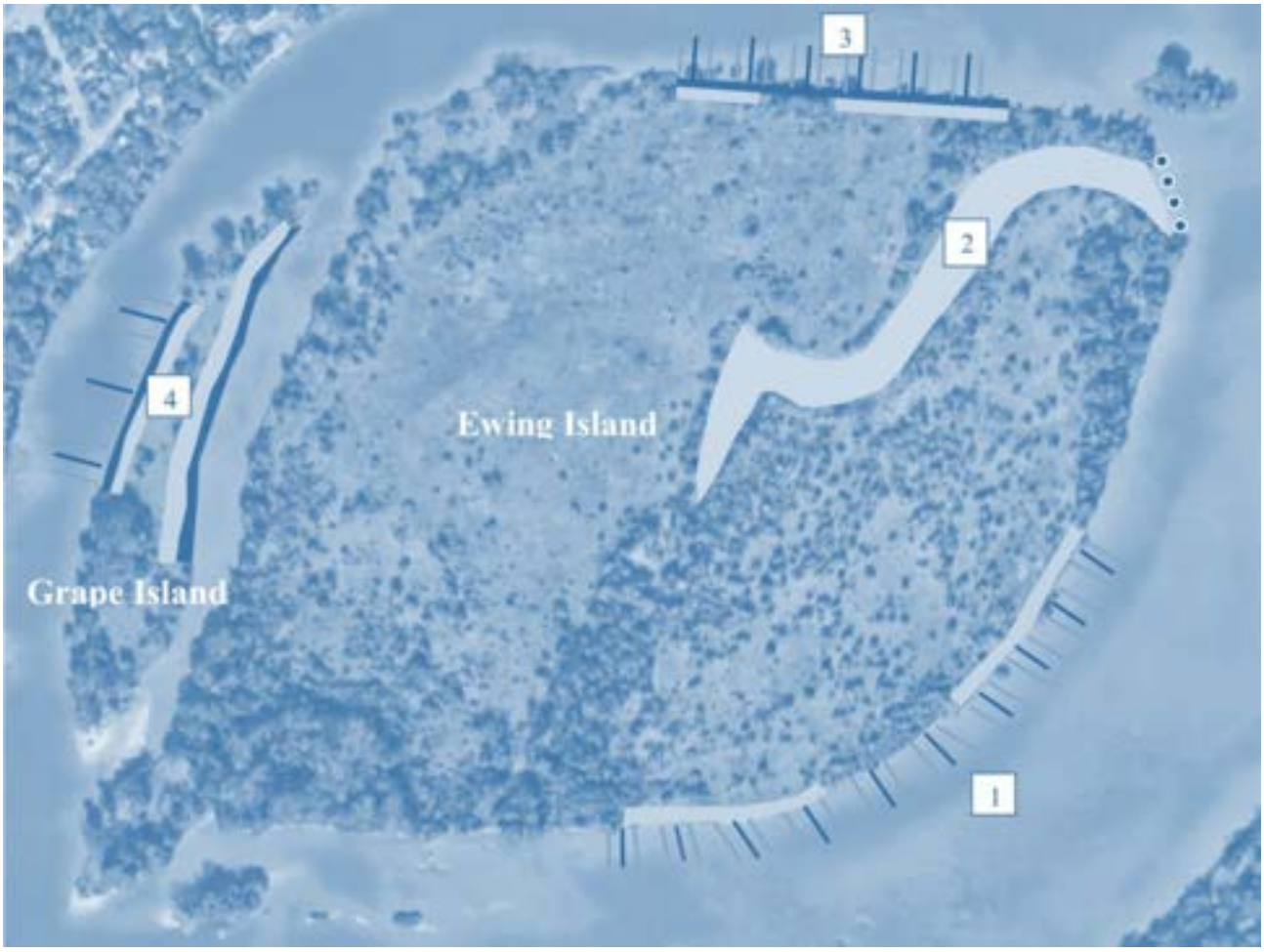
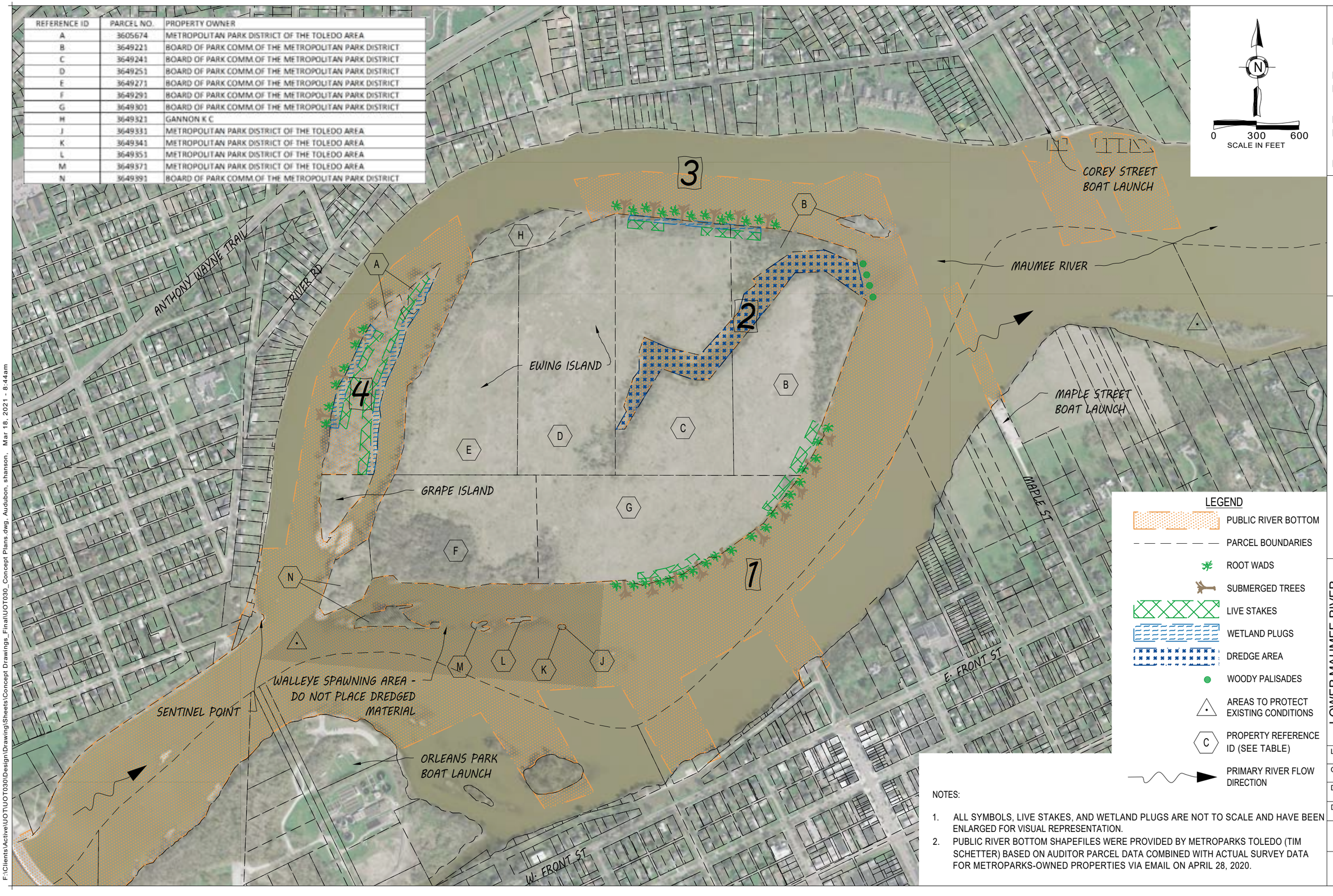
AUDUBON ISLANDS

The Audubon Islands are a nature preserve in Maumee, Ohio located approximately 13.5 miles upstream of the mouth of the Maumee River. The preserve is a set of two islands (Grape and Ewing Islands) separated by a narrow channel and totaling 192 acres. The islands are owned and managed locally by the Toledo Metropolitan Park District, except for one parcel (No. 3649321) on the north side of Ewing Island, which is privately owned by Gannon K C.

Four project sites are currently proposed for these islands, as identified on **Exhibit 2**.



REFERENCE ID	PARCEL NO.	PROPERTY OWNER
A	3605674	METROPOLITAN PARK DISTRICT OF THE TOLEDO AREA
B	3649221	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
C	3649241	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
D	3649251	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
E	3649271	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
F	3649291	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
G	3649301	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT
H	3649321	GANNON K C
J	3649331	METROPOLITAN PARK DISTRICT OF THE TOLEDO AREA
K	3649341	METROPOLITAN PARK DISTRICT OF THE TOLEDO AREA
L	3649351	METROPOLITAN PARK DISTRICT OF THE TOLEDO AREA
M	3649371	METROPOLITAN PARK DISTRICT OF THE TOLEDO AREA
N	3649391	BOARD OF PARK COMM.OF THE METROPOLITAN PARK DISTRICT



0 300 600
SCALE IN FEET

LEGEND

- PUBLIC RIVER BOTTOM
- PARCEL BOUNDARIES
- ROOT WADS
- SUBMERGED TREES
- LIVE STAKES
- WETLAND PLUGS
- DREDGE AREA
- WOODY PALISADES
- AREAS TO PROTECT EXISTING CONDITIONS
- C — PROPERTY REFERENCE ID (SEE TABLE)
- PRIMARY RIVER FLOW DIRECTION

NOTES:

1. ALL SYMBOLS, LIVE STAKES, AND WETLAND PLUGS ARE NOT TO SCALE AND HAVE BEEN ENLARGED FOR VISUAL REPRESENTATION.
2. PUBLIC RIVER BOTTOM SHAPEFILES WERE PROVIDED BY METROPARKS TOLEDO (TIM SCHETTER) BASED ON AUDITOR PARCEL DATA COMBINED WITH ACTUAL SURVEY DATA FOR METROPARKS-OWNED PROPERTIES VIA EMAIL ON APRIL 28, 2020.

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EXHIBIT 2

AUDUBON ISLANDS CONCEPT PLAN

LOWER MAUMEE RIVER AQUATIC MANAGEMENT ACTION PROJECT

UNIVERSITY OF TOLEDO

LAYOUT BY:	JMC/SAH
CHECKED BY:	JMC/PAH
DRAWN BY:	SAH
DATE:	3/18/2021
PROJECT NO.	UOT030
EXHIBIT NO.	2

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Project Site #1 (Audubon Islands)

Existing Habitat and Biological Conditions

Project site #1 encompasses approximately 2,000 linear feet of shoreline along the southeastern side of Ewing Island. This section of the shoreline consists of an eroded bank, which extends approximately 3-4 feet above the water surface depending on water levels, and sparse vegetation (i.e., primarily grasses with a few patches of bushes) on top of this bank (**Figure 7**).

Figure 7. *Segment of eroded bank along the southeastern shoreline of Ewing Island (photo credit: UT and BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 at this location is provided in **Table 1**. Fish species richness and fish abundance scores for July electrofishing and August trawls were low at this site relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install root wads and submerged trees along this shoreline and to plant native vegetation (e.g., live stakes) on top of the eroded bank to augment fish and macroinvertebrate habitat and stabilize the bank (**Figure 8**). Understanding that the primary objective is habitat improvement, the current concept drawings show the root wads and submerged trees spaced 100 ft and 200 ft, respectively. This spacing may be reduced in specific areas that experience stronger erosive forces to protect the shoreline from erosion.

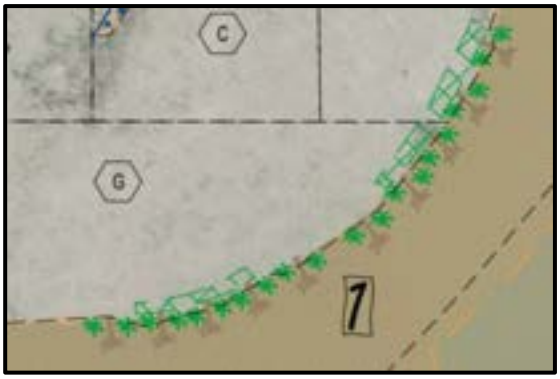


Figure 8. *Concept plan for project site #1 (See **Exhibit 2** for additional detail).*

Table 1: Catch summary data from summer 2019 sampling efforts near project site #1 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project site scores	Average across all sample sites
Fish species richness			
	July electrofishing	6	9.6
	August electrofishing	15	9.7
	August trawl	4	9.8
Fish abundance			
	July electrofishing	6	35
	August electrofishing	48	57.2
	August trawl	7	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	20	17.7
Macroinvertebrate taxa richness		9	6.5
Macroinvertebrate total abundance		894	574.3
Macroinvertebrate %EPT abundance		19.91	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

Project Site #2 (Audubon Islands)

Existing Habitat and Biological Conditions

Project site #2 encompasses an approximately 365,000 square foot existing cove on the eastern side of Ewing Island. No SAV was found by UT and BGSU when running three transects that were at least 328 feet (100 meters) long at the downstream end of this cove in August 2019.

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 2**. Fish and macroinvertebrate sampling did not occur within this cove, but samples were taken near its mouth. At this site, fish species richness and fish abundance scores for July electrofishing were low relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to dredge this cove (**Figure 9**) with a gradual transition from the shoreline to an approximate depth of 3 feet at average water level (based on recent and projected water levels). This will create shallow water habitat with appropriate water depths for SAV and remove loose sediment that would be more easily resuspended, creating turbid water. SAV may then be planted to provide nursery habitat for juvenile fish and a food source for macroinvertebrates. Deeper water holes may also be dredged and specific substrates (e.g., gravels and cobbles) may be added for additional fish habitat. The entrance of the cove is proposed to be protected with woody palisades, rock sills, or similar structures to protect the SAV from high flows and waves.

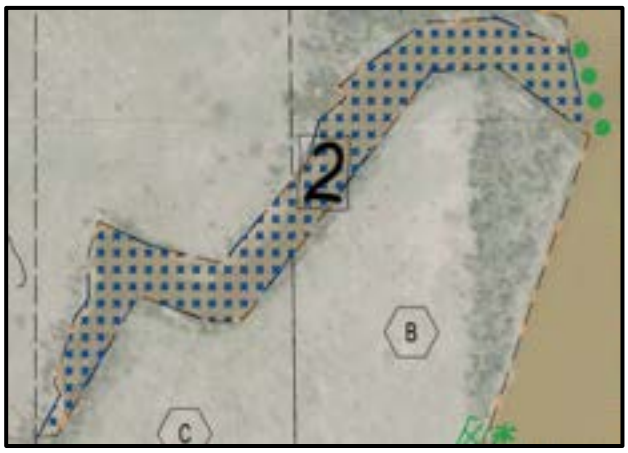


Figure 9. *Concept plan for project site #2 (See* ***Exhibit 2*** *for additional detail).*

Table 2: Catch summary data from summer 2019 sampling efforts near project site #2 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project site scores	Average across all sample sites
Fish species richness			
	July electrofishing	5	9.6
	August electrofishing	10	9.7
	August trawl	10	9.8
Fish abundance			
	July electrofishing	10	35
	August electrofishing	24	57.2
	August trawl	340	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	16	17.7
Macroinvertebrate taxa richness		3	6.5
Macroinvertebrate total abundance		596	574.3
Macroinvertebrate %EPT abundance		24.16	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

Project Site #3 (Audubon Islands)

Existing Habitat and Biological Conditions

Project site #3 encompasses approximately 1,200 linear ft of shoreline along the northern side of Ewing Island. This section of the shoreline contains proportionally more riparian vegetation and woody debris than the eroded southeastern shore; however, this vegetation is spread rather thin, with bare, muddy shoreline making up the space in between stands of trees (**Figure 10**).

Figure 10. *Overview of northern shoreline of Ewing Island (Google Earth Imagery dated 4/29/2018).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 3**. Fish species richness and fish abundance scores for July electrofishing and fish abundance for August trawls were low at this site relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install root wads and submerged trees and to plant native vegetation (e.g., live stakes and wetland plugs) along the shoreline to augment fish and macroinvertebrate habitat and stabilize the bank (**Figure 11**). Similar to project site #1, the current concept drawings show the root wads and submerged trees spaced 100 ft and 200 ft, respectively. This spacing may be reduced in specific areas that experience stronger erosive forces to protect the shoreline from erosion.

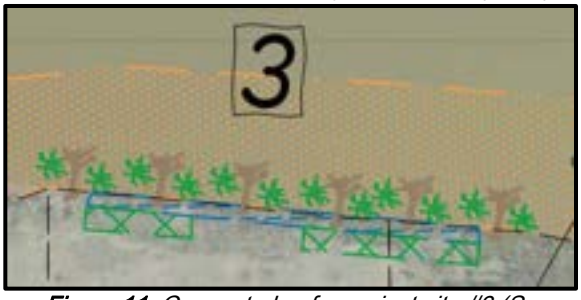


Figure 11. *Concept plan for project site #3 (See* ***Exhibit 2*** *for additional detail).*

Table 3: Catch summary data from summer 2019 sampling efforts near project site #3 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project site scores	Average across all sample sites
Fish species richness			
	July electrofishing	4	9.6
	August electrofishing	13	9.7
	August trawl	7	9.8
Fish abundance			
	July electrofishing	7	35
	August electrofishing	43	57.2
	August trawl	23	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	18	17.7
Macroinvertebrate taxa richness		N/A	6.5
Macroinvertebrate total abundance		N/A	574.3
Macroinvertebrate %EPT abundance		N/A	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. No Hester Dendy macroinvertebrate samples were taken near project site #3.

Project Site #4 (Audubon Islands)

Existing Habitat and Biological Conditions

Project site #4 encompasses approximately 1,200 linear ft of the eastern shoreline and approximately 710 linear feet of the western shoreline of Grape Island. These sections lack riparian vegetation, woody debris or other shoreline structures, and generally contain only grasses and bare mud (**Figure 12**).

Figure 12. *Segment of bank on western shore of Ewing Island (photo credit: UT and BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 4**. Fish species richness and fish abundance scores for July electrofishing and fish abundance for August electrofishing and trawls were low at this site relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install root wads and submerged trees and to plant native vegetation (e.g., live stakes and wetland plugs) along the shoreline to augment fish and macroinvertebrate habitat and stabilize the bank (**Figure 13**). Similar to project site #1, the current concept drawings show the root wads and submerged trees spaced 100 ft and 200 ft, respectively. This spacing may be reduced in specific areas that experience stronger erosive forces to protect the shoreline from erosion.

Figure 13. *Concept plan for project site #4 (See **Exhibit 2** for additional detail).*

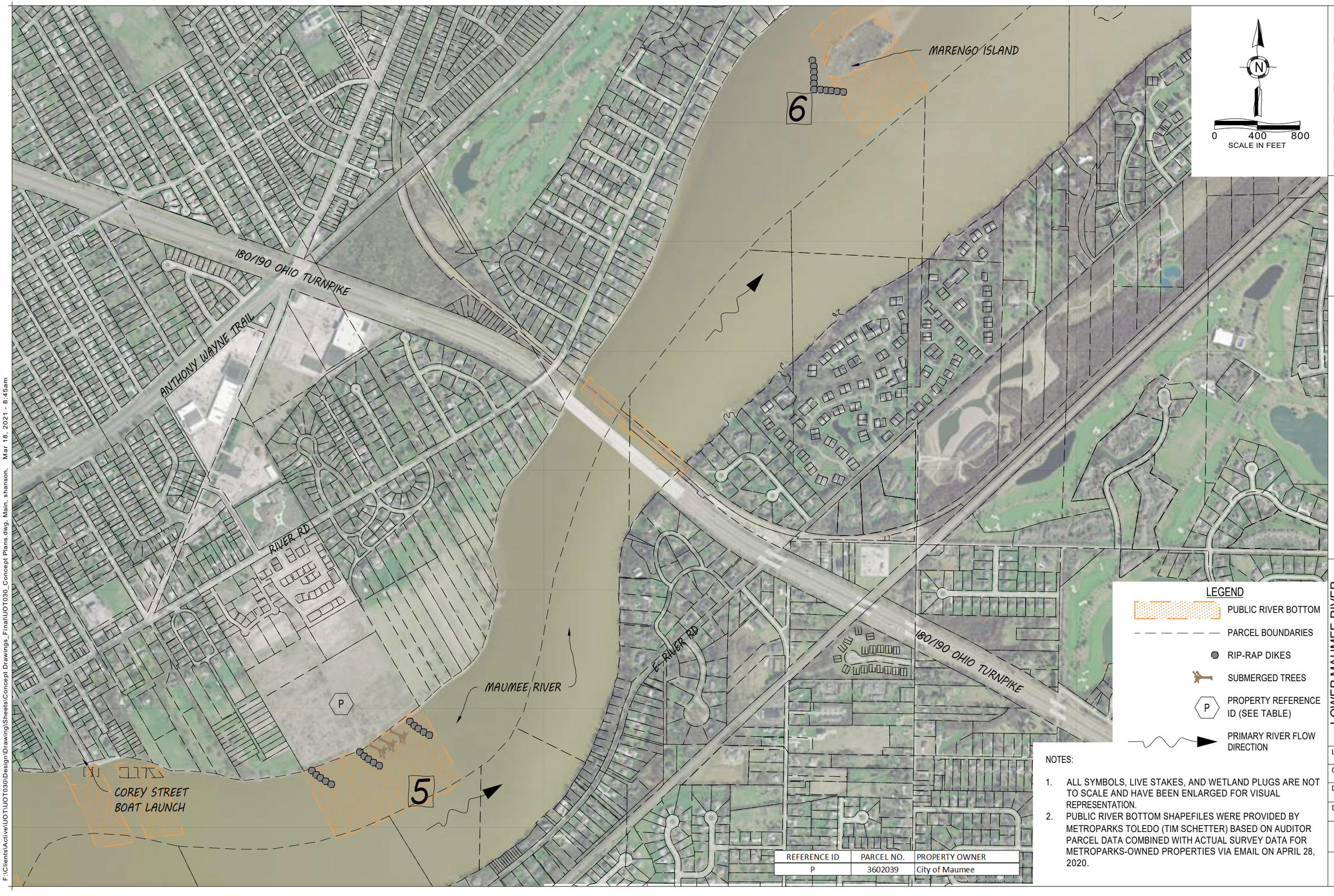
Table 4: Catch summary data from summer 2019 sampling efforts near project site #4 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project site scores	Average across all sample sites
Fish species richness			
	July electrofishing	6	9.6
	August electrofishing	10	9.7
	August trawl	9	9.8
Fish abundance			
	July electrofishing	11	35
	August electrofishing	24	57.2
	August trawl	51	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	18	17.7
Macroinvertebrate taxa richness		N/A	6.5
Macroinvertebrate total abundance		N/A	574.3
Macroinvertebrate %EPT abundance		N/A	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. No Hester Dendy macroinvertebrate samples were taken near project site #4.

MAIN CHANNEL

Two main channel projects are proposed to occur between Audubon Islands and Grassy Island, as identified on **Exhibit 3**.



LEGEND

- PUBLIC RIVER BOTTOM
- PARCEL BOUNDARIES
- RIP-RAP DIKES
- SUBMERGED TREES
- P — PROPERTY REFERENCE ID (SEE TABLE)
- PRIMARY RIVER FLOW DIRECTION

REFERENCE ID	PARCEL NO.	PROPERTY OWNER
P	3602039	City of Maumee

NOTES:

1. ALL SYMBOLS, LIVE STAKES, AND WETLAND PLUGS ARE NOT TO SCALE AND HAVE BEEN ENLARGED FOR VISUAL REPRESENTATION.
2. PUBLIC RIVER BOTTOM SHAPEFILES WERE PROVIDED BY METROPARKS TOLEDO (TIM SCHETTER) BASED ON AUDITOR PARCEL DATA COMBINED WITH ACTUAL SURVEY DATA FOR METROPARKS-OWNED PROPERTIES VIA EMAIL ON APRIL 28, 2020.

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EXHIBIT 3

MAIN CHANNEL CONCEPT PLAN

LOWER MAUMEE RIVER
AQUATIC MANAGEMENT
ACTION PROJECT

UNIVERSITY OF TOLEDO

LAYOUT BY:	JMC/SAH
CHECKED BY:	JMC/PAH
DRAWN BY:	SAH
DATE:	3/18/2021
PROJECT NO.	UOT030
EXHIBIT NO.	3

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Project Site #5 (Main Channel)

Existing Habitat and Biological Conditions

Project site #5 consists of a section of shoreline owned by the city of Maumee (Parcel No. 3602039), which is located south (upstream) of the I-80/I-90 Ohio Turnpike in Maumee and approximately 12.5 miles upstream of the river mouth into Maumee Bay. The shoreline in this area is mostly hardened with rip-rap, with some shrubbery growing just behind and among the rip-rap. In some areas, this shrubbery completely covers the rip-rap (**Figure 14**).

Figure 14. *Shoreline of project site #5 covered in woody debris from shrubbery (photo credit: UT and BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 5**. Fish species richness and fish abundance scores for July electrofishing and fish abundance for August fish trawls were low at this site relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install rip-rap wing dikes and submerged trees along the shoreline to augment fish and macroinvertebrate habitat in this area (**Figure 15**). These wing dikes may extend a few hundred feet out from the shore and could be notched to provide additional habitat variety. Cobbles may also be placed on the sides of the dikes for sturgeon spawning. Design of this project site will include hydrologic and hydraulic (H&H) modeling to evaluate the impacts these dikes may have on flows in nearby sections of the river.

Figure 15. *Concept plan for project site #5 (See **Exhibit 3** for additional detail).(photo credit: UT and BGSU).*

Table 5. Catch summary data from summer 2019 sampling efforts near project site #5 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project Site Scores	Average Across All Sample Sites
Fish species richness			
	July electrofishing	5	9.6
	August electrofishing	14	9.7
	August trawl	8	9.8
Fish abundance			
	July electrofishing	14	35
	August electrofishing	77	57.2
	August trawl	41	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	20	17.7
Macroinvertebrate taxa richness		4	6.5
Macroinvertebrate total abundance		468	574.3
Macroinvertebrate %EPT abundance		55.56	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

Project Site #6 (Main Channel)

Existing Habitat and Biological Conditions

Project site #6 is located north (downstream) of the I-80/I-90 Ohio Turnpike by Marengo Island, an approximately 3.5-acre island located 10.5 miles upstream of the river's mouth into Maumee Bay in Toledo. Based on a historic map from 1934 (**Figure 16**), Marengo Island once had a larger footprint.

Figure 16. *USGS Historic Map of Marengo Island (Adapted from USGS, 1935).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 6**. Fish species richness and fish abundance scores for July electrofishing, August electrofishing, and August trawls were low at this site relative to other summer 2019 sampling sites in the study reach. The IBI for July electrofishing received the lowest possible score. Macroinvertebrate total abundance was also low at this site relative to other sampling sites. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

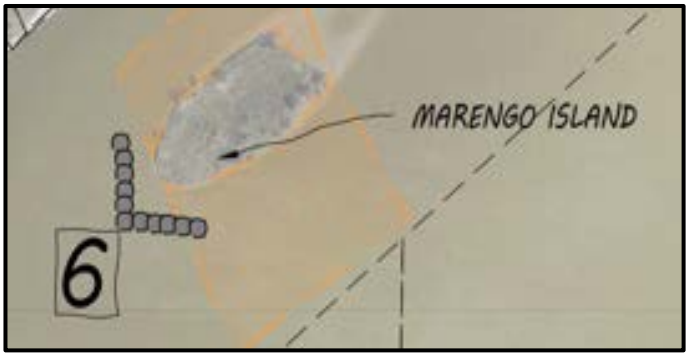


Figure 17. *Concept plan for project site #6 (See* ***Exhibit 3*** *for additional detail).*

Restoration Recommendations

It is proposed to install a chevron dike upstream of Marengo Island to encourage sediment accretion and growth of the island (**Figure 17**). H&H modeling during the design phase will determine the best location, shape and length of the chevron dike, but it is currently anticipated that this dike would be a U-shape with a total length of approximately 800 linear feet. A mixture of sand and gravel may also be placed on the river bottom on the upstream side of the chevron dike to incorporate sturgeon nursery habitat at this project site.

Table 6. Catch summary data from summer 2019 sampling efforts near project site #6 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

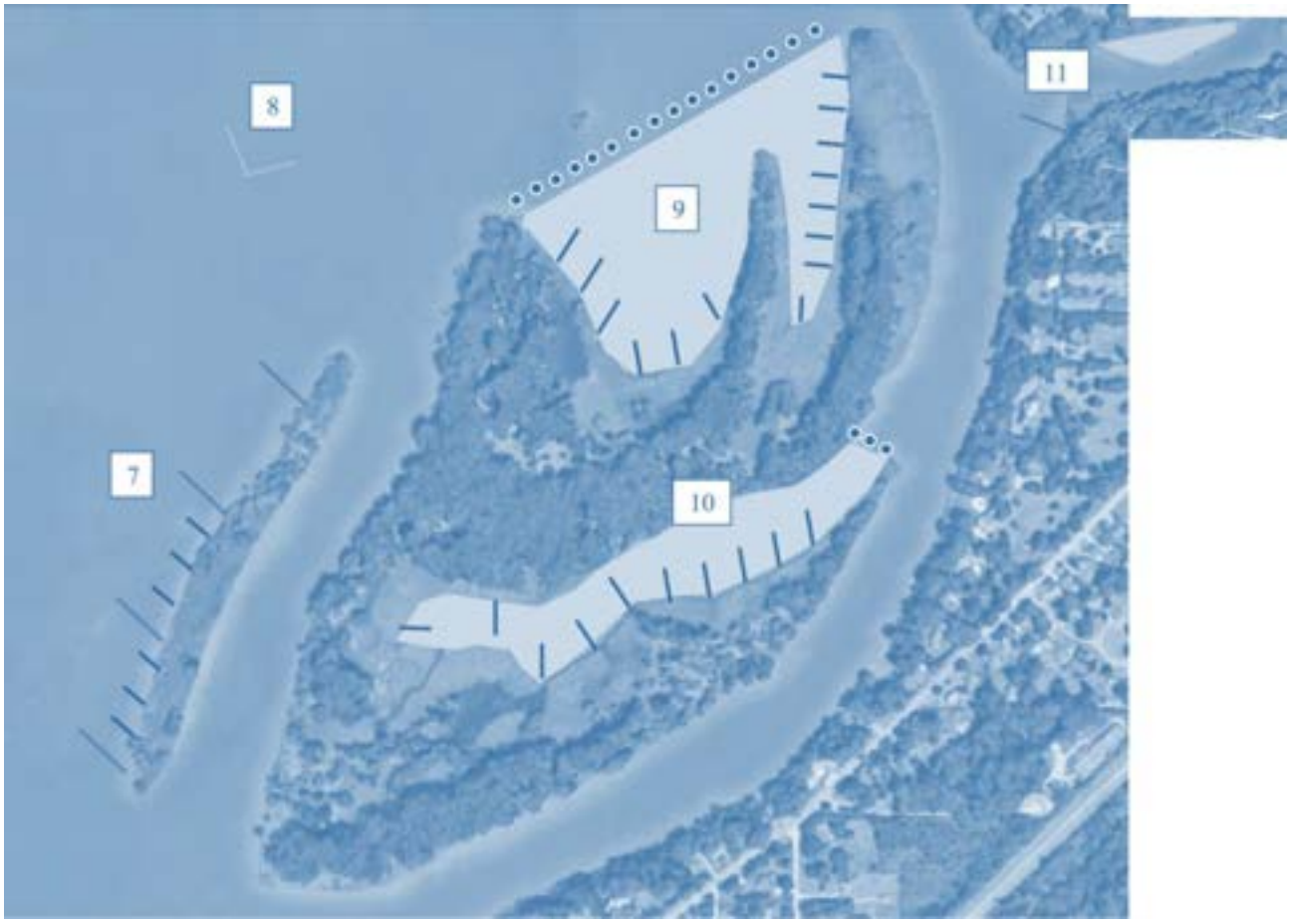
		Project Site Scores	Average Across All Sample Sites
Fish species richness			
	July electrofishing	5	9.6
	August electrofishing	7	9.7
	August trawl	7	9.8
Fish abundance			
	July electrofishing	13	35
	August electrofishing	39	57.2
	August trawl	19	97
IBI			
	July electrofishing	12	17.2
	August electrofishing	14	17.7
Macroinvertebrate taxa richness		7	6.5
Macroinvertebrate total abundance		203	574.3
Macroinvertebrate %EPT abundance		34.98	20.2

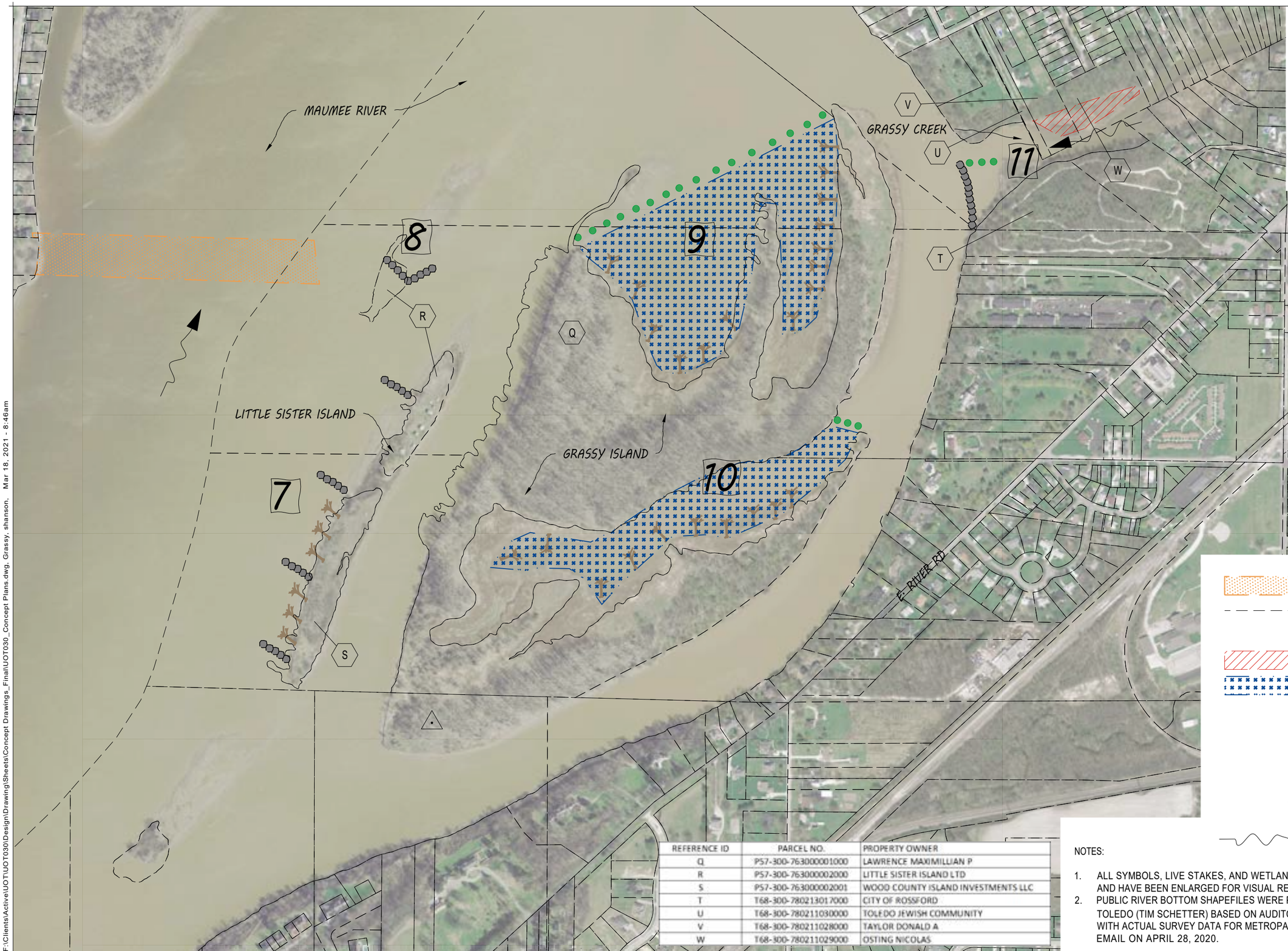
[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

GRASSY ISLAND

Grassy and Little Sister Islands are two privately owned islands located in Perrysburg Township, Wood County. The islands are in the Maumee River approximately 9.5 miles upstream of the river's mouth into Maumee Bay and are separated by an approximately 300 ft wide channel. Little Sister Island has a total area of 6.5 acres and Grassy Island totals 90 acres. The mouth of Grassy Creek, a tributary of the Maumee River that runs through the city of Perrysburg, Perrysburg Township, and city of Rossford before entering the Maumee River, is located just east of the northern tip of Grassy Island. At the confluence with the Maumee River, Grassy Creek is privately owned along the north side and publicly owned along the south side.

Five project sites are currently proposed for this area, as identified on **Exhibit 4**.





N

0 250 500
SCALE IN FEET

LEGEND

- PUBLIC RIVER BOTTOM
- PARCEL BOUNDARIES
- SUBMERGED TREES
- PHRAGMITES REMOVAL
- DREDGE AREA
- WOODY PALISADES
- RIP-RAP DIKE
- AREAS TO PROTECT EXISTING CONDITIONS
- PROPERTY REFERENCE ID (SEE TABLE)
- PRIMARY RIVER FLOW DIRECTION

REFERENCE ID	PARCEL NO.	PROPERTY OWNER
Q	PS7-300-763000001000	LAWRENCE MAXIMILLIAN P
R	PS7-300-763000002000	LITTLE SISTER ISLAND LTD
S	PS7-300-763000002001	WOOD COUNTY ISLAND INVESTMENTS LLC
T	T68-300-780213017000	CITY OF ROSSFORD
U	T68-300-780211030000	TOLEDO JEWISH COMMUNITY
V	T68-300-780211028000	TAYLOR DONALD A
W	T68-300-780211029000	OSTING NICOLAS

NOTES:

1. ALL SYMBOLS, LIVE STAKES, AND WETLAND PLUGS ARE NOT TO SCALE AND HAVE BEEN ENLARGED FOR VISUAL REPRESENTATION.
2. PUBLIC RIVER BOTTOM SHAPEFILES WERE PROVIDED BY METROPARKS TOLEDO (TIM SCHETTER) BASED ON AUDITOR PARCEL DATA COMBINED WITH ACTUAL SURVEY DATA FOR METROPARKS-OWNED PROPERTIES VIA EMAIL ON APRIL 28, 2020.

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EXHIBIT 4
GRASSY ISLAND CONCEPT PLAN

LOWER MAUMEE RIVER
AQUATIC MANAGEMENT
ACTION PROJECT

UNIVERSITY OF TOLEDO

LAYOUT BY: JMC/SAH
CHECKED BY: JMC/PAH
DRAWN BY: SAH
DATE: 3/18/2021
PROJECT NO. UOT030
EXHIBIT NO. 4

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Project Site #7 (Grassy Island)

Existing Habitat and Biological Conditions

Project site #7 is located along the western edge of Little Sister Island, which is privately owned. This island contains mostly shrubs on the southern half of its shoreline.

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 7**. Fish species richness for August electrofishing, fish abundance for August electrofishing and trawls, and IBI for August electrofishing were low for this site relative to other summer 2019 sampling sites in the study reach. Macroinvertebrate % EPT abundance was also low for this site relative to other sampling sites. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install rip-rap wing dikes and submerged trees along the shoreline to augment fish and macroinvertebrate habitat in this area (**Figure 18**). These wing dikes may extend a few hundred feet out from the shore and could be notched to provide additional habitat variety. Cobbles may also be placed on the sides of the dikes for sturgeon spawning. Design of this project site will include hydrologic and hydraulic (H&H) modeling to evaluate the impacts these dikes may have on flows in nearby sections of the river.

Figure 18. *Concept plan for project site #7 (See* ***Exhibit 4*** *for additional detail).*

Table 7. Catch summary data from summer 2019 sampling efforts near project site #7 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

	Project Site Scores	Average Across All Sample Sites
Fish species richness		
July electrofishing	13	9.6
August electrofishing	6	9.7
August trawl	13	9.8
Fish abundance		
July electrofishing	34	35
August electrofishing	42	57.2
August trawl	66	97
IBI		
July electrofishing	18	17.2
August electrofishing	14	17.7
Macroinvertebrate taxa richness	6	6.5
Macroinvertebrate total abundance	879	574.3
Macroinvertebrate %EPT abundance	10.92	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

Project Site #8 (Grassy Island)

Existing Habitat and Biological Conditions

Project site #8 is located immediately northwest of Little Sister Island. Based on a historic map from 1934 (**Figure 19**), there was once an island in this area of the river. As a result, it was recommended to re-establish this island by Hintz et al. (2019).

Restoration Recommendations

It is proposed to install a chevron dike in this area to encourage sediment accretion and growth in the area of the historic island (**Figure 20**). H&H modeling during the design phase will determine the best location, shape and length of the chevron dike, but it is currently anticipated that this dike would be a U-shape with a total length of approximately 400 linear feet. A mixture of sand and gravel may also be placed on the river bottom on the upstream side of the chevron dike to incorporate sturgeon nursery habitat at this project site.

Figure 19. *USGS Historic Map of Marengo Island (Adapted from USGS, 1934).*

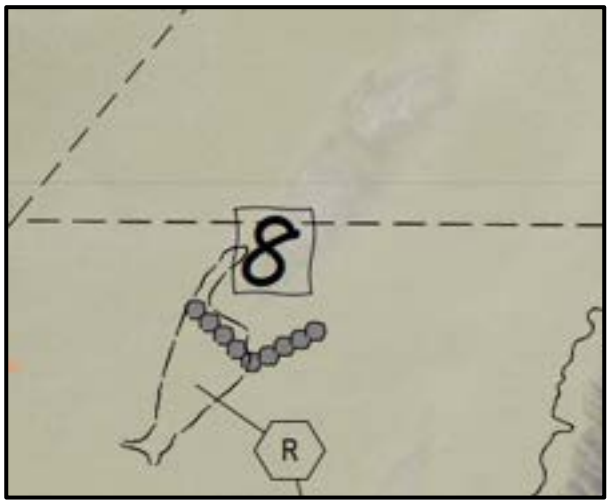


Figure 20. *Concept plan for project site #8 (See* ***Exhibit 4*** *for additional detail).*

Project Site #9 (Grassy Island)

Existing Habitat and Biological Conditions

Project site #9 encompasses an approximately 970,000 square foot cove on the northern side of Grassy Island. The shoreline surrounding the northern cove of Grassy Island is almost exclusively emergent vegetation and is dominated by stands of common reed in some stretches (**Figure 21**).

Figure 21. *Common reed (Phragmites Australis) stands on northernmost tip of Grassy Island (photo credit: UT & BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 8**. Macroinvertebrate taxa richness and macroinvertebrate % EPT abundance scores were low for this site relative to other summer 2019 sampling sites in the study reach. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to dredge this cove (**Figure 22**) with a gradual transition from the shoreline to an approximate depth of 3 feet at average water level (based on recent and projected water levels). This will create shallow water habitat with appropriate water depths for SAV and remove loose sediment that would be more easily resuspended, creating turbid water. SAV may then be planted and submerged trees installed to provide nursery habitat for juvenile fish and a food source for macroinvertebrates. Deeper water holes may also be dredged and specific substrates (e.g., gravels and cobbles) may be added for additional fish habitat. The entrance of the cove is proposed to be protected with woody palisades, rock sills. or similar structures to protect the SAV from high flows and waves.

Figure 22. *Concept plan for project site #9 (See **Exhibit 4** for additional detail).*

Table 8. Catch summary data from summer 2019 sampling efforts near project site #9 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

		Project Site Scores	Average Across All Sample Sites
Fish species richness			
	July electrofishing	13	9.6
	August electrofishing	9	9.7
	August trawl	13	9.8
Fish abundance			
	July electrofishing	82	35
	August electrofishing	88	57.2
	August trawl	267	97
IBI			
	July electrofishing	20	17.2
	August electrofishing	16	17.7
Macroinvertebrate taxa richness		4	6.5
Macroinvertebrate total abundance		1234	574.3
Macroinvertebrate %EPT abundance		3.48	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

Project Site #10 (Grassy Island)

Existing Habitat and Biological Conditions

Project site #10 encompasses an approximately 520,000 square foot cove on the eastern side of Grassy Island.

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 9**. Fish and macroinvertebrate sampling did not occur within the cove, but fish sampling was conducted near its mouth. At this site, fish species richness for August electrofishing was low relative to other summer 2019 sampling sites in the study reach. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to dredge this cove (**Figure 23**) with a gradual transition from the shoreline to an approximate depth of 3 feet at average water level (based on recent and projected water levels). This will create shallow water habitat with appropriate water depths for SAV and remove loose sediment that would be more easily resuspended, creating turbid water. SAV may then be planted and submerged trees installed to provide nursery habitat for juvenile fish and a food source for macroinvertebrates. Deeper water holes may also be dredged and specific substrates (e.g., gravels and cobbles) may be added for additional fish habitat. The entrance of the cove is proposed to be protected with woody palisades, rock sills, or similar structures to protect the SAV from high flows and waves.

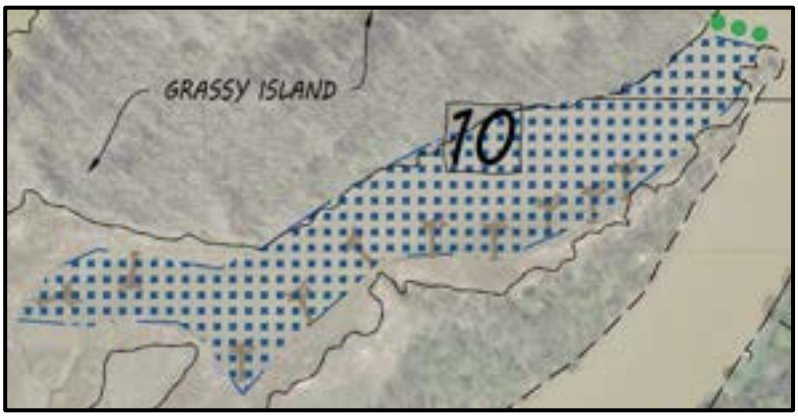


Figure 23. *Concept plan for project site #10 (See* ***Exhibit 4*** *for additional detail).*

Table 9. Catch summary data from summer 2019 sampling efforts near project site #10 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

	Project Site Scores	Average Across All Sample Sites
Fish species richness		
July electrofishing	12	9.6
August electrofishing	6	9.7
August trawl	10	9.8
Fish abundance		
July electrofishing	52	35
August electrofishing	72	57.2
August trawl	97	97
IBI		
July electrofishing	24	17.2
August electrofishing	18	17.7
Macroinvertebrate taxa richness	N/A	6.5
Macroinvertebrate total abundance	N/A	574.3
Macroinvertebrate %EPT abundance	N/A	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/ method. Fish abundances are totals across two transects for each sampling period/method. No Hester Dendy macroinvertebrate samples were taken near project site #10.

Project Site #11 (Grassy Island)

Existing Habitat and Biological Conditions

Project site #11 is located at the confluence of Grassy Creek and the Maumee River. It was observed by UT and BGSU that Grassy Creek is prevented from scouring sediments at this confluence by the strong currents of the Maumee River, and common reed is prevalent in this area (**Figure 24**).

Figure 24. *Common reed (Phragmites Australis) stands near the mouth of Grassy Creek (photo credit: UT and BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 at this project site is provided in **Table 10**. Fish species richness, fish abundance and IBI for August electrofishing were low relative to other summer 2019 sampling sites in the study reach. Macroinvertebrate % EPT abundance was also low relative to other sample sites. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

Construction of a dike near the confluence of Grassy Creek and the Maumee River is proposed to promote scour in Grassy Creek (**Figure 25**). This dike is proposed to follow the existing shoreline of the Maumee River immediately upstream of the confluence with Grassy Creek and is anticipated to be a few hundred linear feet in length. The area on the Grassy Creek side of this dike would be protected by woody palisades or another structure to prevent debris from accumulating in this area. SAV may be planted in this area for additional fish habitat or dredged material may be placed here to create additional upland habitat.

Figure 25. *Concept plan for project site #11 (See **Exhibit 4** for additional detail).*

Removal of the existing stands of common reed in Grassy Creek is also proposed to improve fish and macroinvertebrate habitat and to promote SAV growth within this area (**Figure 25**).

Table 10. Catch summary data from summer 2019 sampling efforts near project site #11 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

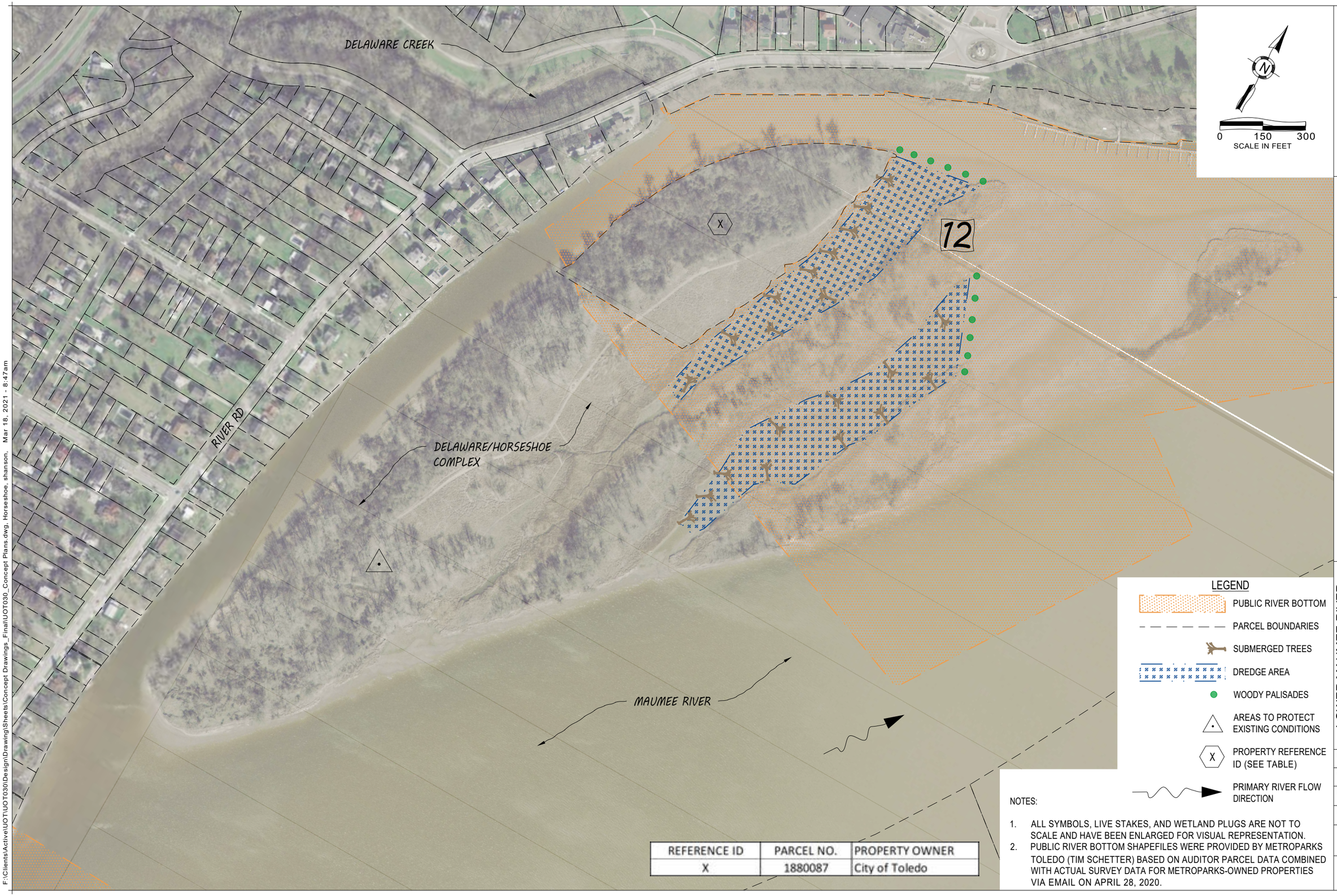
	Project Site Scores	Average Across All Sample Sites
Fish species richness		
July electrofishing	15	9.6
August electrofishing	7	9.7
August trawl	N/A	9.8
Fish abundance		
July electrofishing	57	35
August electrofishing	36	57.2
August trawl	N/A	97
IBI		
July electrofishing	24	17.2
August electrofishing	14	17.7
Macroinvertebrate taxa richness	7	6.5
Macroinvertebrate total abundance	2158	574.3
Macroinvertebrate %EPT abundance	1.34	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing in August 2019. No fish trawls were conducted near project site #11. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

DELAWARE/HORSESHOE ISLANDS

The Delaware/Horseshoe Complex is a set of islands approximately 9 miles upstream of the mouth of the Maumee River in Maumee Bay. The islands are located within the city of Toledo, and only have one parcel identified by the Lucas County Auditor, which is Parcel No. 1880087. This parcel is owned by the city of Toledo. The complex consists of four upland land masses that remain from the original two islands, the two largest areas being the approximately 37-acre Delaware and 13-acre Horseshoe Islands. These two islands appear as a single island in most areal imagery as they are on separated by a very narrow channel. Just east of Horseshoe Island is an approximately 5-acre area that was once part of Horseshoe Island that is now separated by a channel, and about 500 feet downstream of these three areas is another small upland remnant that is approximately 1.7 acres.

One project site is currently proposed for this area, as identified on **Exhibit 5**.



REFERENCE ID	PARCEL NO.	PROPERTY OWNER
X	1880087	City of Toledo

LEGEND

- PUBLIC RIVER BOTTOM
- PARCEL BOUNDARIES
- SUBMERGED TREES
- DREDGE AREA
- WOODY PALISADES
- AREAS TO PROTECT EXISTING CONDITIONS
- X — PROPERTY REFERENCE ID (SEE TABLE)
- PRIMARY RIVER FLOW DIRECTION

NOTES:

1. ALL SYMBOLS, LIVE STAKES, AND WETLAND PLUGS ARE NOT TO SCALE AND HAVE BEEN ENLARGED FOR VISUAL REPRESENTATION.
2. PUBLIC RIVER BOTTOM SHAPEFILES WERE PROVIDED BY METROPARKS TOLEDO (TIM SCHETTER) BASED ON AUDITOR PARCEL DATA COMBINED WITH ACTUAL SURVEY DATA FOR METROPARKS-OWNED PROPERTIES VIA EMAIL ON APRIL 28, 2020.

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FAX: (419) 243-1881
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EXHIBIT 5
DELAWARE/HORSESHOE COMPLEX
CONCEPT PLAN

LOWER MAUMEE RIVER AQUATIC MANAGEMENT ACTION PROJECT
UNIVERSITY OF TOLEDO

LAYOUT BY:	JMC/SAH
CHECKED BY:	JMC/PAH
DRAWN BY:	SAH
DATE:	3/18/2021
PROJECT NO.	UOT030
EXHIBIT NO.	5

Project Site #12 (Delaware/Horseshoe Islands)

Existing Habitat and Biological Conditions

Project site #12 includes two coves on the northern side of the Delaware/Horseshoe Complex, which together encompass approximately 420,000 square feet. The shoreline around these coves mostly consists of emergent wetland vegetation, much of which is dominated by common reed (**Figure 26**).

Figure 26. *Common reed (Phragmites Australis) along the shoreline of the cove between Horseshoe Island and a detached portion of the island (photo credit: UT and BGSU).*

A summary of the sampling data collected by UT and BGSU during 2019 near this project site is provided in **Table 11**. Fish and macroinvertebrate sampling did not occur directly in these coves, but fish sampling was conducted just downstream near a remnant island and a Hester Dendy macroinvertebrate sampling unit was placed between the mouth of these coves and the remnant island. At these sites, fish abundance for August electrofishing was low relative to other summer 2019 sampling sites in the study reach. Macroinvertebrate % EPT abundance was also low relative to other sample sites. As a result, this project site was identified for restoration activities by Hintz et al. (2019).

Restoration Recommendations

It is proposed to dredge these coves (**Figure 27**) with a gradual transition from the shoreline to an approximate depth of 3 feet at average water level (based on recent and projected water levels). This will create shallow water habitat with appropriate water depths for SAV and remove loose sediment that would be more easily resuspended, creating turbid water. SAV may then be planted and submerged trees installed to provide nursery habitat for juvenile fish and a food source for macroinvertebrates. Deeper water holes may also be dredged and specific substrates (e.g., gravels and cobbles) may be added for additional fish habitat. The entrance of the cove is proposed to be protected with woody palisades, rock sills, or similar structures to protect the SAV from high flows and waves.

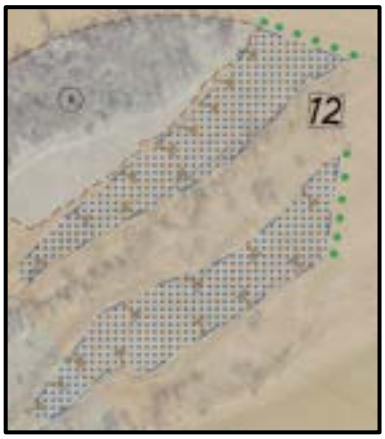


Figure 27. *Concept plan for project site #7 (See **Exhibit 4** for additional detail).*

Table 11. Catch summary data from summer 2019 sampling efforts near project site #12 and averages across all 21 fish sampling sites and 26 Hester-Dendy drop points summer 2019 sampling sites[1].

	Project Site Scores	Average Across All Sample Sites
Fish species richness		
July electrofishing	12	9.6
August electrofishing	12	9.7
August trawl	12	9.8
Fish abundance		
July electrofishing	50	35
August electrofishing	38	57.2
August trawl	190	97
IBI		
July electrofishing	16	17.2
August electrofishing	18	17.7
Macroinvertebrate taxa richness	9	6.5
Macroinvertebrate total abundance	1625	574.3
Macroinvertebrate %EPT abundance	4.31	20.2

[1]Fish were collected between river mile 15 and 7 of the Maumee River via electrofishing during July 2019, and then via electrofishing and trawl in August 2019. Fish species richness and IBI scores are overall scores across two transects for each sampling period/method. Fish abundances are totals across two transects for each sampling period/method. Macroinvertebrate data are from Hester Dendy units deployed for 7 weeks near the project site.

CHALLENGES

The location of these project sites in the Maumee River, with most on or near islands, present several unique challenges to the design, permitting, construction, and operation and maintenance (O&M) phases of the proposed project sites. Projects will require permission and access from landowners, and in some cases, coordination with adjacent riparian property owners. Stakeholder involvement and consideration of feedback received will also be important facets of planning and construction phases.

During the design phase, two important considerations are the ice flows and seiche events experienced in this stretch of the Maumee River (**Figure 28**). The ice flows may exert strong shear forces on the restoration features and therefore present a risk for damage after construction. The seiche events result in significant daily variations in water levels and some of which cause the river to flow upstream, which may affect the performance of some restoration features (e.g., chevron dikes, dredged coves, etc.). Planning for these events during the design phase will minimize damage caused by these events and the resulting required maintenance.

Figure 28. *Ice in the Maumee River near Audubon Islands.*

Additional permits are anticipated to be required for these project sites beyond the typical permits (e.g., nationwide permit under Section 401/404 of the Clean Water Act, permit for floodplain development, etc.) for construction/restoration projects. Since the project sites are located in federally navigable waters, permitting under Sections 9 and 10 of the Rivers and Harbors Act may be required. In addition, there is the potential for the presence of archaeological artifacts in the area of the proposed project sites that will require coordination and potential permitting under Section 106 of the National Historic Preservation Act. Coordination with the State Historic Preservation Office (SHPO) and federally recognized tribes is currently ongoing and may affect the project sites selected for implementation. The restoration efforts recommended for some project sites may also be altered to incorporate feedback from SHPO and federally recognized tribes. Lastly, all project sites are also anticipated to require a mussel survey prior to construction due to the likely presence of threatened and endangered species of mussels in the Maumee River.

The main challenges for construction are accessing the project sites and performing the work on water. Except for project site #5, it is anticipated that access to all project sites will require the use of watercraft. Multiple river access locations are available in the vicinity of the project sites (**Figure 29**), but all may not be suitable for use during construction due to shallow water levels in these areas or narrow and tight access roads. Therefore, contractors may need to travel from further downstream for a suitable launch location. In addition, it is uncertain if the islands will be capable of supporting the necessary equipment for constructing these projects

Figure 29. *Potential river access from Rossford Marina.*

so it is likely that the work will need to be completed from a barge. This may require the contractor to utilize a larger barge that will be stable in the river while the equipment is operating.

Ongoing O&M is anticipated for these projects due to potential damage from strong currents and ice flows (as discussed above) and the potential for invasive plants to become reestablished in these areas. Periodic monitoring is recommended to identify damage or the presence of invasive plants in the early stages. Appropriate maintenance activities may then be implemented before these situations worsen.

In addition, the design phase will involve the following evaluations and consideration that are necessary for refining the current concepts for each project site:

- Pre-design investigations and site characterization to better understand current site conditions, including hydrologic and hydraulic (H&H) modeling, sediment transport modeling, geotechnical investigations, and surface water sampling, depending on the proposed restoration efforts.

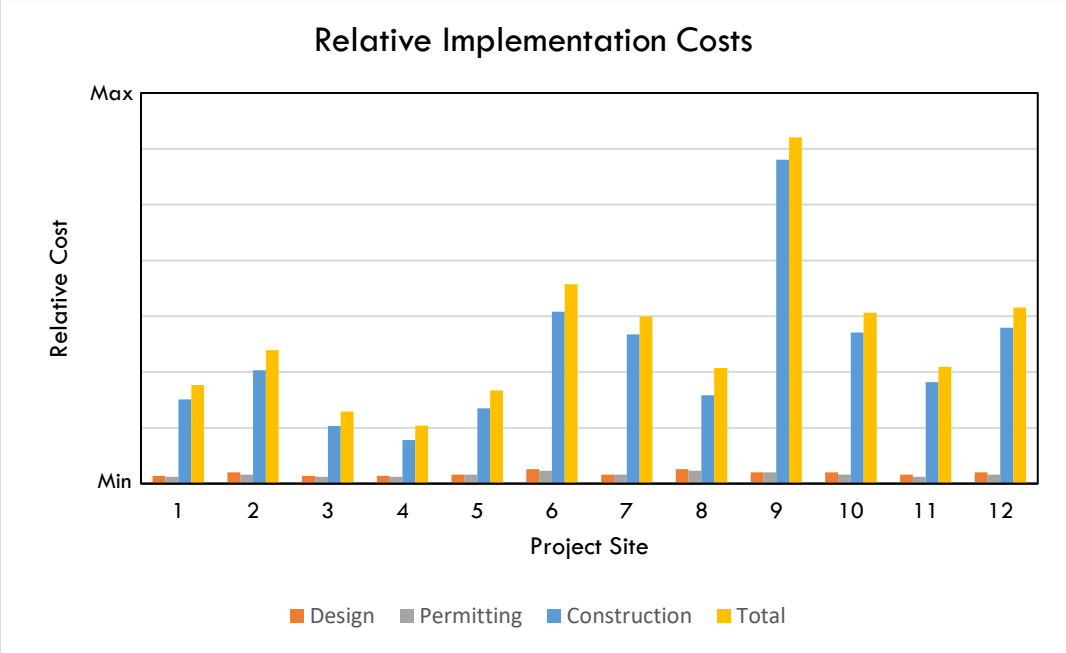
- Determining appropriate locations for installing the selected restoration features (root wads, submerged trees, etc.) that consider the strong currents or ice flows.

- Identifying potential beneficial reuse options for dredged material to minimize costs associated with transportation and upland management.

PRELIMINARY COST ESTIMATE SUMMARY

A preliminary estimate of the potential project costs was prepared for each project site to identify a ballpark range of relative implementation costs and to support the prioritization process. The preliminary estimates include costs for design, permitting, and construction, and include a contingency to account for unknown factors. Estimates assumed a moderate level of effort would be implemented to achieve the desired outcomes for each project site. For example, dredging projects assumed that only a portion of these coves would be actively planted with SAV, with the understanding that active planting will be beneficial to jump start the improved area and planting the entire area may be cost prohibitive.

Graph 1 shows the relative design, permitting, construction, and total costs for each of the project sites. This graph clearly shows that project site #9 is anticipated to have the highest relative cost and project site #4 the lowest. Also, the anticipated costs are primarily associated with construction, and the design and permitting costs are relatively similar for each project site.



Graph 1: Relative design, permitting, construction, and total implementation costs for each project site.

Cost savings may be realized by concurrently implementing multiple projects and costs may be further reduced if the project sites are within the same focus area. These savings may result from such items as site characterization and modeling efforts for design, mussel survey mobilization for permitting, and contractor mobilization and demobilization for construction costs. Therefore, upon selection of the desired project sites to pursue, it is recommended to prepare an overall project cost for the selected sites and evaluate potential savings for identification of additional enhancement work (or projects sites) that may be completed with the available funds.

PROJECT RANKINGS SUMMARY

Project sites were ranked and prioritized through a comparative scoring analysis that focused on general physical attributes, logistics, geographic attributes, habitat areas, initial relative cost estimates, and stakeholder input on the relative importance of five major categories of technical criteria. These categories included feasibility, ecological benefits/effects, environmental impacts/effects, direct human benefits/ effects, and implementation cost. The goal of the comparative scoring analysis was to complete a fair, equitable evaluation of options that can be very dissimilar in overall design, relative ecological impacts/benefits, cost, and implementation. This evaluation may then be used to support allocations of available project funding most efficiently in the near and long-term. As projects are implemented, or other information becomes available (i.e., public input, tribal feedback, etc.), this prioritization matrix may be revised to reflect the new information and determine whether the project site ranking changes as a result. Note that this prioritization matrix is recommended to be used as a guide and not a definitive determination of the projects to be selected. Additional evaluation is recommended to be completed by the project team/stakeholders to consider factors that may not have been captured in the prioritization matrix and to verify the best projects to implement.

The final ranking and prioritization of the project sites considered the technical scoring by the Technical Team and weighted factors assigned by the Selection Team for the five major categories of technical criteria. The Technical Team consisted of individuals from Hull, UT, and BGSU, and the Selection Team was comprised of members of multiple organizations, including the Maumee Area of Concern (AOC) Advisory Committee Beneficial Use Impairment (BUI) 3a, 6, 14a Subcommittee, UT, BGSU, city of Toledo, and Lucas County. For each project site evaluated, the Technical Team assigned technical scores, with higher scores representing benefits, to each criteria. The Selection Team reached a consensus on weighting factors assigned to each technical criteria category, with higher values representing a higher degree of relative importance. For each project site evaluated, the technical scores were multiplied by the weighting factors assigned for that category. The project sites were ranked in descending order, from highest score to lowest score, to represent a potential order to implement the project sites as determined by the comparative analysis. The final weighted ranking is presented in **Table 12**.

The weighted ranking prioritized the project sites located on Audubon Islands and Delaware/Horseshoe Complex over the Grassy Island and Main Channel project sites. Based on the preliminary cost estimate and the prioritization ranking, a potential use of the anticipated $9 million funding recommended by the Maumee AOC Advisory Committee for Lower Maumee River Restoration projects would be implementation of the Audubon Islands and Delaware/Horseshoe Complex project sites with two or three other project sites.

It is recommended to use this ranking as a tool to assist in selecting projects to implement; however, other factors may also influence the final project site selections and/or the order that project sites are constructed. Also, while it is recommended to complete multiple project sites concurrently to realize cost savings related to design, permitting, and mobilization/demobilization costs, it is not necessary to implement every project site within a general area. For example, project sites #2 through #4 may be constructed on Audubon Islands without project site #1. Note that the current ranking may also be altered based on feedback from the State Historic Preservation Office (SHPO), federally recognized tribes, landowners, and project stakeholders.

Table 12. Weighted project site prioritization ranking.

Ranking	Location	Project Site	Restoration Activities	Total Weighted Score
1	Audubon Islands	4	- Install root wads, submerged trees, or other woody debris along bare shorelines - Plant native vegetation along bare shorelines	390.0
2	Audubon Islands	3	- Install root wads, submerged trees, or other woody debris along bare shorelines - Plant native vegetation along bare shorelines	387.0
3	Audubon Islands	2	- Install woody palisades and/or rip rap wall to partially close cove - Dredge cove to 1.5 m - Plant submerged aquatic vegetation	372.0
4	Delaware/ Horseshoe Complex	12	- Install woody palisades and/or rip rap wall to partially close cove - Dredge cove to 1.5 m - Plant submerged aquatic vegetation - Install submerged trees along shorelines	358.0
5	Main Channel	5	- Install rip-rap wing-dikes along exposed shoreline - Install submerged trees between wing dikes along shorelines with little existing woody debris	357.0
6	Audubon Islands	1	- Install root wads, submerged trees, or other woody debris along bare shorelines - Plant native vegetation along bare shorelines	350.5
7	Grassy Island	10	- Install woody palisades and/or rip rap wall to partially close cove - Dredge cove to 1.5 m - Plant submerged aquatic vegetation - Install submerged trees along shorelines	347.5
8	Grassy Island	9	- Install woody palisades and/or rip rap wall to partially close cove - Dredge cove to 1.5 m - Plant submerged aquatic vegetation - Install submerged trees along shorelines	326.5
9	Grassy Island	7	- Install rip-rap wing-dikes along exposed shoreline - Install submerged trees between wing dikes along shorelines with little existing woody debris	326.5
10	Grassy Island	11	- install rip-rap wing dike to shield Grassy Creek flow from Maumee main flow - remove stands of common reed	326.3
11	Main Channel	6	- Install chevron-style riprap dike at upstream end of island	301.8
12	Grassy Island	8	- Install chevron-style rip-rap dike upstream of historical island site	294.5

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