# Braddock Bay Restoration

## 2017 Monitoring and Adaptive Management Report
## APPENDICES

Buffalo District

U.S. Army Corps of Engineers

4/20/2018

US Army Corps of Engineers
Buffalo District
BUILDING STRONG

Great Lakes RESTORATION

# APPENDIX A: BRADDOCK BAY RESTORATION: ADAPTIVE MANAGEMENT PLAN

# Braddock Bay Restoration

## Monitoring and Adaptive Management Plan

Buffalo District

U.S. Army Corps of Engineers

7/23/2015

US Army Corps of Engineers
Buffalo District
BUILDING STRONG

Great Lakes RESTORATION

Contents



**Appendices**

# 1.0 Purpose and Background

This document describes the monitoring and adaptive management plans for evaluating the intended outcome of the Braddock Bay Restoration project. Adaptive management is a formal science-based approach to undertaking goal-directed actions with uncertain outcomes, and evaluating their results in order to direct future actions. Simply stated, adaptive management is doing while learning in the face of uncertain outcomes (Fischenich, 2011).

The U.S. Army Corps of Engineers (USACE), Town of Greece, and the New York Department of Environmental Conservation have formulated this monitoring and adaptive management plan in coordination with interested stakeholders including U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the Braddock Bay Advisory Committee, The Rochester Area of Concern Remedial Action Committee, SUNY Brockport, the Nature Conservancy, and others as part of the design phase for the Braddock Bay restoration project. This document provides a recommended approach to monitoring and adaptive management of the Braddock Bay restoration project.

Restoration of Braddock Bay is a goal and not a guarantee. No one can predict with certainty how the ecosystem will change. Over time existing natural processes will determine the outcome of the restored ecosystem; restoration is only the catalyst that sets up the new natural processes. Given the current limitations of past and present anthropogenic alterations of the landscape and lake levels, the project goals are to maintain the present ecosystem; it cannot return the Braddock Bay ecosystem to a particular historic condition. The lead partners are committed to using the best science available in their efforts to plan, implement and monitor the proposed restoration project.

The implementation of the long term monitoring tasks will depend upon the expertise and capacity of many project partners such as New York Department of Environmental Conservation and the Town of Greece staff, USACE, volunteer organizations (e.g. Braddock Bay Advisory Committee and Rochester Embayment Remedial Advisory Committee) to work together to ensure funding and resources are provided.

## 1.1 Background

Adaptive Management prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state. Adaptive management promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (NRC, 2004).

Several key principles serve as the foundation for adaptive management:

1. Management flexibility is incorporated in the design and implementation of programs or projects.

2. Scientific information obtained through continued monitoring is used to evaluate and manage uncertainties to achieve desired goals and objectives.

3. Scientific information is introduced into the decision-making process and guides managers during project implementation.

4. Projects and programs can be implemented in phases to allow for mid-course corrections based on new information.

5. Interagency collaboration and productive stakeholder participation are key elements to success.

Adaptive ecosystem based management has become a fundamental practice being applied to a variety of environmental protection and restoration actions within New York State (NYS) Great Lakes basin. Adaptive management principles described below are consistent with, although not necessarily identical, to those principles being implemented through Bi-national Great Lakes Water Quality Act the International Joint Commission, Great Lakes Adaptive Management Committee, the US ocean policy, and NYS Great Lakes action agenda.

New York's Great Lakes action agenda includes 2 specific actions (3.1 and 3.5) for monitoring and evaluating beneficial use restoration efforts in AOCs. These monitoring actions follow the steps of adaptive management outlined by Great Lakes Action Agenda (2014) they are:

1. **Conceptualize the problem** by defining the scope, vision, targets and complete situation analysis;

2. **Plan Actions and Monitoring** through development of goals strategies and assumptions. Develop an operation and monitoring plan;

3. **Implement** the Actions and Monitoring by developing a work plan and timeline;

4. **Analyze Use and Adapt the plan** through analysis of the data, and change the plan if necessary to achieve the stated goals and objectives; and

5. **Share the output** of the plan in an outreach or educational environment.


**Figure 1. Adaptive management steps from New York's Great Lakes action agenda.**

## 1.2 Responsible Parties

NYSDEC manages Braddock Bay Wildlife Management Area (BBWMA) under a Management Plan. Work is carried out by NYSDEC and other partners, such as the Town of Greece. The Braddock Bay Advisory Committee (BBAC) consults with the NYSDEC. This adaptive management plan will be become an amendment to the Management Plan. Implementation of the individual tasks of this adaptive management plan will be the responsibility of the partners as outlined. The BBAC will assure that the strategies and rationale of the restoration project are sound and provide advice on the implementation of the adaptive management plan. NYSDEC and USACE will provide technical assistance to the BBAC to determine when ecologic success criteria are achieved and what monitoring to carry forward. The NYSDEC will coordinate yearly monitoring reports with the Town of Greece, BBAC and other partners. The ultimate decision of what individual monitoring components to carry out will be at the discretion of NYSDEC and may be constrained by available funding. If adaptive management measures are required, adequate funds need to be available for any work that may be needed. Intra and inter-agency coordination will be necessary to ensure that funded monitoring and funded adaptive management measures are being performed as outlined in this plan.

## 2.0 Adaptive Management Plan Development

Adaptive Management helps to achieve desired goals by addressing uncertainty, incorporating flexibility into project design, using new information to inform decision-making.

### 2.1 Project Goals and Objectives

The first step in designing an evaluation program for the Braddock Bay Restoration Project is to define the goals and objectives for the project. As stated in the Feasibility Report (September 2014), the planning objectives are as follows:

1. Restore wetland and habitat diversity in Braddock Bay to improve its suitability for fish and wildlife including northern pike, American mink, and the state listed black tern during the planning period of 2015-2065.

2. Protect Braddock Bay wetlands from erosion during planning period of 2015 – 2065.

Together these objectives enhance coastal resiliency and ecosystem integrity.

Goals for a monitoring and adaptive management plan for the project should measure whether these objectives have been met or not. Generally, the monitoring and adaptive management plan should address the following:

- Layout a monitoring plan to collect pertinent ecological data to inform decision making,
- Provide a basis for assessing if project objectives were achieved,
- Formulate a decision making framework for determining if adaptive management actions are necessary to achieve project objectives; and
- Provide a thorough understanding of the ecosystem with and without restoration.

### 2.2 Constraints

Several constraints were identified during the planning phase and where considered during plan selection. Of these, four have residual uncertainty that could be reduced through monitoring and adaptive management plan:

1. Avoid negatively impacting navigability and operation of marinas within bay.

2. Avoid impacts to nutrient dynamics of Braddock Bay that will worsen eutrophication.

3. Avoid negative impacts to Lake Ontario littoral drift system.

4. Avoid project activities that will increase extent of invasive species at project site.

### 2.3 Specific Monitoring Components

The adaptive management plan will focus on addressing key uncertainties associated with the proposed restoration plan. These uncertainties have potential to impact the degree to which project objectives are achieved and project constraints are avoided. In order to adequately determine if restoration outcomes have achieved the project objectives and avoided constraints, the monitoring plan will address the following components:

1. Vegetative diversity of Braddock Bay wetland (Objective 1)
2. Fish and wildlife diversity of Braddock Bay wetland (Objective 1)
3. Erosion rate of central marsh (Objective 2)
4. Navigability of bay mouth (Constraint 1, 3)
5. Water chemistry parameters specific to trophic status (Constraint 2)
6. Local littoral sediment transportation (Constraint 3)
7. Invasive species presence in restoration areas (Constraint 4)

### 2.4 Collaborative Development

This plan was developed in coordination with the Braddock Bay Interagency Technical Committee consisting of various local, state, and Federal organizations with interest in the project. Comments and suggestions were received from the Town of Greece, NYSDEC, Rochester Embayment RAP, SUNY Brockport, USFWS, USEPA, The Nature Conservancy, Ducks Unlimited, New York Department of Transportation, and others.

## 3.0 Monitoring and Performance Criteria

The Monitoring, Adaptive Management Technical Guide drafted by the U.S Department of the Interior outlines four key purposes for adaptive management data (Williams, 2007). These purposes include:

1. Evaluate progress toward achieving objectives.
2. Determine resource status, in order to identify appropriate management actions.
3. Increase understanding of resource dynamics via the comparison of predictions against survey data.

4. To enhance and develop models of resource dynamics as needed and appropriate.

For this project, monitoring will focus on at evaluating progress towards achievement of project objectives and determining if project constrains have been avoided. Comparison of monitoring data to pre-determined performance criteria will be used to assess the status of the resource and determine if adaptive management actions are required.

Monitoring will occur before construction and for a period of five years after construction is complete. This timeframe is expected to be sufficient to determine if wetland restoration measures have been successful at increasing habitat diversity and if wetland loss through erosion has sufficiently been reduced. However, it is uncertain if this time period will be of sufficient length to adequately observe the response of fish and wildlife species to the improved habitat suitability.

Monitoring activities will be coordinated with other projects whenever possible to minimize costs and provide the maximum benefit. While it may be possible that USACE is funded to complete an initial round of monitoring and analysis, long term implementation of the plan relies heavily on current monitoring efforts that are being done within Braddock Bay and in other parts of the Braddock Bay Fish and Wildlife Management Area. Habitat and wildlife surveys that are conducted as part of existing monitoring efforts could serve as a baseline from which to evaluate treated wetland areas. The monitoring activities outlined in this plan compliment other monitoring activities being conducted by the BBAC, NYSDEC, watershed councils, SUNY Brockport, Natural Heritage and non-governmental organizations (e.g. Ducks Unlimited, The Nature Conservancy, Audubon Society) and other entities.

## 3.1 Monitoring Framework

### 3.1.1 Monitoring For Project Objectives

The monitoring framework for the project objectives is aimed at addressing if project activities have successfully achieved both project objectives: 1) restoring wetland and habitat diversity to improve its suitability for fish and wildlife including northern pike, American mink, and the state listed black tern; and 2) protecting Braddock Bay wetlands from erosion. The data from the monitoring plan will be used as part of an adaptive management framework to address key uncertainties associated with proposed project activities.

***Key Uncertainties***:

- Will topographic variability added through channeling and potholing maintain a diversity of vegetation communities; or will cattail invade these higher and lower elevations?
- Will increased open water interspersion improve habitat for fish and wildlife species?
- Will the rate of wetland erosion be consistent with post construction modeling estimates?
- Will native submerged aquatic vegetation species expand their range as a result of the lower wave energy conditions created by the restored barrier?
- Will the diversity of aquatic vegetation beds increase as a result of the lower wave energy conditions created by the restored barrier?
- Will the restoration of a barrier between Braddock Bay and Lake Ontario significantly contribute to eutrophication within the bay?

### 3.1.2 Monitoring for Constraints

The monitoring framework for project constraints is aimed at addressing if project activities have adequately avoided project constraints (Figure 4). This monitoring data will be used as part of an adaptive management framework to address key uncertainties associated with proposed project activities.

***Key Uncertainties***:

- Have project activities resulted in unforeseen negative impacts to navigation?
- Have project activities resulted in unforeseen negative impacts to the trophic state of the bay?
- Have project activities resulted in unforeseen negative impacts to littoral drift?
- Have project activities resulted in unforeseen negative impacts associated with invasive species?

# Monitoring Framework (Objective 1)

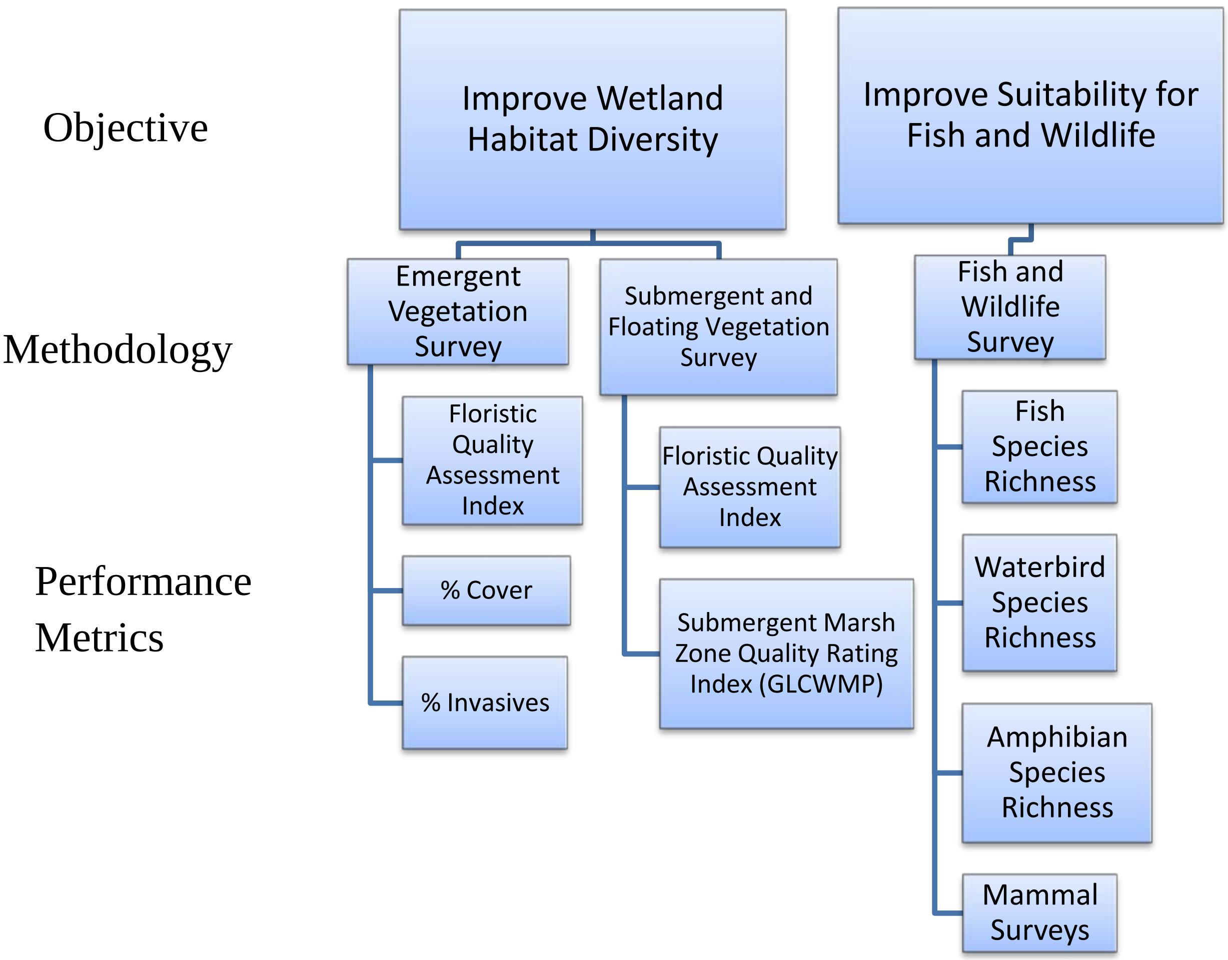



**Figure 2. Monitoring Framework for Objective 1**

# Monitoring Framework (Objective 2)

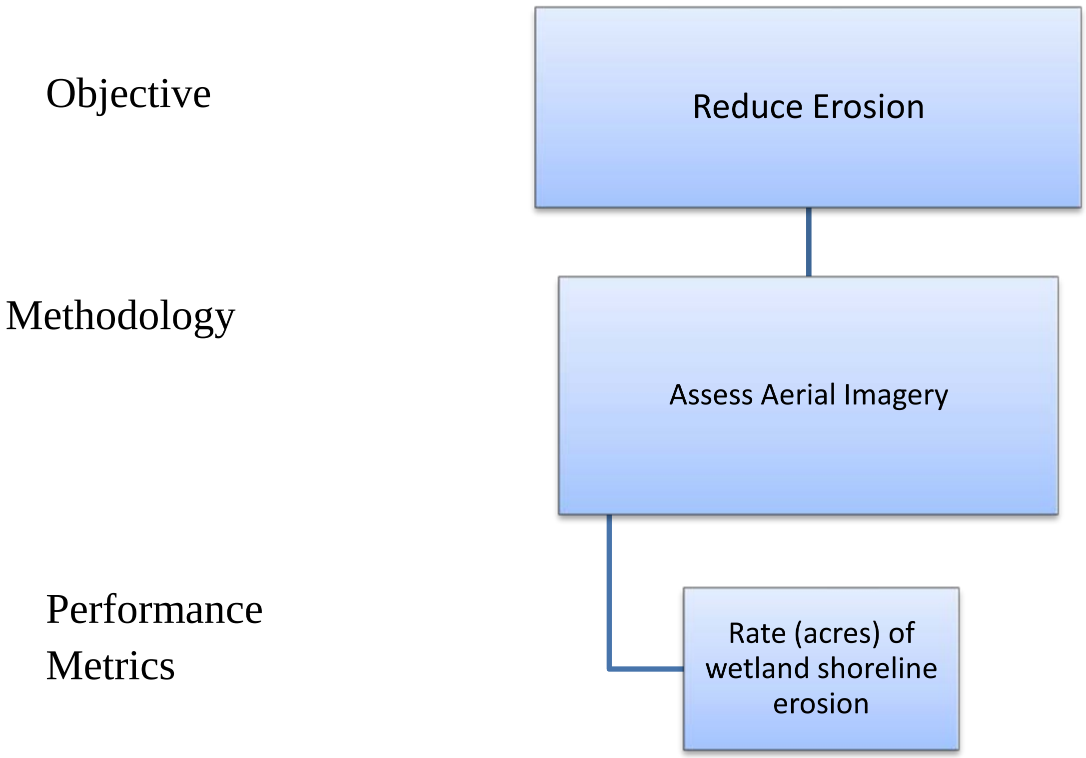



**Figure 3 Monitoring Framework for Objective 2**

# Constraints Monitoring Framework

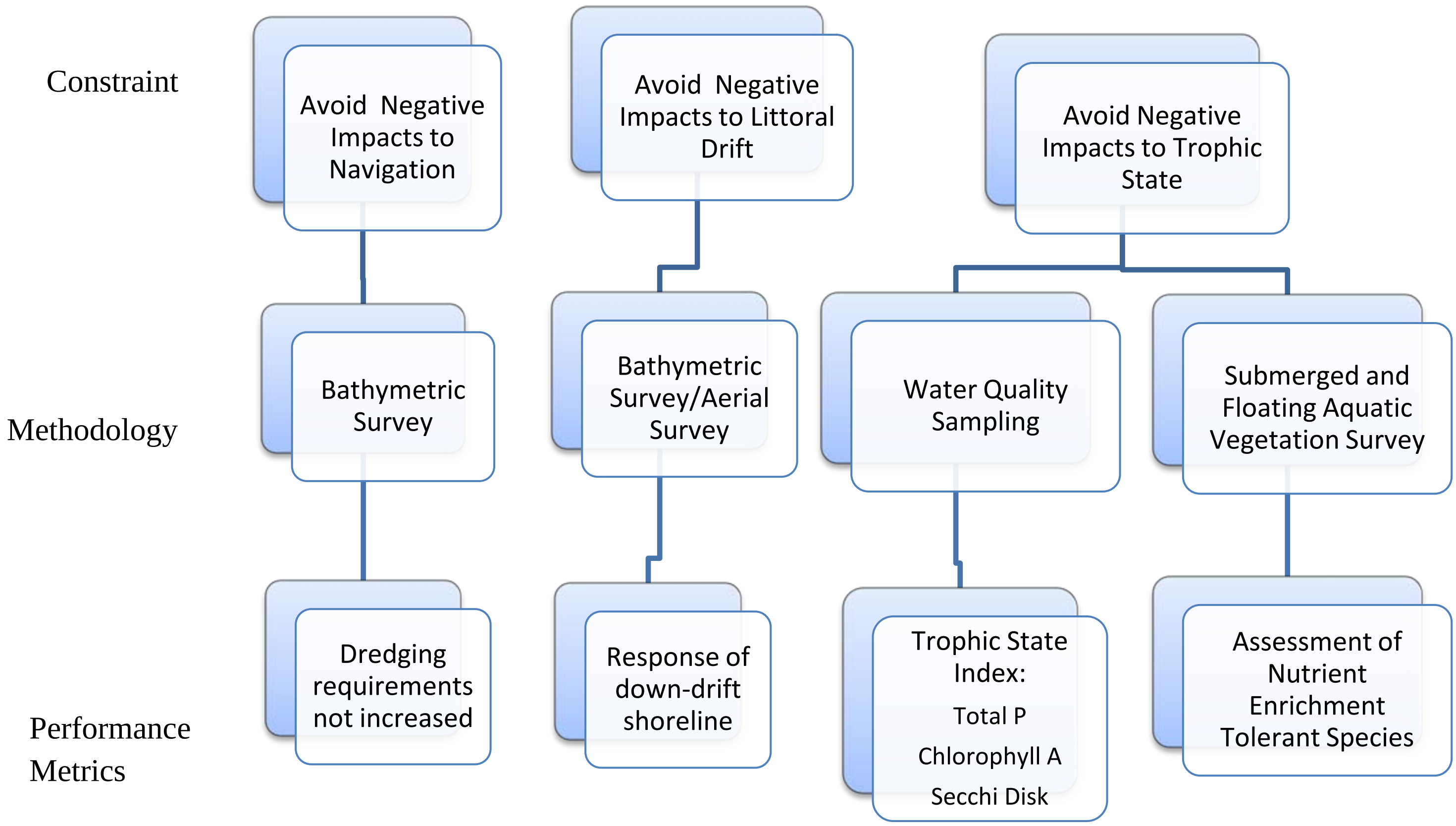



**Figure 4. Monitoring Framework for Constraints**

## 3.2 Vegetation Monitoring

### 3.2.1 Emergent Marsh Monitoring

#### (1) Monitoring

The emergent vegetative community in the area of restoration will be monitored to determine if project measures have been successful at restoring wetland and habitat diversity at Braddock Bay (Objective 1). Data collected regarding invasive species presence and absence will also help in determining if the project has adequately avoided the constraint of spreading invasive species (Constraint 4). If funding allows, vegetation monitoring should begin in the peak of the first growing season following construction of project components as this is a critical time to observe the establishment of both desirable and invasive species.

*Frequency* – Emergent vegetation monitoring will occur once per year during the peak of the growing season (July/August).

*Methodology* – Long-term dedicated $1m^2$ survey plots along transects spanning restoration area. See Appendix A for recommended vegetation monitoring protocols.

*Data Collected* – All species observed, total percent cover, native percent cover, invasive percent cover, species richness, cover type present (e.g. cattail, broad leaf emergent, floating aquatic). Notes on the condition of channels and potholes will also be recorded at sampling location.

#### (2) Ecologic Performance Criteria

**FQAI:** The Floristic Quality Assessment Index (FQAI) will be used to measure improvements to the wetland habitat diversity of Braddock Bay. Calculation of FQAI will use Coefficient of Conservatism (CoC) values from the Michigan FQAI (Herman et al. 2001) as recommended by the Great Lakes Coastal Wetland Monitoring Plan, but scores will be modified to set the CoC value for any New York regulated and prohibited species (as per 6 NYCRR Part 375) to 0 (see (http://www.dec.ny.gov/regulations/93848.html). To determine if wetland habitat diversity has improved from restoration, data from restored areas of Braddock Bay will be compared to control areas that were not restored. Ecological performance criteria will be met if FQAI scores from restored areas exceed scores from unrestored control areas. Currently the FQAI score for the existing emergent marsh at Braddock Bay is 17.8 as calculated from data collected in 2011 (USACE, 2014).

**Percent Vegetative Cover:** Percent vegetative cover will be used to measure the establishment of wetland plants in restored areas. Areas with less than the target percent cover of native wetland species will be considered for additional plantings. The target percent cover is 80% for emergent and sedge grass meadow areas.

**Invasive Species Cover:** Invasive species cover will be used to determine if management actions are necessary to deter the establishment of invasive species in restored areas as a result of construction activities. Any occurrence of *Phragmites* should be addressed immediately through treatment or physical removal. Some establishment of *Typha angustifolia* and *Typha x glauca* is unavoidable; however, treatment or removal should be considered if percent cover exceeds 50% of the area of an individual restored feature (e.g. individual pothole). Other invasive species are not expected to be as aggressive but should be considered for treatment if percent cover exceeds 10% of restored area or 10% of the area of an individual restored feature.

#### (3) Adaptive Management Measures

- *Additional plantings/seedings*
- *Invasive species management*

It is likely that maximum vegetative diversity may take several growing seasons to develop. If the above criteria are not achieved within the first three growing seasons, adaptive management measures should be considered. The trajectory of the vegetative community establishment should be part of this consideration. If the trend of vegetative diversity is increasing, management actions may not be necessary. However, if it appears the development of the community is not progressing on the desired trajectory or, if invasive species are gaining dominance in the communities, management actions may be necessary. These measures could include additional plantings, seedings, and invasive species management.

### 3.2.2 Submerged Aquatic Vegetation and Floating Aquatic Vegetation Beds Monitoring

#### (1) Monitoring

The submerged aquatic vegetation (SAV) and floating aquatic vegetation communities at Braddock Bay will be monitored to determine if project measures have been successful at restoring wetland and habitat diversity at Braddock Bay (Objective 1). Vegetation data will also be used to assess if changes in the trophic state of Braddock Bay are occurring (Constraint 2). Data collected regarding invasive species presence and absence will also help in determining if the project has adequately avoided the constraint of spreading invasive species (Constraint 4).

*Frequency* –Once per year during the peak of the growing season (July/August).

*Methodology* –Direct visual observation or rake method. Wetland quality measured using FQAI. Dominance of nutrient enrichment tolerant vegetation will also be assessed. See Appendix A for recommended vegetation monitoring protocols.

*Data Collected* – Record all species observed (floating, submerged, and algae) and relative abundance at sampling points. Total vegetation cover measured at beginning, middle, and end of transects.

### (2) Ecologic Performance Criteria

The FQAI will be applied to SAV in segments 4 and 5 in the area offshore of the central emergent marsh, that will be protected from wave energy as a result this project. Calculation of FQAI will use Coefficients of Conservatism (CoC) from the Michigan FQAI (Herman et al. 2001) as recommended by the Great Lakes Coastal Wetland Monitoring Plan, but scores will be modified to set the CoC value for any New York regulated and prohibited species (as per 6 NYCRR Part 375) to 0 (see (http://www.dec.ny.gov/regulations/93848.html). The vegetative quality of these areas is anticipated to increase from baseline conditions as a result of project measures. To measure this, an FQAI score will be calculated using data from all survey quadrats in this area. Index scores that exceed the baseline value of 11.31will provide evidence that the quality of the aquatic vegetation in this area is increasing. See Appendix 1 for additional detail on the monitoring methods and data interpretation.

Changes in the trophic state of Braddock Bay will be measured by assessing the relative abundance of aquatic plant species tolerant of nutrient enrichment conditions. In each segment, the number of sample points dominated by nutrient enrichment tolerant species will be compared to sample points dominated by other species that are not-tolerant of nutrient enrichment. Nutrient enrichment tolerant species are those defined in tables 3-6 of the Great Lakes Coastal Wetland Monitoring Plan (2008), see Figure 9. This comparison will be useful in determining if nutrient enrichment tolerant species are expanding their range in Braddock Bay in subsequent monitoring years following restoration. The year to year comparison in the number of sample locations dominated by nutrient enrichment tolerant species will provide evidence regarding shifts in the Braddock Bay submerged aquatic vegetation community. Increases in the occurrence of nutrient enrichment tolerant species may indicate conditions are becoming more eutrophic. This assessment should be used along with water quality data to determine if eutrophication is increasing. See Appendix 1 for additional detail on the monitoring methods and data interpretation.

### (3) Adaptive Management Measures

- *More frequent water quality sampling*
- *Excavate relief valve*
- *Invasive species treatment*

An initial adaptive management measure in response to changes in vegetation should be more frequent water quality sampling to verify that the shifts are associated with changes in water quality and not some other factor. If it is determined that vegetation shifts are related to water quality changes resulting from construction of the barrier beach, adaptive management measures should include excavating the 200 foot "relief valve" channel on the eastern side of the constructed barrier to allow for a greater degree of mixing between Braddock Bay and Lake Ontario during the growing season. If it is determined that vegetative shift are due to occurrence of an invasive species that could be effectively controlled, invasive species treatment should be considered.

## 3.3 Fish and Wildlife Monitoring

### 3.3.1 Monitoring

Surveys of fish, waterbirds, mammals and amphibian species will be conducted in channel and pothole areas to determine if project measures have been successful at improving the suitability of the Braddock Bay wetland for fish and wildlife (Objective 1).

*Frequency* – Monitoring should occur on the $1^{st}$, $3^{rd}$ and $5^{th}$ year after restoration.

Fish monitoring will occur twice in a given sampling year. Once in the early spring during the northern pike (*Esox lucius*) spawning season and once in late-summer. Monitoring in accordance with the Marsh Monitoring Program for birds and amphibians will occur three times during spring and early summer of a sampling year (BSC, 2000). Waterbird species surveys conducted at the restored barrier beach three times in a given sampling year. These surveys will be conducted in late April, mid-June and late August in order to account for waterbird presence during the spring migration, breeding season and fall migration, respectively.

*Methodology* – Monitoring for fish will follow similar protocols to what have been implemented at other restored wetlands in the Braddock Bay WMA by The Nature Conservancy and SUNY Brockport. Monitoring for waterbirds and amphibians will follow Marsh Monitoring Program protocols. The restored barrier beach waterbird surveys will target species richness and will be conducted in order to document habitat use of this restored habitat type.

*Data Collected* – Species abundance and richness. Northern pike adult and young-of-the-year abundance.

### 3.3.2 Ecologic Performance Criteria

**Fish Species Richness and Abundance:** Fish monitoring using Fyke nets will be conducted to determine the presence of fish within restored channels post-construction. Monitoring for fish will follow similar protocols to what have been implemented at other restored wetlands in the

Braddock Bay WMA by The Nature Conservancy (TNC, 2015) and SUNY Brockport. It is anticipated that a total of 4 channels in the restoration will be monitored. The purpose of monitoring is to document utilization of the restored area by northern pike, young-of- the year northern pike, and other fish species. Data indicating presence of adult and juvenile northern pike will be evidence that the suitability of wetland habitat has been increased, and the performance criteria will be considered to be met. Sampling will include the use of fyke nets set up at key newly constructed channels in order to capture northern pike of various age class as well as various other fish species.

**Amphibian and Waterbird Species Richness:** Monitoring for waterbirds and amphibians will follow Marsh Monitoring Program protocols (BSC, 2000). Success will determined to be achieved if species richness of waterbirds and amphibians, exceeds pre-restoration conditions. Baseline data is provided in the Braddock Bay Feasibility Assessment & Design Recommendations (Appendix 6-D; USACE, 2014). Waterbird surveys targeting species richness will also be conducted at the newly constructed barrier island protocols are employed. It is recommended that these surveys be conducted on the same day that the MMP surveys are conducted in order to minimize site visits.

**Mammals and American Mink:** There will be no formal monitoring for mammals or American mink, however evidence of mammal use within channels and potholes should be noted.

### 3.3.3 Adaptive Management Measures

- *Additional habitat enhancements*

It is likely that maximum fish and wildlife richness may take several years to develop. However, if the above criteria are not achieved within five years following construction, adaptive management measures should be considered. The status of wetland and habitat diversity should be accounted for when considering if management measures are necessary. If wetland and habitat diversity are proceeding as desired, it may not be necessary to implement adaptive management measure; it is possible more time is needed for species richness or abundance to increase. However, if it appears that wetland and habitat diversity gained through the project are not providing the necessary requirements to increase habitat suitability, management actions may be necessary. These measures could include additional habitat enhancements such as invasive species treatment, seedings, contouring or emergent wetland restoration.

## 3.4 Wetland Erosion Monitoring

### 3.4.1 Monitoring

The erosion rate of the central wetland will be monitored to determine if restoration measures have been successful at protecting the central wetland of Braddock Bay from erosion (Objective 2). Erosion rates of the emergent wetland shoreline will be surveyed in the field or assessed using aerial imagery or visual inspection.

*Frequency* – Monitoring will occur during or immediately following construction and five years after construction.

*Methodology* – Identify the percent cover of wetland vegetation on aerial photographs, and/or use GPS or traditional survey techniques to map the perimeter of wetland vegetation patches.

*Data Collected* – Area of emergent wetlands eroded. Area of wetland accretion or establishment.

### 3.4.2 Performance Criteria

**Rate of Erosion:** Aerial imagery for Braddock Bay will be used to estimate rates of erosion. Data sources for this aerial imagery includes the National Agriculture Imagery Program (NAIP) and the Monroe County Survey. Success is met if the rate of erosion post-construction is within the range of the projected rate of erosion under Alternative 7c (0.23 to 0.55 acres per year). Calculation of the rate of erosion should account for any wetland accretion or establishment.

### 3.4.3 Adaptive Management Measures

- *Additional shoreline protection*
- *Emergent wetland restoration along existing shoreline*

If the above criteria are not achieved following construction, adaptive management measures should be considered. Additional shoreline protection such as a low-crested green breakwater could be constructed to further reduce erosion of the emergent marsh. Emergent wetlands could be restored along the existing shoreline by filling in shallow open water areas that are devoid of vegetation with sediment from the bay.

## 3.5 Navigation Monitoring

The bathymetry of the Braddock Bay navigation channel will be monitored to determine if proposed restoration measures have successfully avoided disruptions to the navigability of the bay (Constraint 1).

### 3.5.1 Monitoring

*Frequency* - Monitoring will occur once per year during the spring.

*Methodology* – Bathymetric survey.

*Data Collected* – Bathymetry of bay mouth.

### 3.5.2 Performance Criteria

**Dredging Requirement:** Bathymetric data will be collected yearly following construction. The data should qualitatively analyzed to determine the degree of navigability of the Braddock Bay mouth in coordination with the Town of Greece and the Braddock Bay Marina. If navigation channel dredging requirements are not increased from pre-construction requirements this performance criteria will be determined to be met.

### 3.5.3 Adaptive Management Measures

- *Modify Breakwater*
- *Change Location of Navigation Channel*

If the above criteria are not achieved following construction, adaptive management measures should be considered. The measures include changing the location of the navigation channel or modifying the barrier beach structure to improve navigation.

## 3.6 Trophic State Monitoring

Water quality parameters of Braddock Bay will be monitored to determine if the trophic state of Braddock Bay has been negatively impacted by project activities (Constraint 2). To capture the variability of conditions within the bay, it will be divided into separate monitoring segments. Water quality parameters will include total phosphorus (TP), chlorophyll a, and turbidity. Survey data of submerged and floating aquatic vegetation within the bay will also be used in trophic state monitoring as described in Section 3.2.2.

*Frequency* - Monitoring will occur 4 times per year in June, July, August, and September (nutrient concentrations and primary productivity at Braddock Bay are greatest in the months of May to September).

*Methodology* –Braddock Bay will be divided up into several segments and water quality parameters and Secchi Disk depth will be collected from each segment. Sampling data will also include a sample from Lake Ontario, just outside of Braddock Bay, and from Buttonwood and Salmon Creek. The trophic state will be assessed for each segment using the Trophic State Index (TSI) (Carlson, 1977). Aquatic vegetation surveys will also be used in trophic state monitoring as described in Section 3.2.2. See Appendix A for details on monitoring.

*Data Collected* – Total phosphorus, chlorophyll a, and Secchi Disk depth will be used to calculate the TSI. Vegetation data will be used as discussed in section 3.2.2. Other water quality information collected includes dissolved reactive phosphorus, total nitrogen, nitrate/nitrite, dissolved oxygen, turbidity, and total dissolved solids.

### 3.6.1 Performance Criteria

**Trophic State Index (TSI):** The Trophic State Index (TSI) (Carlson, 1977; MPCA, 2008) will be used as the basis for ecologic performance criteria for Braddock Bay. The typical classifications for trophic state (eutrophic, oligotrophic, mesotrophic) are limited in their utility in that there are not clear definitions separating these categories. Assigning ecological thresholds using these categories is especially problematic in situations like Braddock Bay where conditions are currently considered to be eutrophic. The TSI relates measurements of water clarity (Secchi disk depth), chlorophyll-a, and total phosphorus to an index value representing trophic conditions. Scores of 30 and below indicate oligotrophic conditions while scores above 70 represent hypereutrophic conditions. The TSI offers a relatively simple method for assessing the current state trophic state of Braddock Bay and tracking it over years following construction. Water sampling and TSI calculations will be conducted by segment for segments 2, 3, 4 and 5 of Braddock Bay (Table 1). Additional water quality samples will be taken from Salmon Creek, Buttonwood Creek, and Lake Ontario in the vicinity of Braddock Bay. See Appendix A for water quality sampling methodologies.

Based on existing monthly average chlorophyll-a data from 2003 - 2009, Braddock Bay's TSI currently fluctuates in the 50s in the summer months (May– August). Therefore, a TSI of 60 represents an appropriate ecological threshold for Braddock Bay and should be calculated using measurements of chlorophyll-a. This equates to a chlorophyll-a concentration of 20 ug/L (Table 1). Repeated exceedances of this threshold in the months of June – August should be a trigger for assessing the need for adaptive management actions. It would not be appropriate to apply this threshold to September, as existing data indicates average monthly chlorophyll-a concentrations for September exceed this value. Rather, data collected in September should be used to complete a trend calculation after five consecutive years of sampling. A rolling trend can be applied for each subsequent year. A clear increasing trend indicated by this data should be a trigger for adaptive management action. See Appendix B for additional discussion of historic data for justification of this ecological threshold.

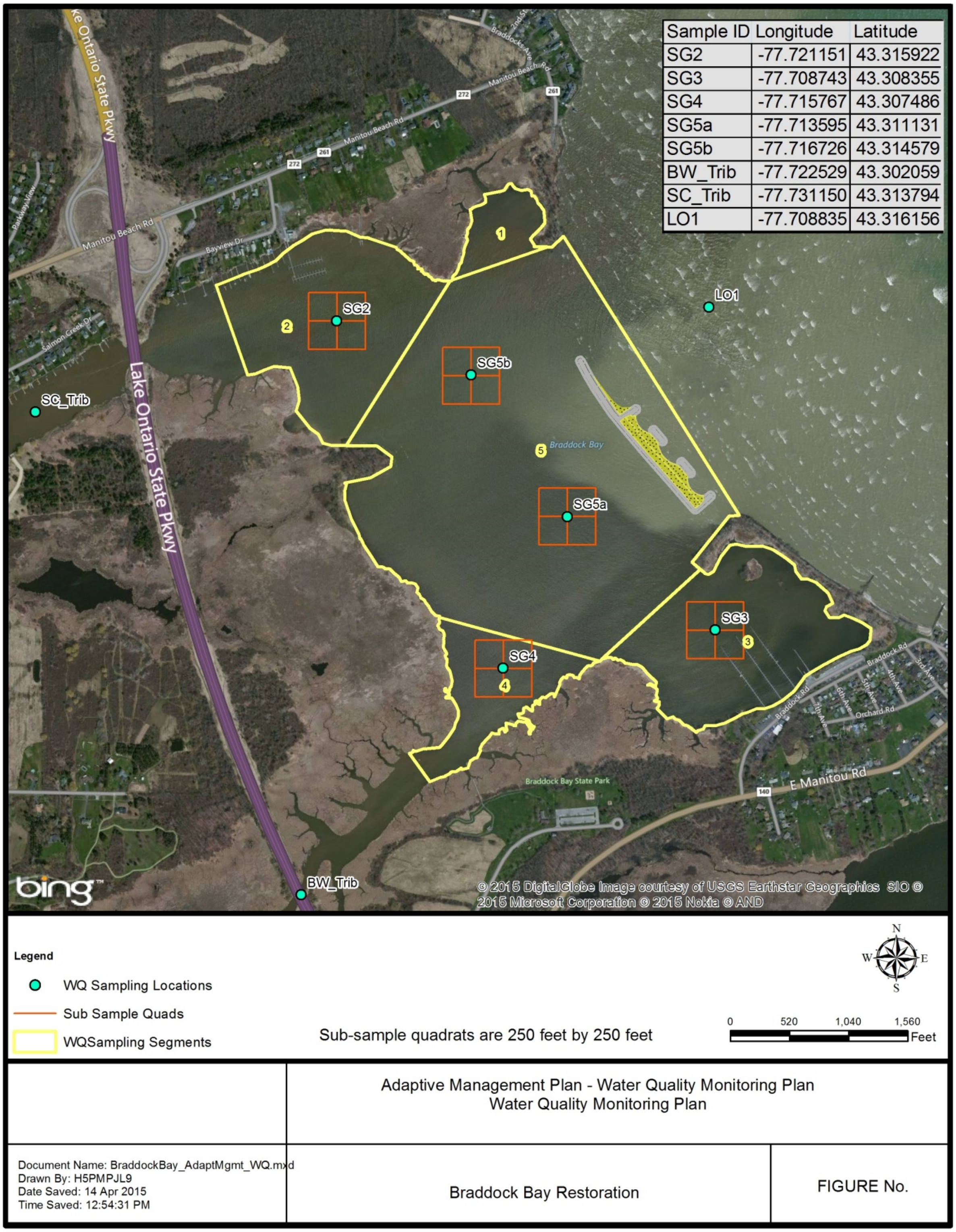
In recent years, New York State Department of Environmental Conservation (NYSDEC) has established an "action level" for chlorophyll of 30 ug/L as a trigger for citing a water body as having potential blue-green algae. This 30 ug/L threshold will also be used as trigger for adaptive management action at Braddock Bay. Exceedances of this threshold require immediate adaptive management actions.

One short coming of the data set used to determine this ecological threshold is that it provided average concentrations of chlorophyll-a for summer months, and therfore did not capture the full range of variability. Additionally, samples were not collected from across Braddock Bay, but only from one location within the bay. This should be taken into consideration when comparing the yearly monitoring data and making determinations about if adaptive management steps are necessary. Exceedences of this ecologic criteria may be within the natural range of variability in conditions in parts of the bay. Therefore decisions on adaptive management actions should be based on clear trends of decreasing water quality supported by repeated exceedances of the trophic state.

Total Phosphorus and Secchi Disk data should also be collected at designated sampling locations. This data should be used to complete a trend analysis after 5 years of sampling data is collected. A clear negative trend should serve as a trigger for adaptive management.

**Table 1. Target Trophic State Index**

| TSI | Secchi Disck (m) | Surface phosphorus (ug/L) | Surface chlorophyll (ug/L) | Water Quality Criteria |
|---|---|---|---|---|
| **60** | 1 | 48 | **20** | **Target** |
| | | | **30** | **Action Level** |




| Sample ID | Longitude | Latitude |
|---|---|---|
| SG2 | -77.721151 | 43.315922 |
| SG3 | -77.708743 | 43.308355 |
| SG4 | -77.715767 | 43.307486 |
| SG5a | -77.713595 | 43.311131 |
| SG5b | -77.716726 | 43.314579 |
| BW_Trib | -77.722529 | 43.302059 |
| SC_Trib | -77.731150 | 43.313794 |
| LO1 | -77.708835 | 43.316156 |

Legend
- WQ Sampling Locations
- Sub Sample Quads
- WQSampling Segments

Sub-sample quadrats are 250 feet by 250 feet

Adaptive Management Plan - Water Quality Monitoring Plan
Water Quality Monitoring Plan

Document Name: BraddockBay_AdaptMgmt_WQ.mxd
Drawn By: H5PMPJL9
Date Saved: 14 Apr 2015
Time Saved: 12:54:31 PM

Braddock Bay Restoration

FIGURE No.

**Figure 5. Water Quality Monitoring**

### 3.6.2 Adaptive Management Measures

- *Dredge relief valve*
- *Reduce watershed loading*
- *Modify breakwater*

If monitoring demonstrates clear evidence of worsening conditions related to trophic state in Braddock Bay, adaptive management measures should be considered. The seasonal and long term trends of the Braddock Bay trophic state should be part of this consideration. In order to avoid unnecessary action or expenditure of resources, adaptive management actions should only be implemented if monitoring clearly indicates trophic state is trending toward exceedance of the established ecological threshold or if trophic state remains elevated over the ecological threshold for consecutive monitoring years. Several adaptive management measures could be implemented to reduce trophic conditions in the bay.

The current plan includes a “relief valve” in the design of the barrier beach structure. This “relief valve” is a 200 ft channel between the proposed structure and the end of the existing jetty on the eastern side of Braddock Bay. As an adaptive management measure, sediment can be dredged from this opening to create a deeper channel and increase exchange of water between the bay and lake. This will provide a relatively low cost and quickly implementable option for reducing eutrophication in the bay if it is determined to be problematic.

A second consideration for adaptive management is to reduce nutrient loading in Braddock Bay watershed. This option may be more costly and more difficult to achieve than the relief valve; however, it will create long lasting improvements to the trophic state of the bay. This option should be explored regardless of the changes in trophic state at Braddock Bay, because reduced loading would further improve conditions in Braddock Bay.

As a last resort, the breakwater could be modified or partially dismantled or removed.. This should be viewed only as a last resort if long term data clearly indicates substantial degradation of habitat quality and the usability of Braddock Bay. This action is also likely to have a large cost. However, if conditions in the bay are clearly worsening to an unacceptable condition, this option could be implemented to return the bay to the pre-construction condition.

## 3.7 Littoral Sediment Transfer Monitoring

The net deposition/erosion of littoral sediment will be monitored to determine if proposed restoration measures have successfully avoided disruptions to the local littoral drift system (Constraint 3). This will be measured through aerial photography and bathymetric surveying.

*Frequency* - Monitoring will occur biennially during the spring.

*Methodology* – *S*urvey of aerial imagery and bathymetric survey.

*Data Collected* – Response of shoreline down-drift of the project.

### 3.7.1 Performance Criteria

**Response of updrift/downdrift shoreline:** Assessments of the restored barrier beach and shorelines updrift and downdrift of Braddock Bay should be completed at least every other year using available aerial imagery. Areas of deposition and erosion should be noted in order to make a qualitative assessment of any impacts to the littoral drift system. Evidence of accumulation of littoral material down drift of Braddock Bay will provide strong evidence that the barrier beach has positively impacted littoral drift processes in the vicinity of Braddock Bay. If at least 2 qualitative assessments over the course of 2-5 years indicate positive impacts to littoral drift processes, or do not indicate any observable impacts to littoral drift processes, the success criteria will be determined to be met, and additional monitoring will not be necessary. Local bathymetric data collected in the vicinity of Braddock Bay can be used to augment the assessment.

### 3.7.2 Adaptive Management Measures

- *Modify Structure*
- *Bypass Sand Around Structure*

If the qualitative assessment indicates, adaptive management measures should be considered. Several adaptive management measures could be implemented to improve littoral drift. The structure could be modified to reduce impacts to littoral drift. Local partners can bypass sand around the structure to increase the down drift movement of littoral sediment.

## 3.8 Barrier Beach Monitoring

The condition of the barrier beach and associated breakwaters should be assessed yearly through a visual survey. Although this visual survey is not tied to any ecological threshold or adaptive management action, the condition of the structure should be visually observed and documented with photos. Evidence of structural failures should be noted so that the need for re-engineering or repairs can be addressed. The U.S. Army

**Table 2. Monitoring and Adaptive Management Plan**

| Objectives | | | | |
|---|---|---|---|---|
| | Monitoring Methodology | Frequency | Ecologic Success Criteria | Adaptive Management Actions to Consider |
| **Wetland Habitat Diversity** | Emergent and Submerged Vegetation Survey – Dedicated 1m^2 sampling plots (Channels and Potholes) | Annual (Late Spring/Summer). | FQAI >= 17.8 | 1. Additional plantings/seedings<br>2. Invasive species management |
| | | | % Cover >= 80% in emergent and sedge grass meadow. | |
| | | | % Invasive Cover = *0% Phragmites*, < 50% *Typha* species, <10% of other invasive species. | 1. Invasive Species Management |
| | SAV and Floating Vegetation Survey – Rake and sample plots (Bay segments 2-5) | Annual (Late Spring/Summer). | FQAI >= 11.3 (Segments 4+5) | 1. Invasive Species Management |
| **Habitat Suitability** | Fish surveys | 2 times annually (spring and late summer). Years 1, 3, and 5. | Increase in species richness and abundance of YOY fish. | 1. Habitat enhancement activities |
| | Marsh Monitoring for waterbirds and amphibians | 3 times annually in accordance with the MMP protocol. | Increase in species richness of waterbirds and amphibians. | 1. Habitat enhancement activities |
| | Barrier beach waterbird surveys | 3 times annually, including late April, mid-June and late August. | Increase in species richness of waterbirds. | 1. Habitat enhancement activities |
| **Reduce Erosion** | Comparison of Aerial imagery corrected for lake level. | Years 0 and 5. | Shoreline erosion within range of 0.23 to 0.55 acres per year | 1. Additional shoreline protection<br>2. Emergent wetland restoration along existing shoreline |
| **Constraints** | | | | |
| | Monitoring Methodology | Frequency | Success Criteria | Adaptive Management Actions to Consider |
| **Avoid Navigation Impacts** | Bathymetric Survey | Annual (Spring). | Navigation channel dredging requirements shall not be increased as a result of project construction. | 1. Modify structure<br>2. Change location of navigation channel |
| **Avoid Littoral Drift Impacts** | Aerial Imagery & Bathymetric Survey | Years 0, 1, 3 and 5. | No impacts to the littoral drift system inferred from qualitative assessment of down drift shoreline. | 1. Modify structure<br>2. Bypass sand around structure |

| | | | | |
|---|---|---|---|---|
| **Avoid Shift in Trophic State** | Total Phosphorus, Chlorophyll a, and Secchi Disk. Calculate TSI using Chl-a for segments 2-5 in Braddock Bay. | 4 times per year (June, July, August, Sept). | TSI <60 for Chl-a (June – Aug)<br>TSI for Chl-a in September no increasing trends after 5 years<br>TSI for Secchi Disk no increasing trends after 5 years<br>TSI for Total P no increasing trends after 5 years | 1. Excavate "relief valve".<br>2. Reduce nutrient loading to Braddock Bay<br>3. Remove breakwater |
| | SAV and Floating Vegetation Survey – Rake and visual Surveys(Bay segments 2-5) | Annual (Late Spring/Summer). | No significant increased in relative abundance of “nutrient enrichment tolerant” species(Segments 3,4, and 5) | 1. More frequent water quality sampling<br>2. Excavate “relief valve” |
| **Other** | Barrier Beach Structural Monitoring | Annually | None. Project structurally stable. | 1. Consider modifications/reengineering if structure is unstable. |

FQAI - Floristic Quality Assessment Index

# 4.0 Monitoring Program Components, Time Frames, and Reporting

## 4.1 Monitoring Time Frames

Due to the variable nature of the adaptive management monitoring parameters, it may not be necessary to monitor every parameter in each year following construction. Through the adaptive management process the BBAC and lead partners will collectively analyze the monitoring data and other available information to determine the outcomes for restoration success or failure and institute actions to make mid-course corrections. Due to the long term timeframe of the monitoring plan a need to modify the plan may be necessary. Factors such as response times of goals may not be determined within a five year timeline or funding for monitoring tasks are uncertain until a given year. The information in this section is intended to act as a guide for the BBAC and lead partners involved in overseeing the adaptive management of Braddock Bay. Table 2 lists the recommended frequency of monitoring for adaptive management components. Ideally, monitoring for each component would continue until data indicate success criteria have been met. For most of the components, it is likely that this could be achieved within the first five years following construction. Monitoring of a specific component only needs to continue until success criteria are achieved for that component.

## 4.2 Modification to Monitoring Plan

In addition to the need for long term monitoring program consistency, it is also important to recognize a potential need to modify the the program (modified after Tanner 2000).

At least three types of changes to the monitoring program can be envisioned at this point.

1. Changes in monitoring tasks. As monitoring progresses, protocols may be modified or improved based on previous monitoring experience or new information. It is likely that other opportunities for improvement will be identified which should be incorporated into the monitoring program.

2. Elimination of monitoring tasks. It is possible that in the future, the BBAC and lead partners might reach consensus that specific success criteria have been met, and that associated monitoring tasks could cease. Similarly, it could be determined that a monitoring task was not returning useful information, and therefore not worth the expense of continuation. It's possible that monitoring funds do not coincide with the plan and monitoring priorities would have to be reconsidered.

3. Modification of project objectives. As suggested by Walters (1986), one of the steps of applying adaptive management principles to restoration projects is the ability to modify project goals during the monitoring period. The most important components that stakeholders have expressed interest are those related to the function of the barrier beach. Trophic state monitoring is the most critical.

**Table 3. Recommended Monitoring and Adaptive Management Time Frames**

| | Years Post-Construction | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6-10 |
| Emergent/SAV Vegetation Survey and Analysis | | ■ | ■ | ■ | ■ | ■ | ■ |
| Fish and Wildlife Survey and Analysis | | ■ | | ■ | | ■ | ■ |
| Erosion/Littoral Drift Survey/Analysis | ■ | ■ | | ■ | | ■ | |
| Navigability Survey and Analysis | ■ | ■ | ■ | ■ | ■ | ■ | |
| Water Quality Monitoring | | ■ | ■ | ■ | ■ | ■ | |

## 4.3 Monitoring Program Tasks

As stated, the BBAC will oversee the implementation of this monitoring plan and lead partners will be responsible for individual tasks monitoring and adaptive management measures (Table 2). The NYSDEC will coordinate yearly monitoring reports with the Town of Greece and the Braddock Bay Advisory Committee to determine when ecologic success criteria are achieved. The U.S. Army Corps will provide technical assistance to the BBAC for the barrier structure and littoral drift evaluations. The determination of specific monitoring components to carry out may be constrained by available funding and be carried out at the discretion of NYSDEC. If adaptive management measures are required, adequate funds need to be available for hiring, contracting, and directing subcontractors as needed. As well as inter-agency coordination to ensure that the monitoring and adaptive management measures are being performed as outlined in this plan. Nothing in this plan supersedes any obligations called for in the Braddock Bay Fish & Wildlife Management Plan or other preexisting plan governing the Braddock Bay management area.

**Table 4. Lead Partner responsible for coordination of monitoring and adaptive management task**

| Task | Task Lead |
|---|---|
| | |
| Emergent/SAV Vegetation Survey and Analysis | DEC |
| | |
| Fish and Wildlife Survey and Analysis | DEC |
| | |
| Erosion/Littoral Drift Survey/Analysis | DEC/ USACE* |
| | |
| Navigability Survey and Analysis | Town Of Greece |
| | |
| Water Quality Monitoring | DEC |
| Barrier Beach Monitoring | Town of Greece/ USACE* |

*USACE ability to provide technical assistance to NYSDEC and the Town of Greece is dependent on the availability of funding.

## 4.4 Pre-construction monitoring

Adequate baseline information has been collected for most monitoring components. Due to the variability and inconsistent sampling of water quality data, water sampling and analysis should occur before construction in summer of 2015. In addition aerial imagery should be collected immediately following completion of construction.

## 4.5 Reporting

In each year of substantial monitoring activity BBAC will prepare a report which presents a summary and evaluation of the monitoring program results. At a minimum, the report will summarize:

1. Monitoring tasks completed (methods, sampling locations, dates);
2. Data and other monitoring results;
3. Trends in data, for both individual plots and the overall project goals;
4. Need for consideration of contingency measures;
5. Externalities that may be influencing monitoring results; and
6. Recommendations and alternatives for action.

Yearly monitoring reports will be made posted to a NYSDEC webpage and made publicly available.

## References


Bird Studies Canada (BSC). 2000. The Marsh Monitoring Program: quality assurance project plan. Prepared for the US Environmental Protection Agency – Great Lakes National Program Office. Accessed online at http://www.bsc-eoc.org/download/mmpqualplan.pdf in April 2015.

Carlson, R. E. 1977. A trophic state index for lakes. Limnology and oceanography, 22(2), 361-369.

Fischenich, C.J. and C. Vogt. 2007. The Application of Adaptive Management to Ecosystem Restoration Projects. ERDC TN-EMRRP-EBA-10. ERDC Environmental Laboratory, Vicksburg, MS.

Great Lakes Coastal Wetlands Consortium. 2008. Great Lakes Coastal Wetlands Monitoring Plan.

Herman K. D, L. A. Masters, M. R. Penskar, A. A. Reznicek, G.S. Wilhelm, W.W Brodovich, and K. P. Gardiner. 2001. Floristic Quality Assessment with Wetland Categories and Examples of Computer Applications for the State of Michigan.

Limnotech. 2014. Total Phosphorus Modeling of Braddock Bay.

Makarewicz, Joseph C. and Nowak, Matthew J., "Braddock Bay Monroe County, New York" (2010). Technical Reports. Paper 42. http://digitalcommons.brockport.edu/tech_rep/42

Makarewicz, Joseph C. and Nowak, Matthew J., "Long Pond Monroe County, New York" (2010). Technical Reports. Paper 51. http://digitalcommons.brockport.edu/tech_rep/51

Madsen, J. D. (1999). "Point intercept and line intercept methods for aquatic plant management." *APCRP Technical Notes Collection* (TN APCRP-M1-02). U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/aqua*.

Minnesota Pollution Control Agency (MPCA). 2008. Citizen Lake-Monitoring Program: Instruction Manual.

National Research Council (NRC). 2004. Adaptive Management for Water Resources Project Planning. National Academies Press, Washington, DC.

Tanner, C.D. 2000. *Intertidal Habitat Projects Monitoring Program*: Elliott Bay/Duwamish Restoration Program. Prepared for the Elliott Bay/Duwamish Restoration Program Panel by U.S. Fish and Wildlife Service, Western Washington Office, Olympia, Washington.

The Nature Conservancy (TNC). 2015. Braddock Bay, Buck Pond Final Report: January 2015

Thom, R.M. 1997. System-development matrix for adaptive management of coastal ecosystem restoration projects. Ecological Engineering 8: 219-232.

Walters, C.J. 1986. Adaptive management of renewable resources. New York: Macmillan Publishing Co.

Williams, B.K., R.C. Szaro and C.D. Shapiro. 2007. Adaptive Management: The U.S. Department of Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington D.C.

# APPENDIX A RECOMMENDED MONITORING PLANS

## A-1 Vegetation Monitoring and Analysis

### *Emergent Vegetation*

*Monitoring*

The combined channel, mound, cattail treatment areas, and remnant sedge grass meadows will be sampled using approximately 14 transects across the 7 identified areas, with one to three transects per area. Each transect will have 14 1-m2 quadrats, with two in the channel, two on the shallow bench, three on the spoil piles, four in the cattail treatment areas, and up to three in the remnant sedge grass meadows. Quadrats will be placed randomly on the transect within habitat zones.

The 12 newly created potholes and associated spoil piles will be sampled with approximately 16 transects. Transects will run from the deepest portion of the potholes to the base of the spoil pile's back slope. Approximately 9 1-$m^2$ quadrats per transect will be established along each transect, with two in the deep zone, two in the intermediate bench, two on the low bench, and three on the mound. Quadrats will be placed randomly on the transect within habitat zones.

The newly created wetland behind the stone berm will be sampled using three transects that run parallel to the long axis of the berm. Each transect will have 10 1-m2 quadrats placed randomly on its length.

Approximately 20 control quadrats randomly in each of the untreated cattail and submerged areas. Data from these quadrats will be used as a baseline to assess change

During vegetation surveys all species within quadrats will be recorded, along with depth to water, and percent cover within quadrats. Visual assessments of the entire restored area including areas outside transects should be done in order to identify large patches of establishing invasive species or other peculiarities. Pictures should be taken, and channel depths and widths should be recorded at each transect. Any evidence wildlife usage should be noted.

This sampling is intended to be rigorous in the first few sampling years so that post restoration condition is accurately captured and the early development of ecosystem function can be quantified. In subsequent years, a less intense level of sampling may be suitable.

*FQAI Calculation*

Calculation of FQAI will use Coefficient of Conservatism (CoC) values from the Michigan FQAI (Herman et al. 2001) as recommended by the Great Lakes Coastal Wetland Monitoring Plan, but scores will be modified to set the CoC value for any New York regulated and prohibited species (as per 6 NYCRR Part 375) to 0 (see (http://www.dec.ny.gov/regulations/93848.html). To determine if wetland habitat diversity has improved from restoration, data from restored areas of Braddock Bay will be compared to control areas that were not restored. Ecological performance criteria will be met if FQAI scores from restored areas exceed scores from unrestored control areas. Currently the FQAI score for the existing emergent marsh at Braddock Bay is 17.8 as calculated from data collected in 2011 (USACE, 2014).

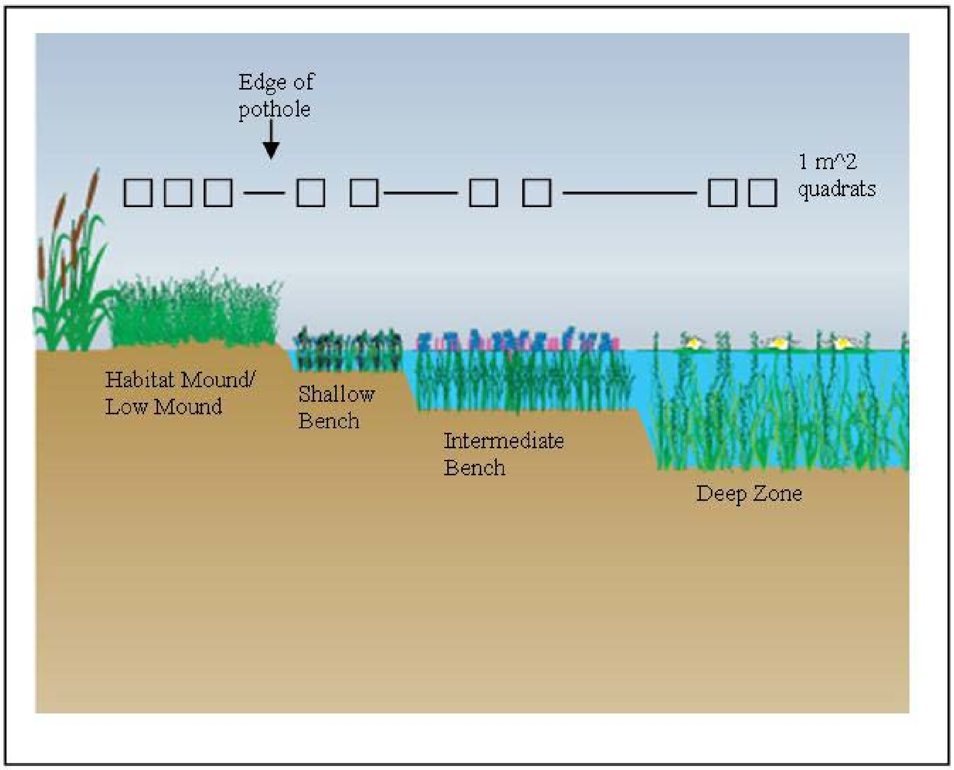



**Figure 6. Pothole Transect/Quadrat Layout**

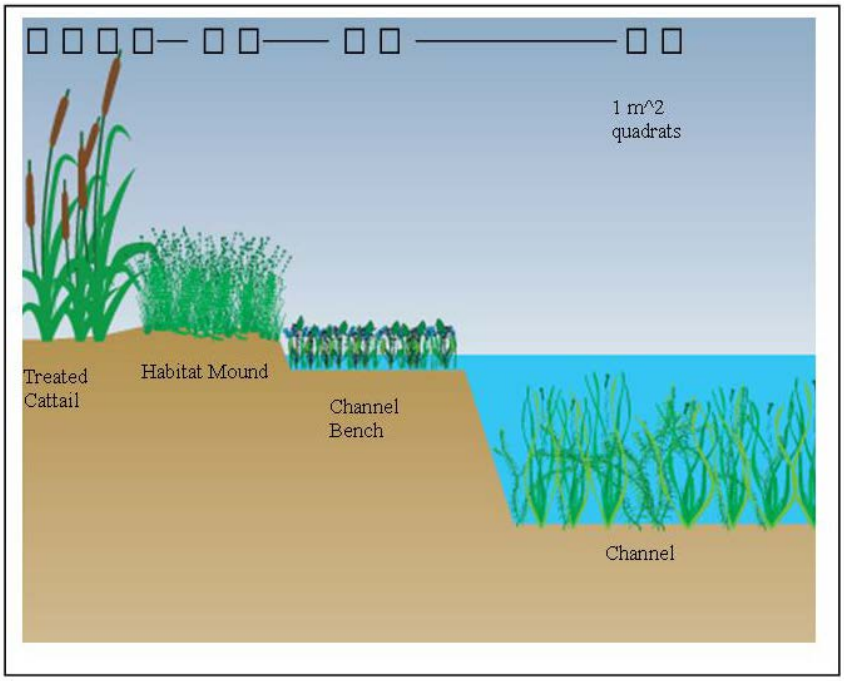



**Figure 7. Channel Transect/Quadrat Layout**

### *Submerged Aquatic Vegetation*

*Monitoring*

The aquatic vegetation communities within Braddock Bay will be sampled using the point intercept method (Madsen, 1999). Transects are spaced approximately 300 foot apart along the existing wetland shoreline, and are oriented perpendicular to the shoreline, and extending beyond the boundary of the submerged aquatic vegetation as observed in the 2013 SAV survey (2015, USACE) . Sample points are placed at 150 foot intervals along each transect beginning approximately 75 feet lakeward of the wetland shoreline. Generally, an effort was made to overlay transects along the path of vegetation transects from a 2013 survey of submerged aquatic vegetation conducted by USACE. The recommended layout for sampling is shown in Figure 8. This design includes approximately 120 sampling points. Many of these transects extend into areas in which there was no vegetation in 2013. The purpose of this is to allow future monitoring efforts to capture any expansion of the SAV community. It is anticipated that this sampling would take between 2- 4 days and require use of a boat.

A GPS with at least 15 foot accuracy should be used to navigate to sample points in the field. At each sample location, observations can be made directly from the surface using using a view scope (e.g., “bathyscope”), or by the use of a rake or other collection device if water is too turbid or deep for direct observation. Since this is a “point” method, it is important to be consistent in sampling the same relative area at each point. If direct visual observations are used, monitor a small area alongside the boat (e.g., an imaginary 3-m by 3-m quadrat). If a rake toss is being used, consistently make the same number of tosses per site.

All floating and submerged aquatic species observed will be recorded and assessed for relative abundance. The following categories can be used for relative abundance >50%, 20%-50%, 5%-20%, or <5%. Anything over 20% will be considered a dominant species. Estimates of absolute cover of all species should be made at the beginning, middle, and endpoint of each transect; and immediate following any obvious change in vegetative cover or community.

*Data Analysis and Interpretation*

Data will be analyzed using the Floristic Quality Assessment Index. Also, an assessment of the extent of dominance by eutrophic tolerant species will be conducted.

*FQAI Calculation*

Calculation of FQAI will use Coefficient of Conservatism (CoC) values from the Michigan FQAI (Herman et al. 2001) as recommended by the Great Lakes Coastal Wetland Monitoring Plan, but scores will be modified to set the CoC value for any New York regulated and prohibited species (as per 6 NYCRR Part 375) to 0 (see (http://www.dec.ny.gov/regulations/93848.html). Data will be organized to compile a list of all species by each segment. The scores from segments 4 and 5, the exposed areas of Braddock Bay that will be most protected by the restored barrier beach, will be combined and compared compared against the baseline data collected by USACE in 2013 (Table 6) and subsequent sampling years to determine if the quality of aquatic vegetation communities has increased. The baseline FQAI score for the exposed area was 11.31. An increase in FQAI scores from these transects will be evidence that restoration has increased the quality of Braddock Bay aquatic vegetation community.

<u>Dominance by Nutrient Enrichment Tolerant Species</u>

Changes in the trophic state of Braddock Bay will be measured by assessing the relative abundance of aquatic plant species tolerant of nutrient enrichment conditions. The relative dominance data of each species collected at each sample point should be organized by segment. In each segment, the number of sample points dominated by nutrient enrichment tolerant species will be compared to sample points dominated by other species that are not-tolerant of nutrient enrichment. Nutrient enrichment tolerant species are those defined in tables 3-6 of the Great Lakes Coastal Wetland Monitoring Plan (2008), see Figure 9 below. Dominant species are those with over 20% cover.

This comparison will be useful in determining if nutrient enrichment tolerant species are expanding their range in Braddock Bay in subsequent monitoring years following restoration.

The comparison of sample locations containing nutrient enrichment tolerant species versus those containing non-nutrient enrichment tolerant species can be statistically tested using Chi-square analysis. This will be useful in determining if changes in the occurrence of nutrient enrichment tolerant species are statistically significant between years. See Madsen (2009) for an example of data analysis using this method. The year to year comparison in the number of sample locations dominated by nutrient enrichment tolerant species will provide evidence regarding shifts in the Braddock Bay submerged aquatic vegetation community.

Other considerations

The above point intercept data is useful in that it can be organized in a variety of ways. For instance, if one were interested in understanding the spread of duckweed, the number of sample locations with duckweed as a dominant could be compared against the number of sample locations without duckweed as a dominant. This data can be compared from year to year to determine if duckweed is expanding. Additionally, statistical testing can be done to determine if changes in duckweed abundance are statistically significant.

A similar assessment of turbidity-tolerant species can also be completed to determine if turbidity in the bay has been decreased by project activities. This assessment is not tied to any specific adaptive management, but may serve to provide support that the condition of Braddock Bay has improved.

The occurrence of vegetation at sampling points that had been devoid of vegetation in previous sampling years should be noted as this provides evidence that submerged aquatic vegetation is expanding within the bay.

The Submergent Marsh Zone Quality Rating Index of the Great Lakes Coastal Wetland Monitoring Plan (2008) can also be applied in order to generate and index score representing the trophic state. See tables 3-5 and 3-6 of the Great Lakes Coastal Wetland Monitoring Plan (2008) for more information on applying this index. Application of this index requires data regarding total cover.

Additionally, an increase in the extent of invasive species or occurrence of new invasive species should be reported to Braddock Bay Wildlife Management Area field staff.

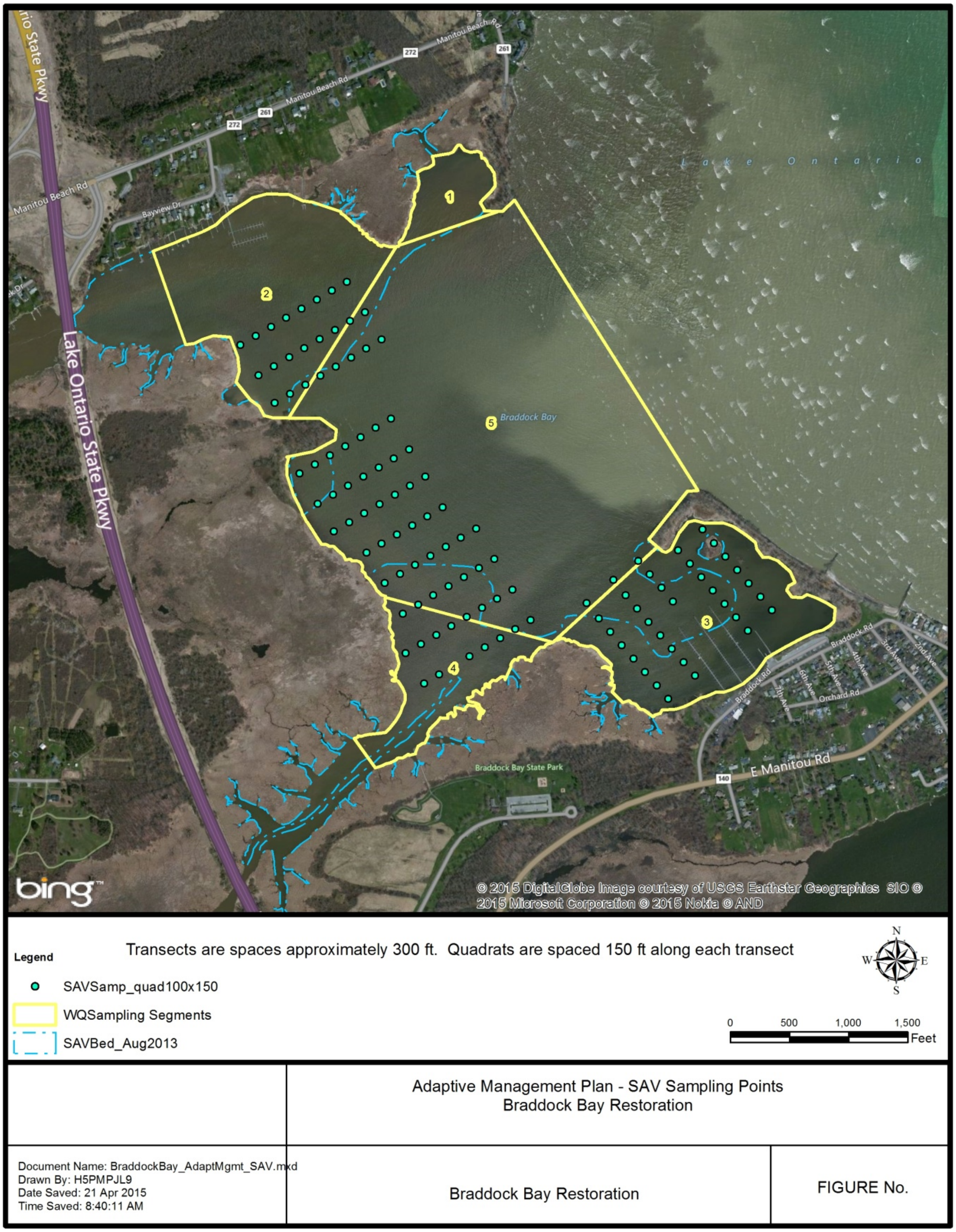



**Figure 8. Recommended SAV sampling design**

**Table 5. Braddock Bay Baseline FQAI Scores (USACE, 2014)**

**FQAI Calculations for Braddock Bay**

Sampling of Braddock Bay submerged aquatic vegetation was conducted on August 6th and 7th of 2013.

| All Species present at Braddock Bay | | Species present in exposed areas. Samples B1-1 to B1-3, B2-2 (Exposed - No Protection) n=5 | |
|---|---|---|---|
| Ceratophyllum demersum | 1 | Ceratophyllum demersum | 1 |
| Elodea canadensis | 1 | Nymphaea odorata | 6 |
| Heteranthera dubia | 6 | Myriophyllum spicatum | 0 |
| Lemna minor | 5 | Potamogeton crispus | 0 |
| Lemna triscula | 6 | Potamogeton pectinatus | 3 |
| Najas minor | 0 | Potamogeton zosteriformis | 5 |
| Nymphaea odorata | 6 | Vallisneria americana | 7 |
| Myriophyllum spicatum | 0 | Wolffia brasiliensis | 10 |
| Potamogeton crispus | 0 | | |
| Potamogeton pectinatus | 3 | | |
| Potamogeton richardsonii | 5 | | |
| Potamogeton robbinsii | 10 | | |
| Potamogeton zosteriformis | 5 | | |
| Spirodela polyrhiza | 6 | | |
| Utricularia vulgaris | | | |
| Vallisneria americana | 7 | | |
| Wolffia brasiliensis | 10 | | |
| **17** | **Total Species** | **8** | **Total Species** |
| 12 | Native Species | 6 | Native Species |
| **4.53** | **Mean C** | **4.00** | **Mean C** |
| 5.00 | Native Mean C | 5.33 | Native Mean C |
| **18.68** | **FQAI** | **11.31** | **FQAI** |
| 17.32 | Native Only FQAI | 13.06 | Native Only FQAI |

In order to quantify the change in the quality of the SAV community that would result from restoring the function of the historical land spits at Braddock Bay the FQAI was calculated for data collected from the area off shore of the central emergent marsh (Transect B1, B-2).This is the area that represents the Braddock Bay SAV community of areas directly exposed to wave energy. Note that the diversity of sample B2-1 was exceptionally high compared to the other samples in the exposed areas. It location at the mouth of buttonwood creek is semi-protected and has physical conditions contributing to its high diversity. This sample is not representative a sampling communities in the exposed areas of Braddock Bay. When it is excluded from analysis the FQAI for exposed areas drops from 17.03 to 11.31.

**Table 3-6.** Species tolerant of nutrient enrichment, sedimentation, or increased turbidity.

| Stress | Species |
|---|---|
| Nutrient Enrichment | *Ceratophyllum demersum* |
| | *Elodea canadensis* |
| | *Lemna minor* |
| | *Myriophyllum spicatum* |
| | *Potamogeton crispus* |
| | *Potamogeton pectinatus* |
| | Algae |
| | |
| Sedimentation and Increased Turbidity | *Butomus umbellatus* |
| | *Ceratophyllum demersum* |
| | *Elodea Canadensis* |
| | *Heteranthera dubia* |
| | *Myriophyllum spicatum* |
| | *Potamogeton crispus* |
| | *P. foliosus* |
| | *P. pectinatus* |
| | *P. pusillus* |
| | *Ranunculus longirostris* |

Figure 9. Species tolerant of nutrient enrichment, sedimentation, or increased turbidity. (pg.48, Great Lakes Coastal Wetlands Monitoring Plan, 2008**)**

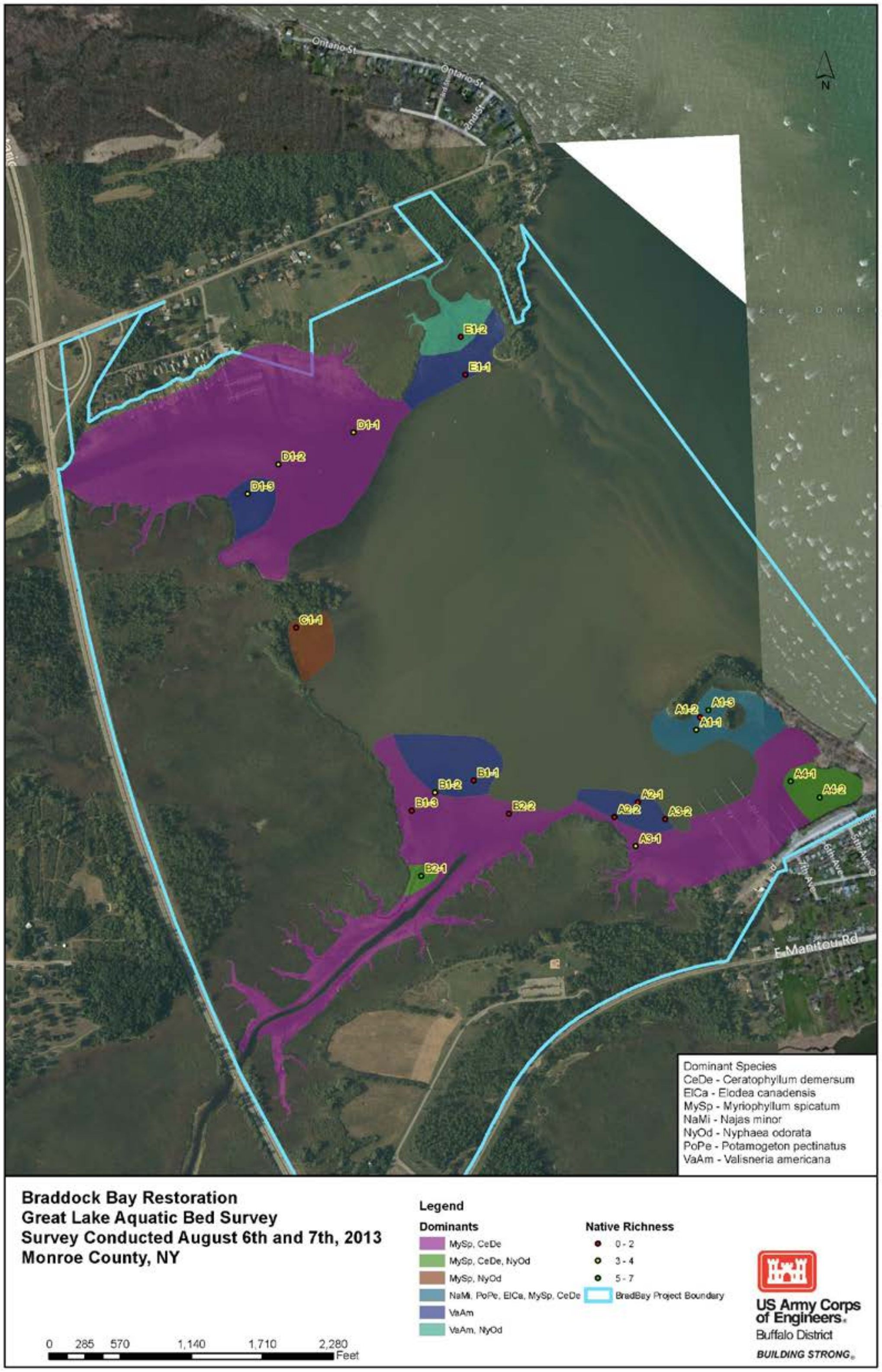



**Figure 10. Submerged aquatic vegetation communities observed during 2013 survey.**

## A-2 Fish and Wildlife Monitoring

*Fish Surveys*

Fish monitoring using Fyke nets will be conducted to determine the presence of fish within restored channels post-construction. It is anticipated that a total of four channels/potoholes in the wetland restoration area will be monitored. The purpose of monitoring is to document utilization of the restored area by northern pike, young-of- the year northern pike, and other fish species. Data indicating presence of adult and juvenile northern pike as well as an increase in fish species richness will be evidence that the suitability of wetland habitat has been increased, and the performance criteria for fish within Braddock Bay will be considered as met. Sampling will include the use of fyke nets set up within newly constructed channels in order to capture northern pike of various age class as well as various other fish species. Table 7 outlines the species that are known to occur within Braddock Bay. Another seven species of fish that are not presently found within Braddock Bay may occur there as a result of project implementation. These species include the state endangered pugnose shiner, bridle shiner, yellow bullhead, grass pickerel, brook silverside, green sunfish and pirate perch.

**Table 7: Braddock Bay fish community species list**

| Scientific Name | Common Name |
|---|---|
| *Lepisosteus osseus* | Longnose gar |
| *Amia calva* | Bowfin |
| *Alosa pseudoharengus* | Alewife [1] |
| *Carassius auratus* | Goldfish [1] |
| *Cyprinus carpio* | Common carp [1] |
| *Notemigonus crysoleucas* | Golden shiner |
| *Notropis atherinoides* | Emerald shiner |
| *Pimephales notatus* | Bluntnose minnow |
| *Ameiurus nebulosus* | Brown bullhead |
| *Esox lucius* | Northern pike |
| *Esox niger* | Chain pickerel |
| *Umbra limi* | Central mudminnow |
| *Catostomus commersonii* | White sucker |
| *Noturus gyrinus* | Tadpole madtom |
| *Fundulus diaphanus* | Banded killifish |
| *Morone americana* | White perch [1] |
| *Micropterus salmoides* | Largemouth bass |
| *Pomoxis negromaculatus* | Black crappie |
| *Ambloplites rupestris* | Rock bass |
| *Lepomis gibbosus* | Pumpkinseed |
| *Lepomis macrochirus* | Bluegill |
| *Etheostoma olmstedi* | Tessellated darter |
| *Perca flavescens* | Yellow perch |
| *Neogobius melanostomus* | Round goby [1] |
| **Species Richness** | **24** |
| **Native Species** | **19** |

[1] Non-native species

Fish sampling will occur twice per year, with one event in early spring during northern pike spawning season and the other in late-summer to assess spawning success. The four sampling locations to be used are outlined in Figure 11. Fyke nets will be utilized over a three day span, with trap employment occurring on the first day, trap checks and re-employment on the second day and trap checks demobilization occurring on the third day.

Of the four fyke nets to be employed during these surveys, two should exhibit a mesh size of 3/16” while the other two are 1/2” mesh size. Utilizing nets with two different mesh sizes will serve to prevent fish size capture bias and allow for the assessment of large and small sized fish community more thoroughly. It is recommended that the fyke net arms utilized will be 25’ long by 3’ feet high, with a weighted lowed arm line and floats on the upper are line. The net frames will be 4’ by 3’, with 5 hoops (hoops approximately 1.5 feet apart) with the first hoop approximately 3’ from the second box. The hoops should be approximately 30” in diameter.

Nets will be set overnight for at least 12 hrs before they are pulled and emptied.  All fish will be identified to the lowest taxonomic level possible, and tallied as either “young of the year” or “adult”, and the length of the first 25 of each species will be measured. Fish will be handled following the appropriate guidelines, and all required sampling permits will be acquired prior to sampling. Fish will be identified using various technical and non-technical keys, with all fish being released on site. Fish that cannot be identified easily in the field will have a representative specimen photographed with a high quality digital camera.

Fish surveyors will set nets in 50-100 cm of water, with sampling occurring directly in the newly created channels to capture fish swimming through the restored habitat. The fyke net wings will be connected to the outer opening on each side of the net and will be set at 45° angles relative to the lead. Flotation bottles will be placed in the cod end of each trap to prevent the drowning of terrestrial wildlife.

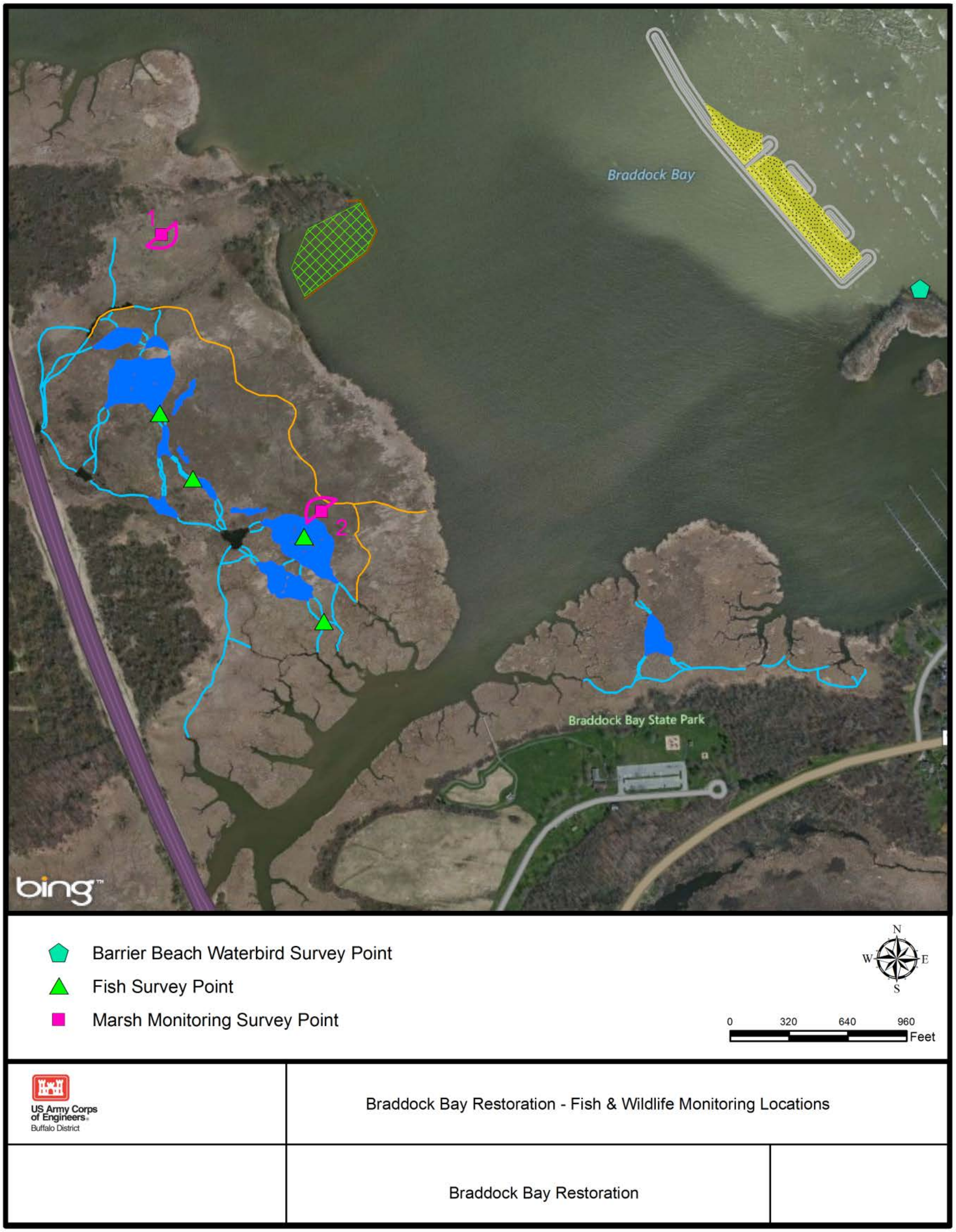



**Figure 11. Fish and Wildlife Monitoring Locations at Braddock Bay.**

*Marsh Monitoring Program Surveys*

The Marsh Monitoring Program was developed and launched by Bird Studies Canada in 1995, with financial support from the Great Lakes Protection Fund, Environment Canada and the U.S. Environmental Protection Agency. It is a long-term bird and amphibian monitoring program that utilizes the field efforts of citizen scientists in order to conduct marsh surveys within the Great Lakes Basin in both Canada and the United States (http://www.bsc-eoc.org/volunteer/glmmp/index.jsp).

The sampling protocols for both birds and amphibians has been slightly modified in order to combine these sampling types during the same site visits in an effort to avoid extraneous site visits. Two survey points will be established within the central emergent wetland (Figure 11). The MMP stations will be approximately 530 m (580 yds) apart in order to avoid biased results of playback surveys for birds. The survey points will be monitored for both birds and amphibians during the same sampling events and will be sampled three times during the active season (between mid-May and July 5$^{th}$) with no less than 15 days between each survey. Surveys will be conducted in the evening for birds (starting with survey point 1 followed by survey point 2) and at night for amphibians (beginning with survey point 2 followed by survey point 1). The surveyor will wait at survey point 2 between the evening bird survey and the night survey of amphibians in order to minimize time in transit between survey points. Weather conditions during the survey periods must be warm with no precipitation and little wind. Nighttime air temperatures for these surveys should be forecasted to be around 5$^{o}$C (41$^{o}$F), 10$^{o}$C (50$^{o}$F) and 17$^{o}$C (63$^{o}$F) for each of the respective survey sessions.

*Sample Protocol Specific to Birds*

Evening surveys will begin approximately two hours before sunset and must be completed before the onset of darkness. The surveys will include the use of a fixed-distance semi-circular area in front of the surveyor with a radius of 100 m (110 yds). The surveyor will face the center of the semi-circular area at each survey point and use a compass to find the correct center azimuth. Survey point 1 will have an azimuth of 30$^{o}$ while survey point 2 has an azimuth of 340$^{o}$. The surveyor will need to add 10$^{o}$ to the compass reading for each survey point in order to account for the appropriate declination for Braddock Bay (see http://www.land-navigation.com/magnetic-declination.html for information concerning declination). A fifteen minute survey will be conducted at each point, with a five-minute passive segment followed by a five-minute active broadcast period followed by another five-minute passive listening segment. The active broadcast segment will target the generally secretive, yet territorial Virginia rail, sora, least bittern, common moorhen, American coot and pied-billed grebe. For more detail on equipment necessary, datasheets and survey approach see the bird sampling protocols provided by Bird Studies Canada (available at http://www.bsc-eoc.org/volunteer/glmmp/index.jsp?targetpg=glmmpbird).

*Sample Protocol Specific to Amphibians*

Amphibian surveys will begin one half hour after sunset and will be completed by no later than midnight. These surveys are conducted over a three-minute span and utilize an unlimited sampling area that is semi-circular in shape. The semi-circular survey area will be centered to the same azimuths used for points 1 and 2 as part of the bird survey. For more detail, see the amphibian sampling protocols and datasheets provided by Bird Studies Canada (available at http://www.bsc-eoc.org/volunteer/glmmp/index.jsp?targetpg=glmmpfrog).

*Barrier Beach Waterbird Surveys*

These surveys will target bird utilization of the newly constructed barrier beach and will take place three times within a sample year during time frames where targeted species would be most likely to occur on the site. These time frames include site visits occurring in mid-May, mid-July and mid-September. It is recommended that some variation in the time of day these ten-minute surveys are conducted be incorporated into the survey approach in order to increase the potential of detecting a greater number of species utilizing the barrier beach. A single barrier beach survey point on the southeast spit will be used for these surveys (Figure 11). Survey equipment to be utilized include a spotting scope and binoculars. While it is expected that a greater richness and abundance of target birds may utilize the barrier beach during inclement weather, detectability may be reduced during these times. It is therefore not recommended that surveys be conducted during significant storms. Barrier beach surveys should be conducted while on site for other adaptive management and monitoring surveys, in order to reduce the number of visits to the project area.

Any and all waterbirds detected utilizing the barrier beach will be recorded on standardized datasheets that will include columns for species names and numbers. Based on the Buffalo Ornithological Society field checklist, a total of 16 waterbirds could potentially utilize habitat created as a result of barrier beach restoration (Table 8). While most shorebird species listed may utilize a restored barrier beach during spring or fall migration, one species, the spotted sandpiper, could potentially utilized the restored beach for breeding. Six of the 16 species listed can also occur within the emergent marsh cover type that occurs within the project area.

**Table 8: Braddock Bay potential waterbird species list**

| Scientific Name | Common Name |
|---|---|
| *Pluvialis squatarola* | Black-bellied plover |
| *Aradrius semipalmatus* | Semipalmated plover |
| *Actitis macularius* | Spotted Sandpiper [1] |
| *Calidris canutus* | Red knot |
| *Calidris pusilla* | Semipalmated sandpiper |
| *Calidris fuscicollis* | White-rumped sandpiper [2] |
| *Calidris melanotos* | Pectoral sandpiper [2] |
| *Calidris himantopus* | Stilt sandpiper |
| *Pluvialis dominica* | American golden-plover |
| *Tringa melanoleuca* | Greater Yellowlegs [2] |
| *Arenaria interpres* | Ruddy Turnstone |
| *Calidris alba* | Sanderling |
| *Calidris minutilla* | Least sandpiper |
| *Calidris bairdii* | Baird's sandpiper [2] |
| *Calidris alpina* | Dunlin [2] |
| *Limnodromus griseus* | Short-billed dowitcher [2] |
| **Number of species that inhabit sandy shorelines** | **16** |

[1] Potential breeder within the project area
[2] Habitat preferences also includes marsh habitat

## A-3 Water Quality Monitoring

Water quality samples will be collected within the bay, tributaries, and Lake Ontario in the vicinity of Braddock Bay (Figure 11). In order to allow for a more spatially accurate representation of trophic conditions, Braddock Bay has been subdivided into 5 sub-segments. Water quality samples will be taken from 4 of these 5 segments (Segments 2- 5). Each segment has one established sampling location, except for segment 5 which has two.

At each sampling location within the bay, four (4) sub-samples will be collected and combined into a single composite sample and stored on ice in preparation for laboratory analysis [total phosphorus, chlorophyll a (spectrophotmetric), dissolved reactive phosphorus, total Kjedahl nitrogen (TKN), ammonia, nitrite/nitrate, and total suspended solids]. The four (4) sub-samples will be taken from the approximate center of each of the 250 foot by 250 quadrats surrounding the sampling location (Figure 11). Additionally, secchi disk depth, turbidity, temperature, dissolved oxygen, and pH quality parameters should be measured in-situ at each sampling location; it is not required to take sub-samples for these in-situ parameters. This sampling method will be applied to the 5 sampling locations within Braddock Bay.

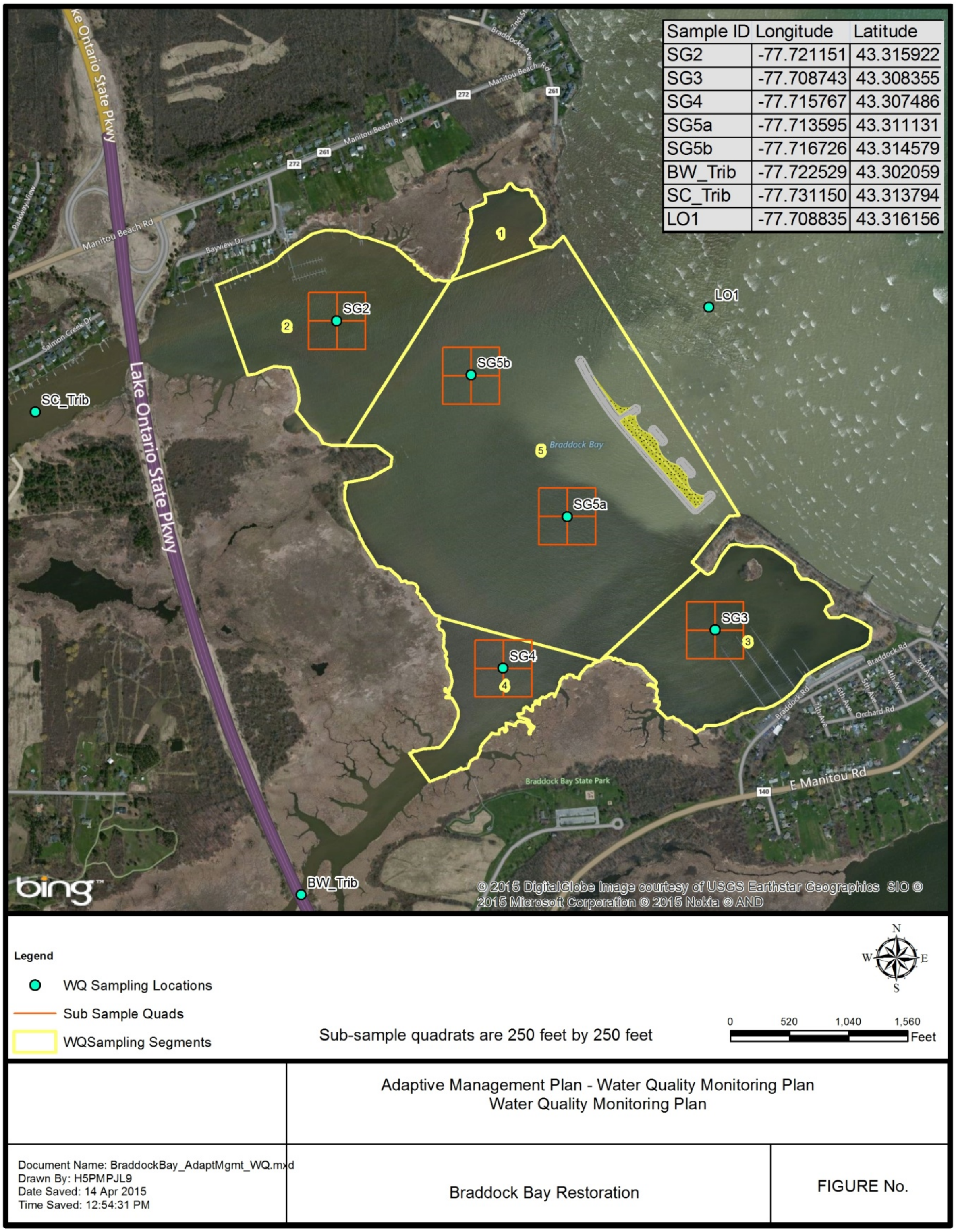
Water quality samples will also be taken from Salmon Creek, Buttonwood Creek, and Lake Ontario. These samples do not require sub-sampling. Secchi disk depth and other water quality parameters should be measured in-situ from each of these locations as described above.

*Lab Analysis*

**Table 6. Lab analysis with approximate costs**

| Water Chemistry | | |
|---|---|---|
| *Description* | *Matrix* | *Cost($)/Unit* |
| Nitrogen - Total Kjeldahl - Liquid | Water | $ 52.53 |
| Nitrogen - Ammonia - Liquid | Water | $ 26.92 |
| Nitrogen – Nitrate/Nitrite - Liquid | Water | $ 23.11 |
| Phosphorus, Total - Liquid | Water | $ 23.11 |
| Phosphorus, Dissolved (Ortho) (365.3) | Water | $ 63.03 |
| Suspended Solids (TSS)- Liquid | Water | $ 16.81 |
| Chlorophyll a (SM 10200H.2 Spectrophotmetric) | Water | $ 65.00 |

A local lab, ALS Environment, has capability to perform the necessary analysis.




| Sample ID | Longitude | Latitude |
|---|---|---|
| SG2 | -77.721151 | 43.315922 |
| SG3 | -77.708743 | 43.308355 |
| SG4 | -77.715767 | 43.307486 |
| SG5a | -77.713595 | 43.311131 |
| SG5b | -77.716726 | 43.314579 |
| BW_Trib | -77.722529 | 43.302059 |
| SC_Trib | -77.731150 | 43.313794 |
| LO1 | -77.708835 | 43.316156 |

**Figure 11.** Water Quality Sampling Locations and Coordinates

## APPENDIX B JUSTIFICATION FOR TSI THRESHOLDS

The existing TSI for Braddock Bay has been estimated using a variety of data sources. The longest continuous data source (Makarewicz, 2010) consists of monthly averages for summer months from 2003 -2009. The limitation of this dataset was that it collected from a single sampling location in Braddock Bay and may not fully represent the range of conditions across the bay. Other water quality data has been collected by USACE, USFWS, and SUNY Brockport, ; however, the parameters, timing, and locations of these samples are variable and do not represent an optimal data set for summarizing conditions at Braddock Bay. Based on the Makarewicz (2010) data, TSI scores during summer months (May to Sept) range from the low 50s to low 60s when calculated using chlorophyll-a data, and the low to upper 60s when calculated using total phosphorus data (Figure 14) . In all months (May to Sept), TSI scores calculated from total phosphorus data are always greater than TSI scores calculated from chlorophyll-a, possibly indicating that productivity in Braddock Bay may not be phosphorus limited. This assertion is consistent with the conclusions of the phosphorus model completed by Limnotech (2014) during the Braddock Bay feasibility study. Additionally, other total phosphorus sampling data provides evidence that locations throughout Braddock Bay have exceed a TSI of 70 during the months of June, August, and October in 2013 (Figure 16). In light of the high variability of phosphorus data and evidence that it does not appear to be directly limiting to productivity in Braddock Bay, establishing a TSI threshold based on phosphorus is not recommended. Rather, ecological thresholds based on chlorophyll-a should be established.

*Analysis of Data*

Calculation of TSI score for the purpose of determining if the target level has been exceeded should be based on concentrations of chlorophyll-a. A graphical representation of the TSI scale is provided in Figure 15, however, all calculations should be done using the equations below as opposed to interpretation of the visual scale.

$$\mathrm{TSI(SD)} = 10\left(6 - \frac{\ln \mathrm{SD}}{\ln 2}\right), \qquad (11)$$

$$\mathrm{TSI(Chl)} = 10\left(6 - \frac{2.04 - 0.68 \ln \mathrm{Chl}}{\ln 2}\right), \quad (12)$$

and

$$\mathrm{TSI(TP)} = 10\left(6 - \frac{\ln \frac{48}{\mathrm{TP}}}{\ln 2}\right). \qquad (13)$$

**Figure 12. TSI Equations (Carlson, 1977)**

| TSI | Secchi disk (m) | Surface phosphorus (mg/m3) | Surface chlorophyll (mg/m3) |
|---|---|---|---|
| 0 | 64 | 0.75 | 0.04 |
| 10 | 32 | 1.5 | 0.12 |
| 20 | 16 | 3 | 0.34 |
| 30 | 8 | 6 | 0.94 |
| 40 | 4 | 12 | 2.6 |
| 50 | 2 | 24 | 6.4 |
| 60 | 1 | 48 | 20 |
| 70 | 0.5 | 96 | 56 |
| 80 | 0.25 | 192 | 154 |
| 90 | 0.12 | 384 | 427 |
| 100 | 0.062 | 768 | 1183 |

**Figure 13. TSI and association parameters (Carlson, 1977)**

Based on existing monthly average chlorophyll-a data from 2003 - 2009, Braddock Bay's TSI currently fluctuates in the 50s in the summer months (May– August). Therefore, a TSI of 60 represents an appropriate ecological threshold for Braddock Bay and should be calculated using measurements of chlorophyll-a. This equates to a chlorophyll-a concentration of 20 ug/L. Repeated exceedances of this threshold in the months of June – August should be a trigger for assessing the need for adaptive management actions. It would not be appropriate to apply this threshold to September, as existing data indicates average monthly chlorophyll-a concentrations for September exceed this value. Rather, data collected in September should be used to complete a trend calculation after five consecutive years of sampling. A rolling trend can be applied for each subsequent year. A clear increasing trend indicated by this data should be a trigger for adaptive management action. See Appendix B for additional discussion of historic data for justification of this ecological threshold.

In recent years, NYSDEC has established an "action level" for chlorophyll of 30 ug/L as a trigger for citing a water body as having potential blue-green algae. This 30 ug/L threshold will also be used as trigger for adaptive management action at Braddock Bay. Exceedance of this threshold require immediate adaptive management actions.

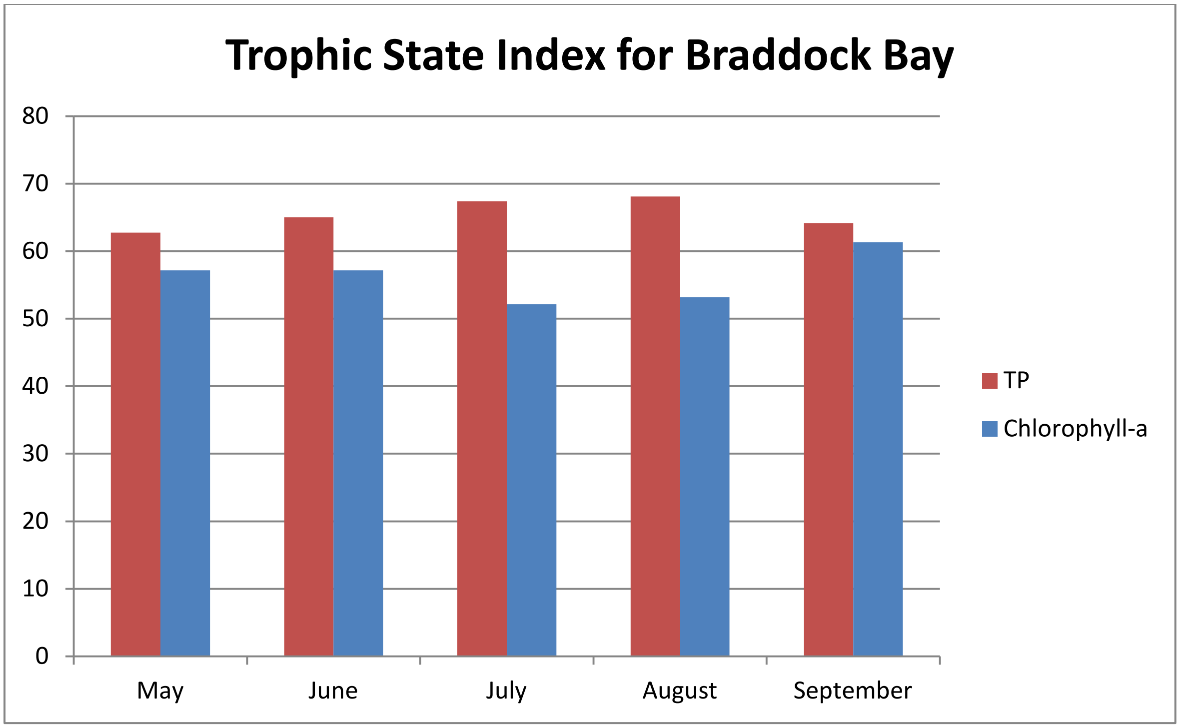



**Figure 14. Braddock Bay TSI scores for total phosphorous and chlorophyll-a (based on Makerewicz et al. 2010).**

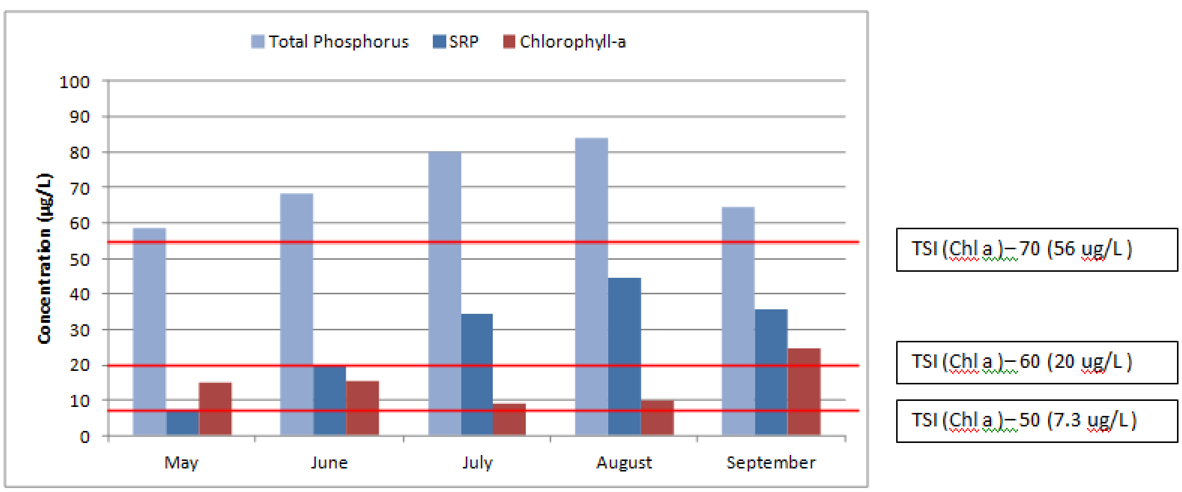
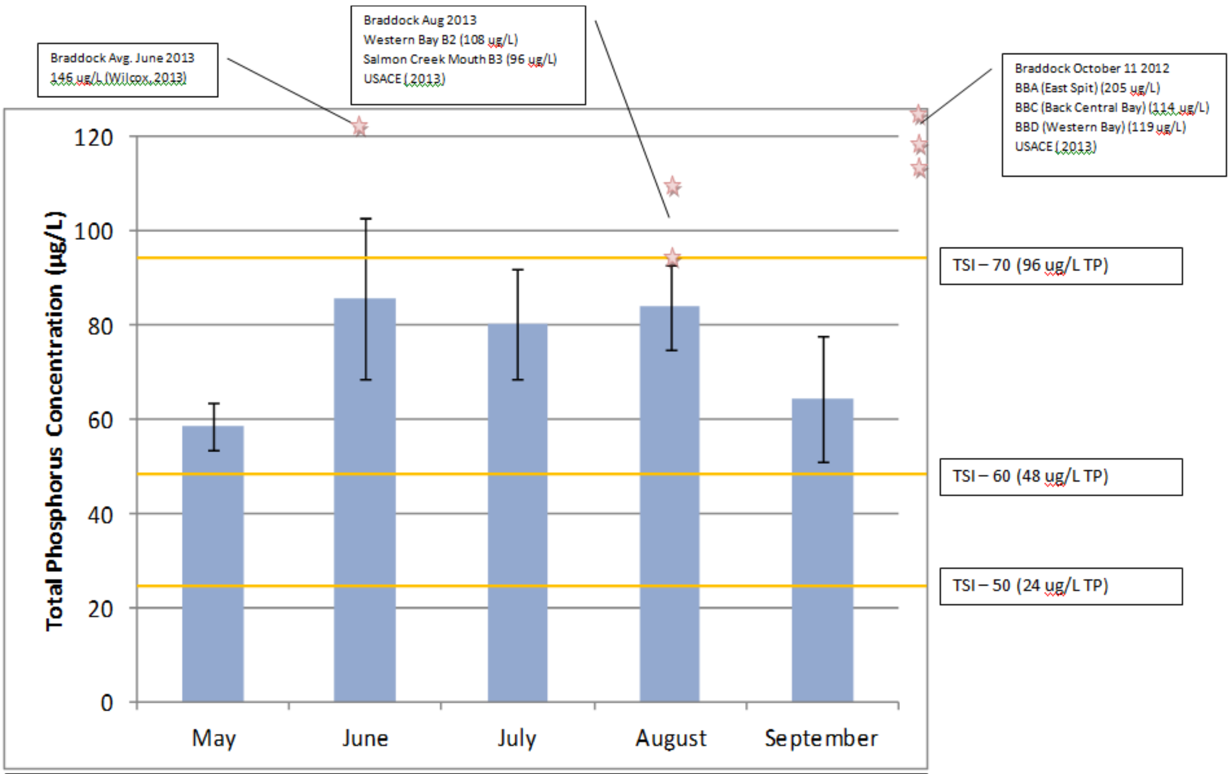
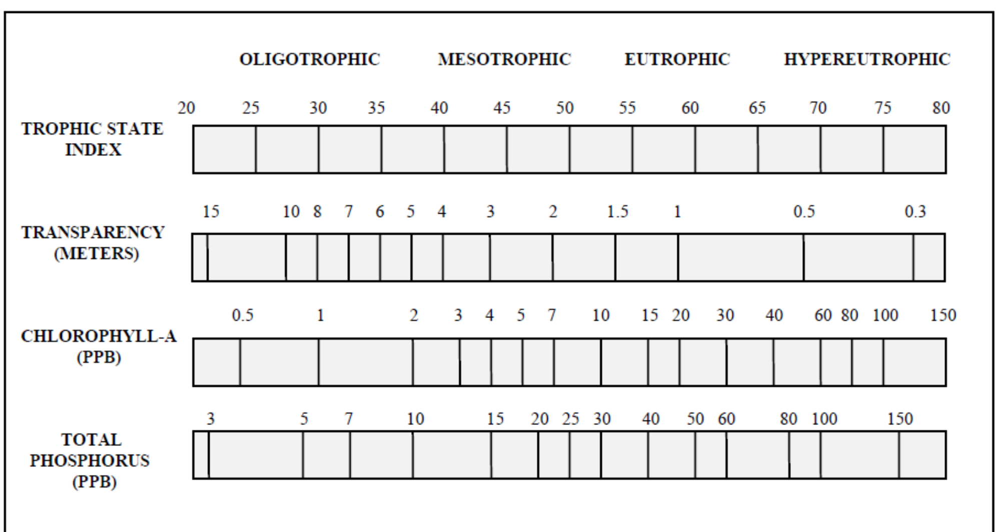



**Figure 15. Avergage concentrations of TP, SRP, and Chlorophyll-a in Braddock Bay (2003-2009) based on Makerewicz et. al; 2010. (Limnotech 2014.)**




Average (± Standard Error) Monthly Total Phosphorus Concentrations in Braddock Bay (Limnotech, 2014 adapted from Makarewicz et al. 2010)

**Figure 16. Total Phosphorus Concentration data from Makarewicz et al. 2010**




After Moore, l. and K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

**Figure 17. TSI Scale**

**Figure 6. Carlson's Trophic State Index**
**R.E. Carlson**

| | |
|---|---|
| **TSI < 30** | Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes. |
| **TSI 30 - 40** | Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anox in the hypolimnion during the summer. |
| **TSI 40 - 50** | Water moderately clear, but increasing probability of anoxia in hypolimnion during summe |
| **TSI 50 - 60** | Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only. |
| **TSI 60 - 70** | Dominance of blue-green algae, algal scums probable, extensive macrophyte problems. |
| **TSI 70 - 80** | Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic. |

**Figure 18. TSI Description of Eutrophication**

# APPENDIX C NYSDEC PROHIBITED AND REGULATED INVASIVE SPECIES

**6 NYCRR Part 575**
**Prohibited and Regulated Invasive Species**
**September 10, 2014**

## ALGAE AND CYANOBACTERIA

**Prohibited:**
*Caulerpa taxifolia*, Killer Green Algae
*Didymosphenia geminata*, Didymo
*Prymnesium parvum*, Golden Algae

**Regulated:**
*Cylindrospermopsis raciborskii*, Cylindro
*Grateloupia turuturu*, Red Algae

## PLANTS

**Prohibited:**
*Acer pseudoplatanus*, Sycamore Maple
*Achyranthes japonica*, Japanese Chaff Flower
*Alliaria petiolata*, Garlic Mustard
*Ampelopsis brevipedunculata*, Porcelain Berry
*Anthriscus sylvestris*, Wild Chervil
*Aralia elata*, Japanese Angelica Tree
*Artemisia vulgaris*, Mugwort
*Arthraxon hispidus*, Small Carpet Grass
*Berberis thunbergii*, Japanese Barberry
*Brachypodium sylvaticum*, Slender False Brome
*Cabomba caroliniana*, Fanwort
*Cardamine impatiens*, Narrowleaf Bittercress
*Celastrus orbiculatus*, Oriental Bittersweet
*Centaurea stoebe (C. biebersteinii, C. diffusa, C. maculosa misapplied, C. xpsammogena)*, Spotted Knapweed
*Cirsium arvense (C. setosum, C. incanum, Serratula arvensis)*, Canada Thistle
*Cynanchum louiseae (C. nigrum, Vincetoxicum nigrum)*, Black Swallow-wort
*Cynanchum rossicum (C. medium, Vincetoxicum medium, V. rossicum)*, Pale Swallow-wort
*Dioscorea polystachya (D. batatas)*, Chinese Yam
*Dipsacus laciniatus*, Cut-leaf Teasel
*Egeria densa*, Brazilian Waterweed
*Elaeagnus umbellata*, Autumn Olive
*Euphorbia cyparissias*, Cypress Spurge
*Euphorbia esula*, Leafy Spurge
*Ficaria verna (Ranunculus ficaria)*, Lesser Celandine
*Frangula alnus (Rhamnus frangula)*, Smooth Buckthorn
*Glyceria maxima*, Reed Manna Grass
*Heracleum mantegazzianum*, Giant Hogweed
*Humulus japonicus*, Japanese Hops
*Hydrilla verticillata*, Hydrilla/ Water Thyme
*Hydrocharis morsus-ranae*, European Frogbit
*Imperata cylindrica (I. arundinacea, Lagurus cylindricus)*, Cogon Grass
*Iris pseudacorus*, Yellow Iris
*Lepidium latifolium*, Broad-leaved Pepper-grass
*Lespedeza cuneata*, Chinese Lespedeza
*Ligustrum obtusifolium*, Border Privet
*Lonicera japonica*, Japanese Honeysuckle
*Lonicera maackii*, Amur Honeysuckle
*Lonicera morrowii*, Morrow's Honeysuckle
*Lonicera tatarica*, Tartarian Honeysuckle
*Lonicera x bella*, Fly Honeysuckle
*Ludwigia hexapetala (L. grandiflora)*, Uruguayan Primrose Willow
*Ludwigia peploides*, Floating Primrose Willow
*Lysimachia vulgaris*, Garden Loosestrife
*Lythrum salicaria*, Purple Loosestrife
*Microstegium vimineum*, Japanese Stilt Grass
*Murdannia keisak*, Marsh Dewflower
*Myriophyllum aquaticum*, Parrot-feather
*Myriophyllum heterophyllum*, Broadleaf Water-milfoil
*Myriophyllum heterophyllum x M. laxum*, Broadleaf Water-milfoil Hybrid
*Myriophyllum spicatum*, Eurasian Water-milfoil
*Nymphoides peltata*, Yellow Floating Heart
*Oplismenus hirtellus*, Wavyleaf Basketgrass
*Persicaria perfoliata (Polygonum perfoliatum)*, Mile-a-minute Weed
*Phellodendron amurense*, Amur Cork Tree
*Phragmites australis*, Common Reed Grass
*Phyllostachys aurea*, Golden Bamboo
*Phyllostachys aureosulcata*, Yellow Groove Bamboo
*Potamogeton crispus*, Curly Pondweed
*Pueraria montana*, Kudzu
*Reynoutria japonica (Fallopia japonica, Polygonum cuspidatum)*, Japanese Knotweed
*Reynoutria sachalinensis (Fallopia sachalinensis, Polygonum sachalinensis)*, Giant Knotweed
*Reynoutria x bohemica (Fallopia x bohemica, Polygonum x bohemica)*, Bohemian Knotweed
*Rhamnus cathartica*, Common Buckthorn
*Rosa multiflora*, Multiflora Rose
*Rubus phoenicolasius*, Wineberry
*Salix atrocinerea*, Gray Florist's Willow
*Silphium perfoliatum*, Cup-plant
*Trapa natans*, Water Chestnut
*Vitex rotundifolia*, Beach Vitex

**Regulated:**
*Acer platanoides*, Norway Maple
*Clematis terniflora*, Japanese Virgin's Bower
*Euonymus alatus*, Burning Bush
*Euonymus fortunei*, Winter Creeper
*Miscanthus sinensis*, Chinese Silver Grass
*Robinia pseudoacacia*, Black Locust

## FISH

**Prohibited:**
*Channa argus*, Northern Snakehead

1

*Channa marulius*, Bullseye Snakehead
*Channa micropeltes*, Giant Snakehead
*Clarias batrachus*, Walking Catfish
*Gambusia affinis*, Western Mosquitofish
*Gambusia holbrooki*, Eastern Mosquitofish
*Hypophthalmichthys harmandi*, Largescale Silver Carp
*Hypophthalmichthys molitrix*, Silver Carp
*Hypophthalmichthys nobilis*, Bighead Carp
*Misgurnus anguillicaudatus*, Oriental Weatherfish
*Mylopharyngodon piceus*, Black Carp
*Neogobius melanostomus*, Round Goby
*Petromyzon marinus*, Sea Lamprey
*Proterorhinus semilunaris (P. marmoratus)*, Tubenose Goby
*Tinca tinca*, Tench

**Regulated:**
*Carassius auratus*, Goldfish
*Cyprinella lutrensis*, Red Shiner
*Cyprinus carpio*, Common Carp/ Koi
*Gymnocephalus cernuus*, Ruffe
*Monopterus albus*, Asian Swamp Eel
*Oreochromis aureus*, Blue Tilapia
*Oreochromis niloticus*, Nile Tilapia
*Pterois miles*, Common Lionfish
*Pterois volitans*, Red Lionfish
*Sander lucioperca (Stizostedion lucioperca)*, Zander
*Scardinius erythrophthalmus*, Rudd

## AQUATIC INVERTEBRATES

**Prohibited:**
*Bellamya chinensis (Cipangopaludina chinensis)*,Chinese Mystery Snail
*Bellamya japonica*, Japanese Mystery Snail
*Bithynia tentaculata*, Faucet Snail
*Bythotrephese longimanus (B. cederstroemi)*, Spiny Water Flea
*Cercopagis pengoi*, Fishhook Water Flea
*Corbicula fluminea*, Asian Clam
*Crassostrea ariakensis*, Suminoe Oyster
*Didemnum spp.*, Carpet Tunicate
*Dreissena polymorpha*, Zebra Mussel
*Dreissena rostriformis bugensis*, Quagga Mussel
*Eriocheir sinensi*, Chinese Mitten Crab
*Hemigrapsus sanguineus*, Asian Shore Crab
*Hemimysis anomala*, Bloody Red Shrimp
*Orconectes rusticus*, Rusty Crayfish
*Potamopyrgus antipodarum*, New Zealand Mud Snail
*Rapana venosa*, Veined Rapa Whelk
*Styela plicata*, Asian Sea Squirt

**Regulated:**
*Carcinus maenas*, European Green Crab
*Daphnia lumholtzi*, Water Flea
*Hemigrapsus takanoi (H. penicillatus)*, Brush-clawed Shore Crab/ Grapsid Crab

## TERRESTRIAL INVERTEBRATES

**Prohibited:**
*Achatina achatina*, Giant Ghana Snail
*Achatina fulica (Lissachatina fulica)*, Giant African Land Snail
*Adelges tsugae*, Hemlock Woolly Adelgid
*Agrilus planipennis*, Emerald Ash Borer
*Amynthas spp.*, Asian Earthworms
*Anoplophora glabripennis*, Asian Longhorn Beetle
*Apis mellifera scutellata x A. mellifera ligustica/ A. mellifera iberiensis*, Africanized Honey Bee
*Archachatina marginata*, Giant West African Snail
*Cryptococcus fagisuga*, Beech Scale
*Lymantria dispar*, Asian and European Gypsy Moth
*Monochamus alternatus*, Japanese Pine Sawyer
*Pityophthorus juglandis*, Walnut Twig Beetle
*Sirex noctilio*, Sirex Woodwasp

## TERRESTRIAL AND AQUATIC VERTEBRATES

**Prohibited:**
*Cygnus olor*, Mute Swan
*Lepus europaeus*, European Hare
*Myocastor coypus*, Nutria
*Nyctereutes procyonoides*, Asian Raccoon Dog
*Sus scrofa (excluding Sus scrofa domestica)*, Eurasian Boar

**Regulated:**
*Alopochen aegyptiacus*, Egyptian Goose
*Cairina moschata*, Muscovy Duck
*Myiopsitta monachus*, Monk Parakeet
*Oryctolagus cuniculus*, European Rabbit
*Trachemys scripta elegans*, Red-eared Slider
*Xenopus laevis*, African Clawed Frog

## FUNGI

**Prohibited:**
*Amylostereum areolatum*, Sirex Wasp Fungus
*Geomyces destructans*, White-nose Syndrome
*Geosmithia morbida*, Thousand Canker Disease
*Phytophthora ramorum*, Sudden Oak Death

For the official regulations and species lists please see: http://www.dec.ny.gov/animals/265.html.

# APPENDIX B: SUNY BROCKPORT RESTORATION MONITORING REPORT - 2017

# Braddock Bay Restoration: 2017 Monitoring Report

Dr. Douglas A. Wilcox, Dr. Clayton J. Williams[ⱡ], Alex O. Silva, and John A. Bateman

15 March 2018

*Department of Environmental Science & Ecology*

*The College at Brockport, State University of New York*

[ⱡ]Current Affiliation: Research Assistant Professor, Rubenstein School of Environment and Natural Resources, The University of Vermont, Aiken Center Burlington VT 05405

**Introduction**

The following report contains summary and interpretation for water quality, vegetation, and wildlife data collected during 2017. The water quality portion of the report includes data from eight points within and around Braddock Bay, as well as comparisons from pre-, during, and post-construction. The vegetation report includes results from 2017 data, as well as a breakdown by type of restored habitat (channel vs. pothole) and comparisons against controls. Wildlife data include data on fish, amphibians and birds. Fish data include counts from sampling done during pike spawning season, pike young-of-year sampling, as well as overall fish community comparisons between restored areas and controls. Bird and amphibian findings include a summary of 2017 data and comparisons to 2016 in restored vs. control areas, as well as bird surveys conducted at the constructed barrier at the mouth of the bay.

**Water Quality Sampling**

Baseline conditions of Braddock Bay were established for barrier pre-construction during summer of 2015 and 2016. Baseline conditions indicate eutrophic to hyper eutrophic conditions within Braddock Bay and ecosystem target criteria were exceeded 86.1%, 80%, 85%, and 94.4% of the time at sites within Braddock Bay for Secchi disc depth, total phosphorus, chlorophyll a, and trophic state index, respectively. Post-barrier construction (2017), target criteria were exceeded 87%, 97%, 73%, and 87% of the time at sites within Braddock Bay for Secchi disc depth, total phosphorus, chlorophyll a, and trophic state index, respectively. Hence, target criteria were exceed at similar levels pre- and post-barrier construction.

Braddock Bay water quality differed significantly between baseline and post barrier conditions. Phosphorus, total suspended solids, and total kjeldahl nitrogen concentrations were higher pre-barrier than they were post-barrier. Phytoplankton biomass (measured as chlorophyll a) was similar before and after barrier construction. These comparisons provide evidence that Braddock Bay's water quality, especially bound nutrients and non-algal suspended solids, was improved post barrier constriction. However, hydrologic conditions differed significantly between years and the water quality patterns among years need to be explored before conclusions can be made about the short-term impacts of the barrier to Braddock Bay's water quality.

Braddock Bay water quality conditions significantly differed between sampling years. 2015 was a normal to wet year with normal lake levels. 2016 was a drought year with lower than average lake levels. 2017 was a normal to wet year with unusually high lake levels. When the annual comparisons are combined with the pre- and post-barrier construction comparisons, a consistent pattern in Braddock Bay begins to emerge. Phytoplankton biomass was similar throughout the study. Phosphorus concentrations were higher during the low water period of 2016 but similar pre-construction during 2016 and post-construction during 2017. Total kjeldahl nitrogen and suspended solids were lowest during 2017 and post-barrier construction. In the short-term, the barrier did not lessen phytoplankton blooms in Braddock Bay and did not clearly influence nutrient concentrations. The evidence suggests barrier construction might have helped improved suspended solid levels and water clarity, but this observation is confounded by the overlap between high water levels, low tributary inputs, and post-barrier sampling.

In 2016, variation in phytoplankton biomass was best explained by variation in total kjeldahl nitrogen. Total phosphorus was never a good predictor of chlorophyll a in Braddock Bay. High water levels in 2017 lead to better water clarity but Braddock Bay remained eutrophic with phytoplankton blooms. In 2015, some poor water clarity conditions were caused by sediment resuspension and/or turbid riverine inputs but during 2016 and 2017 water clarity declines were linked to phytoplankton biomass. Despite evidence of water exchange between the bay and lake, poor water quality conditions seem to be isolated to Braddock Bay and rarely caused undesirable conditions in near shore Lake Ontario.

All together in the short-term, these findings suggest the barrier did not have a strongly positive or negative impact on water quality in Braddock Bay. The influence of uncontrolled environmental variables between sampling year obscured this studies ability to isolate the barrier effect on water quality. More long-term monitoring is needed to minimize the influence of uncontrolled environmental factors and determine the impact of the barrier and associated wetland restoration. This study provides a strong dataset collected under varied weather patterns that can be used to assess how Braddock Bay responds to restoration.

**Purpose**

Braddock Bay is undergoing restoration to improve wetland habitat and protect the wetland from erosion (USACE 2015). Water quality samples were collected from Braddock Bay, its tributaries, and Lake Ontario to determine barrier pre-, during, and post construction condition of Braddock Bay. Samples were collected from June to September over three years (2015, 2016, and 2017). In addition to barrier construction, the three years of data captured distinct lake level and water flow conditions. 2015 and 2017 were normal precipitation years and 2016 was a drought year. 2015 had normal water levels, 2016 had low water levels and 2017 had unusually high water levels. The data in this report will allow adaptive management of Braddock (USACE 2015).

**Methods**

To determine the baseline conditions of Braddock Bay, water samples were collected at five locations within Braddock Bay (SG2, SG3, SG4, SG5a, and SG5b), at the two main tributary inputs to the bay (Salmon Creek (SC) and Buttonwood Creek (BW)), and at a near shore location just outside the bay in Lake Ontario (LO1; Fig. 1). Samples were collected from June to September four times during 2015 and six times during 2016 and 2017. Samples collected from 6/12/2015 to 8/11/2016 were pre-barrier construction, on 8/30/2016 and 9/18/2017 were during barrier construction, and from 5/16/2017 to 9/2/2017 were post barrier construction. During 2015, some sampling events were influenced by storm events. During 2016 and 2017, samples were not collected within five days of a major storm event, which was taken to mean a rain event of 0.5 inches within a 24 hour period. 2015 was a normal year in terms of lake levels and precipitation. 2016 was a drought year with lower than average lake levels. 2017 was a normal precipitation year with high lake levels. For all years when possible, sample events were spaced at least 15 days apart. During all years, water samples were collected 1 to 1.5 ft below the water's surface at four locations around the sampling site coordinates (Fig. 1). During all years, multi-probe sensor measurements and Secchi disc depth were collected at the sampling point. During 2015, water samples were put on ice and shipped to an analytical lab for processing (USACE 2016). During 2016 and 2017, water samples for total nutrients, chlorophyll, suspended solids, and turbidity were stored on ice and filtered or digested within 36 hours of collection. During 2016 and 2017, dissolved nutrient samples were filtered through a 0.45 µm polycarbonate membrane filter on site, stored on ice for transport back to the lab and analyzed fully within 36 hours.

Water quality monitoring variables were determined using standard (SM), Environmental Protection Agency (EPA) and/or American Public Health Association (APHA) methods. Water quality monitoring parameters were Secchi disc depth (ft), Turbidity (NTU), Temperature (C), Specific Conductivity (µS/cm). Oxidation Reduction Potential (ORP; mV), Dissolved Oxygen (DO; mg/L), pH, Phosphate (PO4; mg/L), Total Phosphorus (TP; mg/L), Ammonia (NH4; mg/L), Nitrite plus Nitrate (NO2NO3; mg/L), Total Kjeldahl Nitrogen (TKN; mg/L), Total Suspended Solids (TSS; mg/L), and Chlorophyll a (CHL; µg/L). Hereafter, abbreviations are used to identify water quality variables. Specific methods of analysis, level of detection, and holding times are listed in Table 1. Data with measurements below detection limit were listed as 0. Values above the detection limit but below the reporting level were retained as measured.

All data analysis was conducted in R using R-Studio. To establish baseline conditions, sites were grouped as Braddock Bay, Tributary, and Lake Ontario. Summary statistics and 95% confidence intervals were determined for each group across construction conditions. Due to the large difference in lake levels and precipitation between years, water quality conditions were also compared by year. Analysis of variance was used to look for differences between years and construction period. Pearson's correlation and univariate regression analysis was used to look for trends between variables by year. Carlson's Trophic State Index (TSI) was calculated using Secchi Depth, TP, and CHL (Carlson 1977). Data were log10(x) or log10(x+1) transformed prior to analysis to meet the assumptions of normality. The average of the three parameter TSI scores was used for each site. For Braddock Bay, water quality target criteria (Secchi disc depth = 3.28 ft, TP = 0.048 mg/L, CHL = 20 µg/L, and TSI = 60) were used to access how frequent conditions fail to meet the water quality objectives (USACE 2015). All data are presented in Appendix A, B, and C. This report will focus on nutrient dynamics, CHL, Secchi disc depth, TSS and TSI.

**Results and Discussion**

***Comparisons among construction conditions (pre, during, and post)***

Baseline conditions (pre-barrier construction) for Braddock Bay, Lake Ontario, and Tributaries for the study period (2015 – 2016) are shown in Fig. 2 (See also Table S1 and Appendix A). Conditions during (2016 ) and post (2017) barrier construction are shown in Fig. 2 (See also Table S2, S3 and Appendix B, C). The 95% confidence interval was used in this report as the estimate for the normal range for baseline conditions prior to barrier construction. The 95% confidence interval provides a conservative estimate of normal conditions in Braddock Bay and statistically reduces the impact of extreme events or outlier measurements on baseline conditions in the ecosystem.

Pre-construction conditions (mean and confidence intervals) in Braddock Bay for ecosystem target criteria were 0.014 mg/L (0.003 to 0.131) for PO4, 0.102 mg/L (0.033 to 0.200) for TP, 0.050 mg/L (0.013 to 0.213) for NH4, 0.136 mg/L (0.000 to 0.704) for NO2NO3, 1.123 mg/L (0.573 to 1.800) for TKN, 41.6 µg/L (11.5 to 86.8) for CHL, 1.9 ft (1.0 to 3.4) for Secchi depth, 17.4 mg/L (8.1 to 32.5) for TSS, and 67 (61 to 75) for TSI. Ecosystem target criteria were exceeded 86.1%, 80%, 85%, and 94.4% of the time at sites within Braddock Bay for Secchi depth, TP, chlorophyll a, and TSI, respectively. P levels, turbidity, CHL, and TSI in Lake Ontario were lower than Braddock Bay conditions. Tributary P levels were higher than in Braddock Bay, N levels were variable and often similar to Braddock Bay, and CHL and TSI tended to be lower in the tributary than in Braddock bay.

For the two sampling events during construction conditions (mean and confidence intervals) in Braddock Bay for ecosystem target criteria were 0.041 mg/L (0.001 to 0.123) for PO4, 0.199 mg/L (0.120 to 0.376) for TP, 0.008 mg/L (0.000 to 0.018) for NH4, 0.002 mg/L (0.000 to 0.008) for NO2NO3, 1.127 mg/L (0.549 to 1.528) for TKN, 74.2 µg/L (8.6 to 118.0) for CHL, 1.6 ft (0.8 to 3.4) for Secchi depth, 16.3 mg/L (2.3 to 30.4) for TSS, and 74 (64 to 80) for TSI. Ecosystem target criteria were exceeded 90%, 100%, 80%, and 100% of the time at sites within Braddock Bay for Secchi depth, TP, chlorophyll a, and TSI, respectively. P levels, turbidity, CHL, TKN, and TSI in Lake Ontario were lower than Braddock Bay conditions and NO2NO3 was higher in the lake than in the bay. Tributary $PO_4$ levels were higher than in Braddock Bay, N levels were variable and often similar to Braddock Bay, TP levels were similar between the bay and tributary, and CHL and TSI tended to be lower in the tributary than in Braddock bay.

Post construction conditions (mean and confidence intervals) in Braddock Bay for ecosystem target criteria were 0.010 mg/L (0.000 to 0.040) for PO4, 0.071 mg/L (0.042 to 0.114) for TP, 0.030 mg/L (0.000 to 0.116) for NH4, 0.042 mg/L (0.000 to 0.146) for NO2NO3, 0.712 mg/L (0.560 to 0.833) for TKN, 34.9 µg/L (23.5 to 48.1) for CHL, 2.5 ft (1.5 to 4.0) for Secchi depth, 10.6 mg/L (4.8 to 21.1) for TSS, and 65 (59 to 70) for TSI. Ecosystem target criteria were exceeded 87%, 97%, 73%, and 87% of the time at sites within Braddock Bay for Secchi depth, TP, CHL, and TSI, respectively. P levels, turbidity, CHL, and TSI in Lake Ontario were lower than Braddock Bay conditions. Tributary P levels were higher than in Braddock Bay, N levels were variable and often similar to Braddock Bay, and CHL and TSI were similar in the tributary than in Braddock bay.

Tributary inputs to Braddock Bay were nutrient rich, especially with respect to PO4. Tributaries were generally free of phytoplankton blooms (except during 2017 high water) and relatively clear. The Tributaries always loaded PO4 but often had levels of dissolved inorganic nitrogen (NO2NO3 + NH4) near detection limits. Hence, the Tributary complexes of Braddock Bay are significant source of phosphorus to the bay but typically buffer against inorganic nitrogen contaminants entering the bay. Interesting, Lake Ontario has higher levels of NO2NO3 on average than Tributaries and could act as a nitrogen source to Braddock Bay.

Braddock Bay water quality differed significantly between baseline (pre-construction) and post barrier construction conditions. Because only two sampling events occurred during construction, water quality parameters during construction were not statistically compared to pre- and post-construction conditions. Phosphorus concentrations were significantly lower post barrier construction than during pre-construction (PO4, $F = 7.9$, $p = 0.006$; TP, $F = 4.9$, $p = 0.030$). TKN ($F = 18.4$, $p < 0.001$), TSS ($F = 20.2$, $p < 0.001$), and TSI ($F = 5.7$, $p = 0.020$) followed a similar pattern as phosphorus and were lower post barrier construction. Secchi disc depth ($F = 8.8$, $p = 0.004$) was significantly deeper (i.e., greater light penetration) post construction. CHL, NH4, and NO2NO3 were exceptions and did not significantly differ pre- and post-barrier construction. These comparisons provide evidence that Braddock Bay's water quality, especially bound nutrients and non-algal suspended solids, was improved post barrier constriction. However, hydrologic conditions differed significantly between years and the water quality patterns among years need to be explored before conclusions can be drawn about the short-term impacts of the barrier to Braddock bay's Water quality.

*Comparisons among years (2015, 2016, and 2017)*

Water quality differed significantly among sampling years in Braddock Bay and its tributaries (Fig. 3). Conditions in Lake Ontario were similar among years despite the difference in lake levels (Fig. 3). CHL was similar among years in Braddock bay but significantly higher in the tributaries during 2017 ($F = 16.6$, $p < 0.001$). PO4 ($F = 12.3$, $p < 0.001$) and TP ($F = 9.1$, $p = 0.001$) were significantly lower in the tributaries during 2017 than other years. In Braddock Bay, PO4 was higher during 2016 than 2017 ($F = 4.9$, $p = 0.010$), PO4 tended to be lower in 2017 than in 2015 ($p = 0.100$), and TP was significantly higher during 2016 than the other years ($F = 15.9$, $p < 0.001$). In tributaries and Braddock Bay, NO2NO3 ($F = 3.8$, $p = 0.033$ and $F = 7.1$, $p = 0.001$, respectively) and NH4 ($F = 5.6$, $p = 0.011$ and $F = 8.2$, $p = 0.001$, respectively) were significantly higher during 2015 than the other years. TKN was higher in 2015 than other years in tributaries ($F = 6.8$, $p = 0.004$). Moreover, TKN differed during all years in Braddock Bay ($F = 20.0$, $p < 0.001$) with concentrations in 2015 > 2016 > 2017. TSS was similar among years in tributaries and significantly lower in Braddock Bay during 2017 than other years ($F = 7.2$, $p = 0.001$). Secchi disc depth followed a similar pattern as TSS in Braddock Bay, suggesting light conditions were better during 2017 with higher water levels.

The above patterns suggest that the one near shore site in Lake Ontario was not influenced statistically by differences in water level and tributary flow between years. This absence of impact is likely due to the sites location, which acted as a mixing zone between the bay and the lake. A site located farther away from shore would likely be more sensitive to water quality impacts associated with lake level fluctuation. Tributaries, sampled just upstream of Braddock Bay, appeared more bay like during 2017 than in other years, suggesting the river to bay confluence had moved upstream. Low water levels in 2016 seemed to make phosphorus more available in Braddock Bay, possibly through internal loading. The reason behind the decline in nitrogen in Braddock Bay from 2015 to 2017 is unclear. High water levels improved water clarity in Braddock Bay but phytoplankton blooms were still common. During 2015 phytoplankton blooms were not as sever and the water appeared turbid due to sediment resuspension (USACE 2016). In contrast during 2016 and 2017, Braddock Bay experienced large phytoplankton blooms with little evidence of sediment resuspension (Fig. 4). Most sampling events during all years failed to meet water quality target criteria for ecosystem health.

Given the differences in water quality between years, it is not surprising that relationships among water quality parameters were not always consistent between years (Table 2). Phytoplankton blooms are a major concern in water quality studies. To help facilitate better understanding of blooms in Braddock Bay, this report investigates what covaries with blooms in the bay. In 2016 and 2017, CHL strongly correlated with TSS, Turbidity, and Secchi disc depth, suggesting that phytoplankton biomass negatively impacted light conditions (water clarity) in Braddock Bay (Fig. 4). These relationships were absent in 2015, providing further evidence that water clarity was influenced by non-microbial suspended solids (sediment, soil, and mineral particles). Moreover, there were two outliers in the CHL vs water clarity relationships in 2015, which when removed, do reveal a negative impact of phytoplankton biomass on water clarity.

In 2015 and 2016, CHL correlated negatively with PO4 but not in 2017 when PO4 concentrations remained low all season (Fig. 4). Throughout the study period, CHL did not correlate with TP (Fig. 4), which is surprising given the positive correlations between TP and phytoplankton biomass are commonly observed in the Great Lakes and other freshwater systems. Nitrogen correlated differently with phytoplankton biomass across years (Table 2). The strongest pattern observed was a positive correlation between TKN and CHL during 2016 (Fig. 4). This relationship was absent in 2015 and weaker in 2017, though the 2017 points fell fully on the pattern established in 2016. This relationship suggests phytoplankton were N limited during 2016.

To explore relative changes in nutrient availability further, nitrogen to phosphorus stoichiometric ratios were calculated by mole for total and dissolved inorganic nutrients (Fig. 5). As a reference N:P ratios of 16:1 would indicate balanced nutrition for phytoplankton. N:P ratios < 16:1 provide evidence of N limitation and N:P ratios > 16:1 provide evidence of P limitation (Redfield 1958; Harpole et al. 2011). Lake Ontario N:P levels were high and indicated potential P limiting conditions in all years. The N:P ratios revealed large changes in the relative availability of nitrogen and phosphorus among years in Braddock Bay and its tributaries. In tributaries, N:P ratios suggested relatively balanced nutrient inputs in 2015 and 2017 but N deplete inputs in 2016. Similarly, Braddock Bay N:P ratios were around to slightly above 16:1 in 2015 and 2017 but shifted to below 16:1 in 2016. Changes in N:P ratios suggest a shift from co-limiting conditions during normal and high water periods to nitrogen-limiting conditions during low water periods. Together, these findings suggest that both nitrogen and phosphorus pollution are important to control phytoplankton blooms in Braddock Bay and improve ecosystem health.

**Conclusion**

When the annual comparisons are combined with the pre- and post-barrier construction comparisons, a consistent pattern in Braddock Bay begins to emerge. Phytoplankton biomass was similar throughout the study. Phosphorus concentrations were higher during the low water period of 2016 but similar pre-construction during 2016 and post-construction during 2017. Total kjeldahl nitrogen and suspended solids were lowest during 2017 and post-barrier construction. Ammonia and nitrite+nitrate were low during high and low water years. In the short-term, the barrier did not lessen phytoplankton blooms in Braddock Bay and did not clearly influence nutrient concentrations. The evidence suggests barrier construction might have helped improved suspended solid levels and water clarity, but this observation is confounded by the overlap between high water levels, low tributary inputs, and post-barrier sampling.

Pre-barrier construction, baseline conditions in Braddock Bay indicate eutrophic to hyper eutrophic conditions. Ecosystem target criteria pre-barrier were exceeded 86.1%, 80%, 85%, and 94.4% of the time at sites within Braddock Bay for Secchi depth, TP, chlorophyll a, and TSI, respectively. Similarly, post-barrier construction, ecosystem target criterial were exceeded 87%, 97%, 73%, and 87% of the time at sites within Braddock Bay for Secchi depth, TP, CHL, and TSI, respectively. Additional monitoring is needed to determine the long-term impact of the barrier on water quality conditions in Braddock Bay because the hydrological conditions varied greatly throughout the study. Part of the challenge in identifying significant effects of the barrier was due to variation among precipitation, tributary discharge, and lake levels among years. Braddock Bay significantly differed in its water quality between sampling years, but frequently exceeded target criteria in all sampling years. The effects among years tended to be stronger than the effects between baseline and post-barrier construction but there was considerable overlap between these two factors. More data need to be collected with the barrier in place to better separate the effects of barrier from year, which varied by hydrologic condition.

Phytoplankton biomass was high in Braddock Bay. The evidence suggests that both nitrogen and phosphorus are important in understanding blooms in the bay and, hence, effort is needed to mitigate nutrient pollution to Braddock Bay in order to limit bloom development. Despite evidence of water exchange between the bay and lake, poor water quality conditions observed in Braddock Bay rarely caused undesirable conditions in near shore lake Ontario. Post barrier construction this pattern did not seem to change, although the high water conditions prevent over generalization of this observation. Lake Ontario was nitrate rich relative to the bay. The tributaries and the lake could both be important sources of nitrogen to the bay. For example, when tributary inputs were low in N:P ratios, phytoplankton biomass was coupled with reduced forms of nitrogen. During high water Braddock Bay N:P ratios indicated balanced nutrient conditions, which plausibly could have been support by influx of lake nitrogen. Overall, phytoplankton blooms were most severe during low water, drought conditions when nitrogen seemed limiting and phosphorus was more abundant in dissolved form.

Overall, the results of this study are inconclusive. It is unclear from the data collected in this study how barrier construction and wetland restoration will impact water quality in Braddock Bay over the long-term. 2015 was the only normal year with respect to lake levels and hydrology. This study provides a strong dataset collected under varied weather patterns that can be used to assess how Braddock Bay responds to restoration. To account for this uncertainty, water quality should be tracked again in 2018 and periodically into the future as the restored wetland matures. The pre-restoration and current water quality conditions in Braddock Bay are poor and upstream management actions should be considered to help improve ecosystem health. Reductions in internal and external loads of phosphorus and nitrogen are likely required in this system in order to control phytoplankton blooms.

**Vegetation Sampling**

All of the plant data were collected between 7 June 2017 and 16 August 2017. Once entered into a spreadsheet, each plant species was given a corresponding C-score based on the New York State preliminary C-score list with reference to the Michigan C-score list. These C-scores for each individual species were then averaged to determine mean C-scores for each quadrat, which were then compiled for each zone (see below) and were used to calculate the Floristic Quality Assessment Index (FQAI) for each zone. This FQAI statistic is used to evaluate the nativeness of an area based on the plant species present. A C-score of 0 indicates non-native taxa with a widened range of tolerance in terms of environmental limits, with a score of 10 being a very specialized, narrow range of limits that the specific plant species can handle. These scores were then averaged to yield a mean FQAI and mean C-score for each transect, which were then grouped into zones. All of these data were averaged to determine a mean FQAI and C-score for all of the channel transects and all of the pothole transects, respectively. The means for total species within each quadrat, zone, and transect were calculated similarly. The overall mean values are shown in Table 3.

The calculated mean values show a trend of channel transects having the highest mean FQAI, mean C-score, and species richness, followed by pothole transects, then the control quadrats. Channel transects had 6.9 species in each quadrat, on average, as opposed to 5.8 in the pothole transects and 4.3 within the control quadrats. From this broader point of view, we can then look further into Braddock Bay by separating these transect data to look at each individual habitat type within a group, or zone, that contains transects based on location or pothole variation.

We grouped channel transects into three zones (Figure 6) based on their location and proximity to one another. Throughout the three separate zones, there are no overall trends being shown from these data, where the sedge-grass meadow (SGM), mounds (M), intermediate bench (IB), and channels (C) have some higher values for mean FQAI and mean C-score, but with variation as to which habitat has the highest, depending on the zoning (Table 4). The higher mean FQAI on the mounds and the IB was driven by species richness, opposite to that of the SGM and channels that were driven by a higher mean-C within the zones. The sedge-grass zone is expected to have some species, such as *Carex lacustris* (C-score of 6.5), *Fraxinus pennsylvanica* (C-score of 5.5), and *Calamagrostis Canadensis* (C-score of 5) with C-scores higher than other habitat types in these transects. These species were present in the sedge-grass meadow, which is expected, and created higher zone FQAI values of 8.3 in Zone 1, 8.3 in Zone 2, and 7.7 in Zone 3 (Table 4). Whereas, the channel zone had *Utricularia vulgaris* (C-score of 6), *Stuckenia pectinatus* (C-score of 5.5), and *Lemna trisulca* (C-score of 5). These species contributed to higher zone FQAI values of 8.3 in Zone 1 and 7.9 in Zone 3 (Table 4).

We were able to separate the pothole transects into two different groupings: 1) individual zones based on location and proximity to each other (Figure 7) and 2) connected vs isolated potholes (Figure 8). The only zone that does not differ between pothole groups is the zone of isolated potholes (Table 5 – zone 3, Table 6 – zone 2).

In group 1, the mound (M) habitats seem to have the highest FQAI values and average number of species (Table 5), which may be correlated since a greater number of plant species with a high C-score could potentially increase the average and FQAI. The mounds are expected to have some species with higher C-scores than the bench and deep water habitat types, such as *Decodon verticillatus* (C-score of 7.5), *Thelyptris palustris* (C-score of 6), and *Boehmeria cylindrica* (C-score of 4). These species contributed to higher zone FQAI values of 12.4 in Zone 1, 7.4 in Zone 3, and 8.7 in Zone 4 (Table 5). The bench zone showed a similar trend with a high FQAI value and average number of species (Table 5). Aided by the presence of *Thelyptris palustris* (C-score of 6) and *Utricularia vulgaris* (C-core of 6) that caused the higher FQAI values of 8.4 in Zone 1, and 7.7 in Zones 2 and 4 (Table 5).

In group 2, when data are grouped by connected vs isolated potholes (Figure 8), the results are the same, with the mound (M) habitats having the highest mean FQAI value along with the mound (M) and bench (B) zones having the same highest value for average species per plot (Table 6). Within the connected potholes, it is driven by species richness, and not mean-C. But within the isolated potholes, the high FQAI values is attributed to a combination of species richness and the mean-C scores. Similar to the previous pothole groupings, species presence and abundance of certain species can explain these observations. The same species are responsible for these trends as those in the grouping based on location and proximity.

Within the channel transects, few species were dominant (mean cover percentage > 10.00) across all habitat types (Table 7). In the sedge grass meadow (SGM), there were no dominant species with values of over 10.0, with species such as *Hydrocharis morsus-ranae* having the highest mean percent cover value of 8.9. In the treatment area (TR), the dominant vegetation was *Hydrocharis morsus-ranae* with a mean percent cover of 10.6. On the mounds (M), the dominant vegetation included *Persicaria hydropiper* with a value of 10.1, followed by less dominant values of 7.1 for *Hydrocharis morsus-ranae* and 6.7 for *Typha x glauca.* On the shallow bench (SB), the dominant vegetation was *Typha x glauca*, which had a mean percent cover of 17.4 followed by less dominant *Hydrocharis morsus-ranae* with a value of 8.5. On the intermediate bench (IB), there were no species with values over 10.0, leaving the highest mean percent cover as *Hydrocharis morsus-ranae* (mean percent cover of 6.7) and *Utricularia vulgaris* (mean percent cover of 8.9). Within the channel (C), the highest mean percent cover was *Utricularia vulgaris* with a value of 8.2.

Within the pothole transects (Table 8), the deep water zone (D) had no species with a value of over 10.0, leaving *Utricularia vulgaris* with the highest mean percent cover of 9.5. There were also no species with a value of over 10.0 in the bench habitat (B), *Hydrocharis morsus-ranae* had a mean percent cover of 9.9, *Typha x glauca* had a value of 8.2, and *Utricularia vulgaris* had a value of 9.4. The mounds (M) slightly had the most vegetation on the pothole transects; *Impatiens capensis* and *Persicaria hydropiper* were the dominant vegetation, with mean percent cover of 10.0 and 10.5, respectively. Lastly, within the control quadrats, only Typha x glauca was dominant with a value of 20.6 (Table 9).

**Fish Sampling**

Fish were sampled within restored and control areas for a total of 25 net nights between 13 April and 4 November 2017. Timing of sampling coincided with northern pike (*Esox lucius)* spawning in early spring (13 and 20 April) and northern pike young-of-year (YOY) during late spring (31 May and 1 June). In addition, fish data from two other projects have been included in other analyses to better describe the fish community in control and restored areas. Those sets occurred during summer (6 and 10 July) and late fall (4 November). For the northern pike sampling, two mesh sizes were used (4.8 and 12.7mm) on large frame fyke nets. Dimensions for the nets include 7.6 x 0.9 m leads attached to 1.2 x

0.9 m frames, with the tram containing two mesh funnels with inside diameters of 0.17 m. One net of each mesh size was set in both restored and controlled areas to avoid biases associated with small and large mesh, as large mesh is used for larger fish that might be net-shy, while small mesh is used to prevent biasing against small juvenile fish. We used the same nets during summer (Coastal Wetland Monitoring) and fall (Functional Indicators) projects, however different methodologies were followed. For both of those projects, two nets were set in restored areas while a third was set in a control. Net locations can be found in Figure 9.

For the sampling that coincided with pike spawning, 326 fish across 22 species were caught over the eight net nights (Table 10). All 22 species and 244 fish total were caught in the control zones, while 7 species and 82 fish in total were caught in areas that had been restored. In total, three northern pike were caught in control nets, while one was caught in a restored area. The most abundant species caught in the control nets was brown bullhead (*Ameiurus nebulosus*) (n= 123), while only four were caught in restored areas. The two most common species found in the restored areas included pumpkinseed sunfish (*Lepomis gibbosus*) (n= 33) and bowfin (*Amia calva*) (n=32).

For the sampling that was meant to capture young-of year-northern pike, a total of 146 fish across 16 different species were caught over the eight net nights (Table 11). In total, 13 species and a total of 116 fish were caught in the control nets, while 8 species and 30 fish total were caught in the restored areas. Eight species were found only in control zones, while only three were caught only in restored areas, including northern pike, bowfin, and banded killifish (*Fundulus diaphanous*). Of note, only two YOY individuals were caught over these two days. Both were northern pike, and each was caught in a restored area. The presence of these fish indicates the ecological success criteria set forth by the Adaptive Management Plan was met for 2017.

When the additional data from the Coastal Wetland Monitoring and Functional Indicators were added to the data set, a total of 566 fish across 25 species were caught in Braddock Bay during 2017 over the 28 net nights (Table 12). Of those, 382 fish of 23 species were caught in control nets, while 184 fish of 11 species were caught in restored areas. While overall abundance and diversity appear to be greater in control areas, greater spawning success was observed in the restored sites, with 54 YOY fish of 5 species caught in those nets, versus only 3 species and 18 fish in total in control nets (Table 13).

**Bird and Anuran Sampling**

Bird and calling amphibian surveys were conducted at three locations throughout the bay (Figure 10), with three visits for the anuran community that followed traditional Marsh Monitoring Protocol (MMP) timing. Amphibian counts were conducted between 15 April and 10 July, while bird counts took place between 20 May and 7 July, 2017. In addition to the three calling amphibian surveys that were conducted as part of this project, data from an additional three point counts that were part of the Great Lakes Coastal Wetland Monitoring Program were added to the data set for a total of six point counts per station. Counts for that project took place within the same time frame as the counts for this project. Calling amphibian surveys were 3 minutes long, with surveyors recording all species detected in the marsh using call codes that serve as an index of abundance. Call code descriptions are provided in Appendix D. The bird community was surveyed with an intensified version of the MMP, using roughly weekly samples during the bird survey period, resulting in six surveys per point. Data from an additional point count collected as part of the Great Lakes Coastal Wetland Monitoring Program were also added to the data set, raising the total to seven counts per station. Methods set forth in MMP were followed for survey weather limitations, survey timing and length, and data recording. Briefly, these include morning (half hour before to four hours after sunrise) and evening surveys (four hours before to one half hour after sunset); each survey was 15 minutes long and contained 5 minutes of passive listening, 5 minutes of marsh bird song audio playback to entice calls, and a final 5 minutes of passive listening; all birds detected either aurally or visually were recorded.

A total of 27 and 32 bird species were detected in survey stations 1 and 2, respectively. These survey locations cover the cattail treatment, channel, and pothole portions of the restoration (Table 14). Survey station 3, the station farthest away from the cattail treatment, channel, and potholes of the restoration had 31 species present. Tree Swallow (*Tachycineta bicolor*) was the most commonly detected species across all points, with a total of 269 individuals detected across the three locations and was generally more prevalent at the control point, station 3, where 200 birds were observed during one point count. Ring-billed Gull (*Larus delawarensis*), Red-Winged Blackbird (*Agelaius phoeniceus*), Marsh Wren (*Cistothorus palustris*), and Barn Swallow (*Hirundo rustica*) were the four next most commonly detected species, each with greater than 50 detections across all surveys and locations. Two invasive bird species, Mute Swan (*Cygnus olor*) and Double-crested Cormorant (*Phalacrocorax auritus*) were detected in the surveys and were mostly observed at survey stations 1 and 3, the stations with the best view of open water where these species are often detected. Few marsh-nesting obligate focal species were detected, with only three Least Bittern (*Ixobrychus exilis*) and four Virginia Rail (*Rallus limicola*) present during counts. One Least Bitterns was detected at station 1 and two at station 2, both near the restoration activities, and the four Virginia rails were detected at survey station 2, close to the restoration activities.

Six anuran species were detected during the six surveys at each station in 2017 (Table 15). We report anuran abundance data using only the maximum call code (Appendix D) recorded by species, as the maximum call code mitigates some of the issues encountered with estimating calling anuran abundance, including their sensitivity to slight weather changes affecting calling intensity and the difficulty in estimating the true abundance in the field based on calls. American bullfrog (*Lithobates catesbeianus*) and American toad (*Anaxyrus americanus*) were the species of the lowest calling intensity, call code 1, at station 1. American toads were also recorded at call code 1 at station 3, as was gray treefrog (*Hyla versicolor*). Northern leopard frog (*Lithobates pipiens*) and green frog (*Lithobates clamitans*) were each detected at a call code 2 at all three stations Finally, spring peeper (*Pseudacris crucifer*) was the only species to be detected in Braddock Bay with a full chorus, call code 3, and it called at this intensity at all three stations. American bullfrogs called at a greater intensity this year at two stations when compared to their overall calling effort in 2016. This included a call code of 2 near the restored area where station 2 is located and also the control area at station 3. American toad also had a greater calling intensity (call code 2) at station 2. This is an upland species that utilizes wetlands to complete its life cycle, so a higher call code in the restored area indicates that these toads could be selecting the newly-constructed potholes as sites for ovipositing.

**Implications for Adaptive Management**

From 2016 to 2017, there was an increase of 62 birds at station 1, for a 25% increase (Table 16). While there was an overall net loss of one species at this point count station (28 to 27), this well exceeds the ecological success criterion of >14 species set by the Monitoring and Adaptive Management Plan. Another indicator of restoration success is an increase in marsh-dependent bird species. While it is important to note that two additional point counts were performed in 2017 than 2016, there was more than a 50% increase in Marsh Wren observations at this station (30 to 47), and Tree Swallows also had a significant increase in presence over the prior year (23 to 40). Numbers for several other marsh-dependent species were relatively similar to those in 2016, including Red-winged Blackbird (39 to 36), Swamp Sparrow (*Melospiza georgiana*) (13 to 12), and Yellow Warbler (*Setophaga petechia*) (6 to 5), indicating that was no change in numbers for these species since the prior year. Also, one Least Bittern, a marsh-dependent focal species, was observed near the newly restored areas in 2017 after being absent in 2016. This is another positive sign that wetland birds are benefitting from the restoration. While several birds increased in numbers, a couple showed some slight decreases. These include Common Yellowthroat (10 to 5) and Mallards (*Anas platyrhynchos*) (9 to 5).

While station 2 experienced a 5% decrease in total bird abundance since last year, as there were 10 fewer birds observed in 2017 (183 to 169), it still exceeded the ecological success criterion with 32 species present at the site. Several other results indicate that birds are benefitting from newly restored areas near where these birds were observed. Station 2 had the highest overall bird richness in 2017 (32 species), which was slightly greater than the control at station 3 (31 species) and the other restored area at station 1 (27 species). Red-winged Blackbird abundance increased by 12 birds (39 to 51), and Common Yellowthroat increased by 6 birds (7 to 13). While there were two new wetland-dependent focal bird species from a year ago, Least Bittern (2 birds) and Virginia Rail (4 birds), two focal species that were observed in 2016 were not detected this past summer (American Bittern (*Botaurus* lentiginosus) and American Coot *(Fulica americana*). Other notable decreases include Barn Swallow (13 to 8) and Swamp Sparrow (21 to 14).

The control area, station 3, experienced a 188% increase in total bird count over the prior year, with an increase of 299 birds from the 2016 results (159 to 458). These data were highly skewed by Tree Swallow (+200) and Ring-billed Gull (+77) increases. No focal species were observed at this station in 2017, while two Least Bittern were recorded here in 2016. This suggests that these birds may have a selection preference for the restored areas over the monotypic cattail habitat at the control point.

While restoration activities undoubtedly had an impact on bird abundance and diversity, we can only speculate on the effects of the unusually high waters in the 2017 field season on birds at this time. At station 3, the spot where birds are recorded was inundated by more than a meter of water at times. This suggests that some optimal nesting areas may have been flooded, resulting in failed nests. The increase in overall numbers this past season, including focal species, suggests that adult birds have some degree of resistance to the high waters. Inferences about bird resiliency might be drawn after next year when we see how juvenile recruitment might have been impacted by the high waters.

Amphibian richness varied little from 2016, as the same six species were present at two of the three stations. Overall, amphibian richness exceeds the ecological success criteria of four species set by the Braddock Bay Monitoring and Adaptive Management Plan (>4 species). It is important to note that none of the six species called at a lesser intensity in 2017 than in 2016. Frogs are sensitive to environmental change, and die-offs have been noted at other restoration sites within Braddock Bay Wildlife Management Area. Hundreds of northern leopard frogs were found dead or dying in 2015-2017 at an adjacent restoration site, yet despite the number of hours spent in Braddock Bay by the Brockport crew this past summer, we did not find evidence of such an event taking place near the restored areas or elsewhere within the wetland.

**East Spit Barrier Monitoring**

The College at Brockport conducted 9 non-standardized bird samples to examine avian use of the barrier skeleton on the east spit of Braddock Bay. These surveys took place between August 30$^{th}$ and November 11$^{th}$, 2017. All birds encountered on site were documented, with a special focus on birds on the skeleton of the barrier or within the protected lagoons. For a bird to be considered as using the barrier, it had to be either on the barrier or within the protected lagoons. In total, 3,699 birds of 112 species were recorded over these 9 trips (Table 17). Highlights include a red knot (*Calidris canutus*), 3 Pied-billed Grebe (*Podilymbus podiceps*), 10 American Coot, and 2 Virginia Rail. Twelve different shorebird species were observed on or around the barrier, demonstrating that even though the structure is not finished, it is still providing habitat for species.

**Tables**

*Table 1. List of parameter methods used during the 2015, 2016, and 2017 Braddock Bay water quality monitoring.*

| Parameter | 2015 Method | 2016 Method | Precision and Accuracy (≤% RPD) | Range | Units | Preservation | Sample Fraction | Method Holding Times | Project Holding Times |
|---|---|---|---|---|---|---|---|---|---|
| Nitrogen - Ammonia | SM_4500-NH3-D | SM 4500-NH3 G-97 | 20% | 0.002 - 1 | mg/L | Chill to 4°C; acidify | Filtered (≤ 0.45 µm) | 36 H; 28 D | 36 H; 14 D |
| Nitrogen – Nitrate/Nitrite | SM_4500-NO3-H | SM_4500-NO3-F | 20% | 0.002 - 2 | mg/L | Chill to 4°C; acidify | Filtered (≤ 0.45 µm) | 36 H; 28 D | 36 H; 14 D |
| Nitrogen - Total Kjeldahl | EPA_351.2 | TN (SM 4500 P J) minus SM 4500-NO3- F | 20% | 0.01 - 2 | mg/L | Digested; Chill to 4°C | Total | 36 H; 28 D | 36 H; 14 D |
| Phosphorus, Total | SM_4500-P-F | SM_4500-P-F | 20% | 0.01 - 1 | mg/L | Digested; Chill to 4°C | Total | 36 H; 28 D | 36 H; 14 D |
| Phosphorus, Dissolved (Ortho) | EPA 365.1 | EPA 365.1; SM_4500-P-F | 20% | 0.002 - 1 | mg/L | Chill to 4°C; acidify | Filtered (≤ 0.45 µm) | 36 H; 28 D | 36 H; 14 D |
| Total Suspended Solids (TSS) | SM_2540D | SM 2540-D | 25% | NA | mg/L | Chill to 4°C | Particles Filtered on to Whatman GF/C | 1 W | 1 W |
| Chlorophyll a | APHA (2012) Method 10200H.2 (Spectrophotometric) | APHA (2012) Method 10200H.2; EPA 445.0 | 25% | NA | µg/L | Chill to 4°C; Frozen at -20°C | Particles Filtered on to Whatman GF/C; Particles | 36 H; 28 D | 36 H; 14 D |
| Temperature, pH, DO, ORP, Conductivity, Turbidity, Secchi Disk | Field Measurement | Field Measurement | NA | NA | Multiple Field | | Field | Field | Field |
| Nitrogen - Total | Not Determined | SM 4500 P J; SM 4500 NO3- F | 20% | 0.01 - 2 | mg/L | Digested; Chill to 4°C | Total | 36 H; 28 D | 36 H; 14 D |

NA = Not Applicable

*Table 2. Pearson correlation matrix of water quality parameters within Braddock Bay across sampling years. All variables were Log10(x or x+1) transformed to better meet assumptions of normality. Significant correlations are in bold and italic type. Values are correlation coefficients.*

| **2015** | CHL | PO4 | NH4 | NO2NO3 | TP | TSS | TKN | pH | DO | ORP | Cond | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHL | - | | | | | | | | | | | |
| PO4 | **-0.66** | - | | | | | | | | | | |
| NH4 | **-0.72** | **0.56** | - | | | | | | | | | |
| NO2NO3 | -0.28 | 0.26 | 0.20 | - | | | | | | | | |
| TP | -0.43 | **0.77** | **0.64** | 0.08 | - | | | | | | | |
| TSS | -0.29 | 0.09 | **0.62** | -0.31 | 0.39 | - | | | | | | |
| TKN | -0.01 | 0.02 | -0.02 | 0.36 | -0.21 | 0.03 | - | | | | | |
| pH | 0.42 | **-0.58** | **-0.69** | 0.02 | **-0.72** | **-0.61** | 0.12 | - | | | | |
| DO | 0.21 | -0.22 | **-0.63** | 0.23 | -0.43 | **-0.83** | -0.07 | **0.78** | - | | | |
| ORP | 0.00 | 0.29 | 0.32 | -0.38 | 0.35 | *0.51* | 0.02 | **-0.65** | **-0.78** | - | | |
| Cond | -0.29 | *0.55* | **0.65** | 0.04 | **0.84** | *0.52* | -0.43 | **-0.74** | *-0.56* | 0.40 | - | |
| Turbidity | -0.32 | 0.16 | **0.64** | -0.24 | 0.35 | **0.92** | 0.14 | **-0.61** | **-0.86** | **0.64** | 0.42 | - |
| Secchi | 0.30 | -0.12 | **-0.63** | 0.18 | -0.37 | **-0.95** | -0.05 | **0.63** | **0.82** | *-0.52* | *-0.52* | **-0.92** |
| TSI | - | 0.15 | 0.23 | -0.25 | - | *0.53* | -0.15 | *-0.53* | *-0.56* | *0.53* | **0.68** | *0.45* |
| **2016** | CHL | PO4 | NH4 | NO2NO3 | TP | TSS | TKN | pH | DO | ORP | Cond | Turbidity |
| CHL | - | | | | | | | | | | | |
| PO4 | *-0.42* | - | | | | | | | | | | |
| NH4 | -0.26 | 0.11 | - | | | | | | | | | |
| NO2NO3 | -0.32 | -0.12 | 0.17 | - | | | | | | | | |
| TP | 0.22 | *0.41* | -0.31 | **-0.48** | - | | | | | | | |
| TSS | **0.85** | *-0.40* | 0.13 | -0.22 | 0.09 | - | | | | | | |
| TKN | **0.90** | -0.21 | *-0.41* | -0.35 | *0.45* | **0.72** | - | | | | | |
| pH | **0.52** | 0.10 | -0.09 | -0.21 | 0.31 | **0.50** | **0.50** | - | | | | |
| DO | *0.54* | -0.06 | **-0.69** | -0.04 | 0.28 | 0.30 | *0.53* | **0.68** | - | | | |
| ORP | 0.18 | -0.10 | -0.04 | -0.09 | 0.10 | 0.01 | 0.15 | -0.16 | 0.03 | - | | |
| Cond | *-0.40* | **0.68** | 0.21 | -0.19 | 0.14 | -0.31 | -0.27 | -0.03 | -0.35 | -0.10 | - | |
| Turbidity | **0.75** | -0.16 | **-0.52** | -0.04 | 0.25 | **0.49** | **0.78** | **0.50** | **0.74** | 0.24 | -0.36 | - |
| Secchi | **-0.92** | *0.40* | 0.37 | *0.47* | -0.31 | **-0.78** | **-0.92** | *-0.46* | *-0.55* | -0.20 | 0.33 | **-0.85** |
| TSI | - | -0.18 | -0.33 | **-0.60** | - | **0.73** | **0.91** | **0.53** | *0.52* | 0.15 | -0.24 | **0.74** |
| **2017** | CHL | PO4 | NH4 | NO2NO3 | TP | TSS | TKN | pH | DO | ORP | Cond | Turbidity |
| CHL | - | | | | | | | | | | | |
| PO4 | 0.20 | - | | | | | | | | | | |
| NH4 | 0.08 | **0.70** | - | | | | | | | | | |
| NO2NO3 | **0.51** | 0.11 | 0.26 | - | | | | | | | | |
| TP | 0.27 | **0.66** | *0.40* | -0.25 | - | | | | | | | |
| TSS | **0.67** | 0.30 | 0.22 | 0.16 | **0.68** | - | | | | | | |
| TKN | 0.26 | 0.33 | 0.23 | 0.21 | 0.21 | *0.36* | - | | | | | |
| pH | 0.03 | **-0.86** | **-0.62** | 0.01 | **-0.58** | -0.25 | -0.28 | - | | | | |
| DO | -0.07 | **-0.85** | **-0.80** | -0.10 | **-0.52** | -0.27 | -0.30 | **0.90** | - | | | |
| ORP | **0.57** | 0.29 | 0.14 | 0.20 | **0.49** | **0.59** | 0.09 | -0.18 | -0.12 | - | | |
| Cond | 0.25 | 0.31 | 0.03 | -0.34 | **0.69** | **0.71** | 0.35 | -0.30 | -0.15 | 0.27 | - | |
| Turbidity | **0.68** | 0.36 | 0.24 | 0.26 | **0.58** | **0.92** | *0.39* | -0.36 | -0.35 | **0.47** | **0.67** | - |
| Secchi | **-0.57** | -0.32 | -0.19 | -0.06 | **-0.72** | **-0.92** | -0.22 | 0.29 | 0.27 | **-0.58** | **-0.76** | **-0.84** |
| TSI | - | **0.52** | 0.30 | 0.04 | - | **0.90** | 0.26 | *-0.41* | *-0.39* | **0.66** | **0.72** | **0.81** |

Table 3. Overall FQAI, mean C, and species richness values based on the different sampling areas.

| | *Control Quadrats* | *Channel Transects* | *Pothole Transects* |
|---|---|---|---|
| **Mean FQAI** | 4.7 | 7.6 | 6.7 |
| **Mean C** | 2.2 | 2.9 | 2.8 |
| **Mean # of spp.** | 4.3 | 6.9 | 5.8 |

Table 4. FQAI, mean C, and mean species richness for all channel transects and individual zonation of these transects based on location, with zone groupings shown in Figure 1. (SGM = Sedge-grass meadow, TR = Treatment area, M= Mound habitat, SB = Shallow Bench Habitat, IB = Intermediate Bench habitat, C = Channel habitat).

| ***ALL CHANNEL ZONES*** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *All Zones* | | **SGM** | **TR** | **M** | **SB** | **IB** | **C** |
| | **Mean FQAI** | 8.1 | 7.0 | 8.3 | 6.5 | 7.7 | 7.7 |
| | **Mean C** | 3.2 | 2.9 | 2.7 | 2.4 | 2.8 | 3.5 |
| | **Mean # of spp.** | 6.7 | 6.0 | 9.3 | 7.2 | 7.6 | 4.8 |
| | | | | | | | |
| *Zone 1* | | **SGM** | **TR** | **M** | **SB** | **IB** | **C** |
| | **Mean FQAI** | 8.3 | 7.4 | 8.8 | 7.3 | 7.7 | 8.3 |
| | **Mean C** | 3.3 | 3.1 | 2.8 | 2.5 | 2.7 | 3.2 |
| | **Mean # of spp.** | 6.6 | 6.1 | 9.8 | 7.9 | 8.1 | 6.8 |
| *Zone 2* | | **SGM** | **TR** | **M** | **SB** | **IB** | **C** |
| | **Mean FQAI** | 8.3 | 6.4 | 7.5 | 6.0 | 6.9 | 6.6 |
| | **Mean C** | 3.2 | 2.9 | 2.5 | 2.4 | 2.6 | 3.7 |
| | **Mean # of spp.** | 7.0 | 4.9 | 8.7 | 6.3 | 6.9 | 3.5 |
| *Zone 3* | | **SGM** | **TR** | **M** | **SB** | **IB** | **C** |
| | **Mean FQAI** | 7.7 | 6.9 | 8.3 | 5.9 | 8.5 | 7.9 |
| | **Mean C** | 3.2 | 2.6 | 2,7 | 2.2 | 3.1 | 4.0 |
| | **Mean # of spp.** | 6.4 | 7.0 | 9.3 | 7.0 | 7.6 | 3.1 |

Table 5. FQAI, mean C, and mean species richness for all pothole transects and individual zonation of these transects based on their location, with transect and quadrat zone groupings shown in Figure 2 (D = Deep water habitat, B = Bench habitat, M = Mound habitat).

| ***ALL POTHOLE ZONES*** | | | | |
|---|---|---|---|---|
| All Zones | | **D** | **B** | **M** |
| | **Mean FQAI** | 5.1 | 7.2 | 7.8 |
| | **Mean C** | 2.9 | 2.7 | 2.9 |
| | **Mean # of spp.** | 3.1 | 7.1 | 7.3 |
| | | | | |
| *Zone 1* | | **D** | **B** | **M** |
| | **Mean FQAI** | 5.2 | 8.4 | 12.4 |
| | **Mean C** | 3.1 | 3.1 | 3.7 |
| | **Mean # of spp.** | 3.0 | 7.0 | 11.5 |
| *Zone 2* | | **D** | **B** | **M** |
| | **Mean FQAI** | 5.5 | 7.7 | 6.5 |
| | **Mean C** | 2.8 | 2.6 | 2.4 |
| | **Mean # of spp.** | 3.8 | 8.3 | 7.1 |
| *Zone 3* | | **D** | **B** | **M** |
| | **Mean FQAI** | 3.5 | 5.9 | 7.4 |
| | **Mean C** | 1.7 | 2.6 | 2.8 |
| | **Mean # of spp.** | 2.0 | 5.3 | 6.4 |
| *Zone 4* | | **D** | **B** | **M** |
| | **Mean FQAI** | 7.1 | 7.7 | 8.7 |
| | **Mean C** | 4.0 | 2.7 | 3.3 |
| | **Mean # of spp.** | 3.6 | 8.2 | 6.7 |
| *Zone 5* | | **D** | **B** | **M** |
| | **Mean FQAI** | 4.5 | 6.7 | 6.5 |
| | **Mean C** | 2.5 | 2.6 | 2.6 |
| | **Mean # of spp.** | 2.6 | 6.4 | 6.5 |

Table 6. FQAI, mean C, and mean species richness for the connected and isolated potholes, with quadrat and transect groupings shown in Figure 3 (D = Deep water habitat, B = Bench habitat, M = Mount habitat).

| *Connected potholes* | | | | |
|---|---|---|---|---|
| *Zone 1* | | **D** | **B** | **M** |
| | **Mean FQAI** | 5.4 | 7.5 | 7.9 |
| | **Mean C** | 3.0 | 2.7 | 2.9 |
| | **Mean # of spp.** | 3.2 | 7.5 | 7.5 |
| ***Isolated potholes*** | | | | |
| *Zone 2* | | **D** | **B** | **M** |
| | **Mean FQAI** | 3.5 | 5.9 | 7.4 |
| | **Mean C** | 1.7 | 2.6 | 2.8 |
| | **Mean # of spp.** | 2.0 | 5.3 | 6.4 |

Table 7. Mean percent cover by species found in channel transects (SGM = Sedge-grass meadow, TR = Treatment area, M = Mound habitat, SB = Shallow Bench habitat, IB = Intermediate Bench habitat, C = Channel habitat).

***Channel Transects***

| SPECIES | SGM | TR | M | SB | IB | C |
|---|---|---|---|---|---|---|
| Acer spp. | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Agrostis stolonifera | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 |
| Asclepias incarnata | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Azolla caroliniana | 1.1 | 1.3 | 0.4 | 0.3 | 1.0 | 0.5 |
| Bidens cernua | 0.0 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 |
| Bidens frondosa | 0.4 | 1.1 | 2.6 | 2.7 | 0.5 | 0.0 |
| Boehmeria cylindrica | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| Bolboschoenus fluviatilis | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| Butomus umbellatus | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Calamagrostis canadensis | 4.4 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 |
| Calystegia sepium | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Carex hystericina | 1.0 | 0.0 | 0.6 | 0.2 | 0.0 | 0.0 |
| Carex lacustris | 4.6 | 0.1 | 0.9 | 0.7 | 0.0 | 0.0 |
| Carex spp. | 0.0 | 0.2 | 0.7 | 0.1 | 0.0 | 0.0 |
| Cephalanthus occidentalis | 0.2 | 0.5 | 3.8 | 0.7 | 0.1 | 0.0 |
| Ceratophyllum demersum | 0.0 | 0.2 | 0.3 | 1.1 | 1.8 | 1.7 |
| Chenopodium glauca | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Cicuta bulbifera | 0.1 | 0.1 | 0.8 | 1.6 | 0.3 | 0.0 |
| Cirsium arvense | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 |
| Cornus amomum | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cornus sericea | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| Cyperus odoratus | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Decodon verticillatus | 0.0 | 0.0 | 0.2 | 0.9 | 0.2 | 0.0 |
| Eleocharis obtusa | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Elodea canadensis | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.7 |
| Elymus virginicus | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 |
| Erichtites hieracifolia | 0.0 | 0.1 | 1.1 | 0.0 | 0.0 | 0.0 |
| Fragaria spp. | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Fraxinus pennyslvanica | 1.9 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gallium trifidum | 0.0 | 0.1 | 1.1 | 0.1 | 0.0 | 0.0 |
| Hibiscus moscheutos | 0.0 | 0.0 | 0.9 | 0.1 | 0.0 | 0.0 |
| Hydrocharis morsus-ranae | 8.9 | 10.6 | 7.1 | 8.5 | 6.7 | 1.5 |
| Impatiens capensis | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 |
| Iris spp. | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 |
| Juncus effusus | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Leersia oryzoides | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| Lemna minor | 1.0 | 1.4 | 0.7 | 1.4 | 2.8 | 1.3 |
| Lemna trisulca | 0.4 | 1.2 | 0.3 | 0.4 | 0.8 | 1.3 |
| Lycopus americanus | 0.1 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 |
| Lycopus spp. | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 |
| Lythrum salicaria | 0.5 | 0.9 | 2.6 | 1.1 | 0.3 | 0.4 |
| Mentha arvense | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Myosotis scorpiodes | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Myriophyllum spicatum | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 0.8 |
| Nymphaea odorata | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.6 |
| Onoclea sensibilis | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Persicaria amphibia | 1.8 | 2.1 | 0.7 | 1.4 | 1.5 | 0.3 |
| Persicaria hydropiper | 0.0 | 0.0 | 10.1 | 0.2 | 0.0 | 0.0 |
| Persicaria hydropiperoides | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 |
| Persicaria lapathifolium | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Persicaria maculosa | 0.0 | 0.0 | 0.3 | 0.2 | 0.0 | 0.0 |
| Persicaria sagittata | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pontedaria cordata | 0.2 | 0.3 | 0.3 | 0.0 | 0.0 | 0.1 |
| Populus tremuloides | 0.2 | 0.1 | 0.4 | 0.1 | 0.0 | 0.0 |
| Potamogeton foliosus | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.6 |
| Ricciocarpus natans | 0.9 | 1.5 | 0.3 | 0.4 | 0.4 | 0.2 |
| Rorippa palustris | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Rumex spp. | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Sagittaria latifolia | 0.0 | 0.1 | 0.7 | 0.4 | 0.4 | 0.0 |
| Salix fragilis | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Schoenoplectus tabernaemontanii | 0.1 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 |
| Scutellaria galericulata | 0.0 | 0.0 | 1.8 | 0.1 | 0.0 | 0.0 |
| Sium suave | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Solanum dulcamara | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Sparganium eurycarpum | 0.3 | 1.3 | 1.9 | 0.6 | 0.2 | 0.3 |
| Sparganium spp. | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 |
| Spiraea alba var. latifolia | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Spirodela polyrrhiza | 2.3 | 2.1 | 1.3 | 3.5 | 3.4 | 3.0 |
| Stachys tenuifollium | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 |
| Stuckenia pectinatus | 0.0 | 0.0 | 0.0 | 1.0 | 3.0 | 3.7 |
| Taraxacum officinale | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Typha x glauca | 4.9 | 2.2 | 6.7 | 17.4 | 2.3 | 0.0 |
| UNK grass (1) | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Utricularia vulgaris | 2.8 | 4.2 | 0.0 | 2.4 | 8.9 | 8.2 |
| Vallisneria americana | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Verbena hastata | 0.0 | 0.0 | 4.1 | 0.0 | 0.0 | 0.0 |
| Vernonia noveboracensis | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| Vitis riparia | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Table 8. Mean percent cover by species found in pothole transects (D = Deep water habitat, B = Bench habitat, M = Mount habitat).

***Pothole Transects***

| **SPECIES** | **D** | **B** | **M** |
|---|---|---|---|
| Asclepias incarnata | 0.0 | 0.0 | 0.4 |
| Bidens cernua | 0.0 | 0.0 | 0.4 |
| Bidens frondosa | 0.0 | 0.1 | 0.7 |
| Boehmeria cylindrica | 0.0 | 0.2 | 5.8 |
| Carex hystericina | 0.0 | 0.0 | 0.1 |
| Carex lacustris | 0.0 | 0.5 | 0.9 |
| Carex spp. | 0.0 | 0.0 | 0.1 |
| Cephalanthus occidentalis | 0.0 | 0.1 | 0.1 |
| Ceratophyllum demersum | 1.6 | 0.2 | 0.0 |
| Cicuta bulbifera | 0.0 | 0.7 | 0.5 |
| Cirsium arvense | 0.0 | 0.1 | 0.4 |
| Cuscuta spp. | 0.0 | 0.0 | 0.4 |
| Decodon verticillatus | 0.0 | 3.0 | 7.3 |
| Elodea canadensis | 0.2 | 0.0 | 0.0 |
| Erichtites hieracifolia | 0.0 | 0.0 | 0.1 |
| Fragaria spp. | 0.0 | 0.0 | 0.2 |
| Gallium trifidum | 0.0 | 0.5 | 3.0 |
| Hydrocharis morsus-ranae | 0.8 | 9.9 | 1.1 |
| Impatiens capensis | 0.0 | 0.2 | 10.0 |
| Juncus effusus | 0.0 | 0.1 | 0.0 |
| Lathyrus palustris | 0.0 | 0.0 | 0.1 |
| Lemna minor | 0.4 | 1.7 | 0.1 |
| Lemna trisulca | 0.4 | 0.6 | 0.0 |
| Lycopus americanus | 0.0 | 0.8 | 0.5 |
| Lythrum salicaria | 0.8 | 5.7 | 8.3 |

| | | | |
|---|---|---|---|
| Mentha arvense | 0.0 | 0.0 | 1.7 |
| Myriophyllum spicatum | 0.4 | 0.2 | 0.0 |
| Nymphaceae spp. | 0.0 | 0.1 | 0.0 |
| Persicaria amphibia | 0.2 | 0.0 | 0.0 |
| Persicaria hydropiper | 0.0 | 0.2 | 10.5 |
| Persicaria hydropiperoides | 0.0 | 0.0 | 1.2 |
| Persicaria maculosa | 0.0 | 0.0 | 0.4 |
| Persicaria sagittata | 0.0 | 0.0 | 0.2 |
| Pontedaria cordata | 0.0 | 0.5 | 0.1 |
| Potamogeton foliosus | 0.1 | 0.0 | 0.0 |
| Potentilla spp. | 0.0 | 0.0 | 0.1 |
| Rhus typhina | 0.0 | 0.0 | 0.5 |
| Rumex orbiculatus | 0.0 | 0.0 | 0.3 |
| Sagittaria latifolia | 0.2 | 1.0 | 0.4 |
| Schoenoplectus tabernaemontanii | 0.0 | 0.1 | 0.1 |
| Scutellaria galericulata | 0.0 | 0.0 | 0.1 |
| Solanum dulcamara | 0.0 | 0.0 | 0.1 |
| Sparganium eurycarpum | 0.2 | 0.4 | 0.0 |
| Spirodela polyrrhiza | 0.5 | 2.6 | 0.1 |
| Stuckenia filiformis | 1.1 | 0.1 | 0.0 |
| Thelyptris palustris | 0.0 | 1.4 | 2.9 |
| Triadenum fraseri | 0.0 | 0.0 | 0.1 |
| Typha x glauca | 1.0 | 8.2 | 6.0 |
| UNK grass (1) | 0.0 | 0.0 | 0.1 |
| UNK moss (1) | 0.0 | 0.2 | 0.0 |
| Utricularia vulgaris | 9.5 | 9.4 | 0.0 |
| Verbena hastata | 0.0 | 0.2 | 4.3 |
| Vitis riparia | 0.0 | 0.0 | 0.2 |

Table 9. Mean percent cover by species found in control quadrats in the unrestored cattail zone (CAT = cattail mat).

| ***Control Quadrats*** | |
|---|---|
| **SPECIES** | **CAT** |
| Bidens frondosa | 0.4 |
| Boehmeria cylindrica | 0.6 |
| Bolboschoenus fluviatilis | 0.3 |
| Calystegia sepium | 0.6 |
| Cicuta bulbifera | 0.6 |
| Decodon verticillatus | 0.1 |
| Gallium trifidum | 0.1 |
| Hibiscus moscheutos | 1.3 |
| Hydrocharis morsus-ranae | 2.3 |
| Impatiens capensis | 0.7 |
| Lemna minor | 0.6 |
| Lemna trisulca | 0.1 |
| Lythrum salicaria | 2.8 |
| Nymphaceae spp. | 0.1 |
| Onoclea sensibilis | 0.1 |
| Pontedaria cordata | 0.1 |
| Scutellaria galericulata | 0.1 |
| Solanum dulcamara | 0.3 |
| Sphagnum spp. | 0.3 |
| Spirodela polyrrhiza | 1.9 |
| Thelyptris palustris | 2.2 |
| Triadenum fraseri | 0.6 |
| Typha x glauca | 20.6 |
| Vitis riparia | 0.1 |

Table 10. Counts for species caught in control and restored areas on 13 and 20 April 2017 at Braddock Bay.

| Common name | Control habitat | Created habitat |
|---|---|---|
| Banded killifish | 4 | |
| Black crappie | 2 | |
| Blacknose shiner | 2 | |
| Bluegill Sunfish | 10 | 5 |
| Bowfin | 13 | 32 |
| Brook silverside | 2 | |
| Brown bullhead | 123 | 4 |
| Central mudminnow | 1 | |
| Common carp | 3 | |
| Emerald shiner | 8 | |
| Gizzard shad | 1 | |
| Golden shiner | 3 | |
| Largemouth bass | 2 | 1 |
| Northern pike | 3 | 1 |
| Pumpkinseed sunfish | 41 | 33 |
| Round goby | 2 | |
| Rudd | 1 | |
| White perch | 5 | |
| White sucker | 4 | |
| Yellow Perch | 14 | 6 |
| **Grand Total** | **244** | **82** |

Table 11. Counts for species caught in control and restored areas on 31 May and 1 June 2017 at Braddock Bay

| Common name | Control habitat | Restored habitat |
|---|---|---|
| Alewife | 82 | |
| Banded killifish | 2 | 17 |
| Bluegill Sunfish | 1 | 1 |
| Bowfin | | 3 |
| Brook silverside | 2 | |
| Brown bullhead | 7 | 1 |
| Central mudminnow | | 3 |
| Common carp | 3 | |
| Emerald shiner | 2 | |
| Longnose gar | 3 | |
| Northern pike | | 2 |
| Pumpkinseed sunfish | 6 | 2 |
| Rock bass | 2 | |
| Round goby | 2 | |
| White perch | 1 | |
| Yellow perch | 3 | 1 |
| **Grand Total** | **116** | **30** |

Table 12. Counts for species caught in control and restored areas between 13 April and 4 November 2017 at Braddock Bay.

| Common name | Control habitat | Created habitat |
|---|---|---|
| Alewife | 82 | |
| Banded killifish | 8 | 17 |
| Black crappie | 2 | |
| Blacknose shiner | 2 | |
| Bluegill Sunfish | 13 | 31 |
| Bowfin | 13 | 35 |
| Brook silverside | 4 | |
| Brown bullhead | 130 | 5 |
| Central mudminnow | 1 | 23 |
| Common Carp | 6 | |
| Emerald shiner | 10 | |
| Gizzard Shad | 1 | |
| Golden shiner | 3 | |
| Goldfish | | 1 |
| Green Sunfish | | 1 |
| Largemouth Bass | 2 | 2 |
| *Lepomis* spp. | 14 | |
| Longnose gar | 3 | |
| Northern pike | 3 | 4 |
| Pumpkinseed sunfish | 49 | 58 |
| Rock bass | 2 | |
| Round goby | 4 | |
| Rudd | 1 | |
| White perch | 6 | |
| White sucker | 4 | |
| Yellow perch | 19 | 7 |
| **Grand Total** | **382** | **184** |

Table 13. Young-of-year counts for species caught in control and restored areas between 13 April and 4 November 2017 at Braddock Bay.

| **Common name** | **Control habitat** | **Created habitat** |
|---|---|---|
| Banded killifish | 2 | |
| Bluegill sunfish | 2 | 25 |
| Central mudminnow | | 4 |
| Largemouth bass | | 1 |
| *Lepomis* spp. | 14 | |
| Northern pike | | 3 |
| Pumpkinseed sunfish | | 21 |
| **Grand Total** | **18** | **54** |

Table 14: Bird species ranked by total abundance across the three survey stations in Braddock Bay during the spring 2017 surveys. Abundance data show the total number of detections across seven surveys for each location.

| Species | Station 1 | Station 2 | Station 3 | Total abundance |
|---|---|---|---|---|
| American Crow | | 1 | | 1 |
| American Goldfinch | 12 | 6 | | 18 |
| American Robin | 1 | 1 | 4 | 6 |
| Bald Eagle | 1 | 2 | 1 | 4 |
| Baltimore Oriole | 2 | | 1 | 3 |
| Barn Swallow | 36 | 8 | 8 | 52 |
| Blue Jay | | 2 | | 2 |
| Canada Goose | 20 | | 5 | 25 |
| Caspian Tern | | 1 | 1 | 2 |
| Cedar Waxwing | | 1 | | 1 |
| Chimney Swift | | | 1 | 1 |
| Common Grackle | | | 2 | 2 |
| Common Yellowthroat | 5 | 13 | 4 | 22 |
| Double-crested Cormorant | 3 | | 4 | 7 |
| Eastern Kingbird | | 3 | 18 | 21 |
| Eastern Phoebe | 1 | | | 1 |
| Eastern Wood Pewee | | 1 | | 1 |
| European Starling | | | 8 | 8 |
| Gray Catbird | | 2 | 9 | 11 |
| Great Blue Heron | 5 | 2 | 1 | 8 |
| Great-crested Flycatcher | | 1 | 1 | 2 |
| Herring Gull | | | 1 | 1 |
| House Wren | | 1 | | 1 |
| Least Bittern | 1 | 2 | | 3 |
| Mallard | 5 | 2 | | 7 |
| Marsh Wren | 47 | 6 | 10 | 63 |
| Mourning Dove | 2 | | 1 | 3 |
| Mute Swan | 3 | | 9 | 12 |
| Northern Cardinal | 1 | 1 | | 2 |
| Northern Rough-winged Swallow | 18 | 3 | | 21 |
| Osprey | 1 | 2 | 1 | 4 |
| Pileated Woodpecker | | 1 | | 1 |
| Purple Martin | 5 | 2 | 1 | 8 |
| Red-eyed Vireo | | | 1 | 1 |
| Red-winged Blackbird | 36 | 51 | 35 | 122 |
| Ring-billed Gull | 31 | 10 | 82 | 123 |
| Song Sparrow | 5 | 2 | 8 | 15 |
| Swamp Sparrow | 12 | 14 | 3 | 29 |
| Tree Swallow | 40 | 11 | 218 | 269 |

| | | | | |
|---|---|---|---|---|
| Unidentified Gull | 1100 | 150 | 90 | 1340 |
| Virginia Rail | | 4 | | 4 |
| Warbling Vireo | | 3 | 3 | 6 |
| Willow Flycatcher | 8 | 6 | 1 | 15 |
| Wood Duck | 1 | | 1 | 2 |
| Yellow Warbler | 5 | 10 | 17 | 32 |
| Species total | 27 | 32 | 31 | |

Table 15: Anuran species detected in Braddock Bay in spring 2017, ranked by the maximum call code. Call code descriptions are provided in Appendix 1.

| Common Name | Scientific Name | Maximum call code<br>Station 1 | Station 2 | Station 3 |
|---|---|---|---|---|
| American bullfrog | *Lithobates catesbeianus* | 1 | 2 | 2 |
| American toad | *Anaxyrus americanus* | 1 | 2 | 1 |
| Green frog | *Lithobates clamitans* | 2 | 2 | 2 |
| Grey treefrog | *Hyla versicolor* | 2 | 2 | 1 |
| Northern leopard frog | *Lithobates sylvaticus* | 2 | 2 | 2 |
| Spring peeper | *Pseudacris crucifer* | 3 | 3 | 3 |
| | Species Richness | 6 | 5 | 6 |

Table 16. Comparison of bird abundance between 2016 and 2017 at three point count stations within Braddock Bay. Approximate point count locations can be found in Figure 1

| Species | Station 1 | | Station 2 | | Station 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| American Bittern | | | 1 | | | | 1 | 0 |
| American Coot | | | 1 | | | | 1 | 0 |
| American Crow | | | | 1 | | | 0 | 1 |
| American Goldfinch | | 12 | 6 | 6 | 1 | | 7 | 18 |
| American Kestrel | | | 1 | | | | 1 | 0 |
| American Robin | 4 | 1 | 2 | 1 | 2 | 4 | 8 | 6 |
| Bald Eagle | 1 | 1 | 1 | 2 | | 1 | 2 | 4 |
| Baltimore Oriole | | 2 | | | 1 | 1 | 1 | 3 |
| Bank Swallow | 3 | | | | | | 3 | 0 |
| Barn Swallow | 29 | 36 | 13 | 8 | 12 | 8 | 54 | 52 |
| Bobolink | 1 | | | | | | 1 | 0 |
| Canada Goose | 19 | 20 | 5 | | | 5 | 24 | 25 |
| Caspian Tern | 3 | | | 1 | 6 | 1 | 9 | 2 |
| Cedar Waxwing | | | 1 | 1 | 4 | | 5 | 1 |
| Common Grackle | 2 | | 3 | | 7 | 2 | 12 | 2 |
| Common Yellowthroat | 10 | 5 | 7 | 13 | 3 | 4 | 20 | 22 |
| Double-crested Cormorant | 1 | 3 | | | 2 | 4 | 3 | 7 |
| Eastern Kingbird | 3 | | | 3 | | 18 | 3 | 21 |
| Eastern Phoebe | | 1 | | | | | 0 | 1 |
| Eastern Wood Pewee | | | | 2 | | | 0 | 1 |
| European Starling | 6 | | | | 4 | 8 | 10 | 8 |
| Gray Catbird | 1 | | 1 | 2 | 4 | 9 | 6 | 11 |
| Great-crested Flycatcher | | | 1 | 1 | | 1 | 1 | 2 |
| Great Blue Heron | | 5 | 1 | 2 | 1 | 1 | 2 | 8 |
| Great Egret | | | | | 1 | | 1 | 0 |
| Killdeer | | | 2 | | | | 2 | 0 |
| Least Bittern | | 1 | | 2 | 2 | | 2 | 3 |
| Mallard | 9 | 5 | | 2 | 3 | | 12 | 7 |
| Marsh Wren | 30 | 47 | 7 | 6 | 17 | 10 | 54 | 63 |
| Mourning Dove | 1 | 2 | | | | 1 | 1 | 3 |
| Mute Swan | 2 | 3 | | | 16 | 9 | 18 | 12 |
| Northern Cardinal | 3 | 1 | | 1 | 2 | | 5 | 2 |
| Northern Rough-Winged Swallow | 1 | 18 | | 3 | | | 1 | 21 |
| Osprey | | 1 | 3 | 2 | | 1 | 3 | 4 |
| Purple Martin | | 5 | 3 | 2 | 3 | 1 | 6 | 8 |
| Pileated Woodpecker | | | | 1 | | | 0 | 1 |
| Red-Bellied Woodpecker | 1 | | | | | | 1 | 0 |
| Red-eyed Vireo | | | | | | 1 | 0 | 1 |
| Red-Winged Blackbird | 39 | 36 | 39 | 51 | 22 | 35 | 100 | 122 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ring-Billed Gull | 19 | 31 | 29 | 10 | 5 | 82 | 53 | 123 |
| Song Sparrow | 6 | 5 | 10 | 2 | 4 | 8 | 20 | 15 |
| Swamp Sparrow | 13 | 12 | 21 | 14 | 2 | 3 | 36 | 29 |
| Tree Swallow | 23 | 40 | 11 | 11 | 18 | 218 | 52 | 269 |
| Virginia Rail | | | | 4 | | | | 4 |
| Warbling Vireo | 2 | | | 3 | 5 | 3 | 7 | 6 |
| Willow Flycatcher | 7 | 8 | 6 | 6 | 1 | 1 | 14 | 15 |
| Wood Duck | | 1 | | | | 1 | 0 | 2 |
| Yellow Warbler | 6 | 5 | 8 | 10 | 11 | 17 | 25 | 32 |
| Grand Total | 245 | 307 | 183 | 173 | 159 | 458 | 587 | 937 |

Table 17: Bird species ranked alphabetically that were recorded during the fall of 2017 while monitoring the barrier on the east spit of Braddock Bay. Abundance data show the total number of detections across seven surveys for each location. Species observed on the skeleton of the barrier or within the protected lagoons are in bold. Species not in bold were observed elsewhere within the bay or along the east spit.

| Species | Total abundance |
|---|---|
| **American Black Duck** | 7 |
| **American Coot** | 10 |
| **American Crow** | 3 |
| **American Golden-Plover** | 1 |
| American Goldfinch | 16 |
| **American Pipit** | 15 |
| American Redstart | 5 |
| American Robin | 6 |
| American Tree Sparrow | 5 |
| **American Wigeon** | 53 |
| **Bald Eagle** | 5 |
| Bank Swallow | 6 |
| Barn Swallow | 150 |
| Bay-breasted Warbler | 2 |
| **Belted Kingfisher** | 8 |
| **Black-bellied Plover** | 5 |
| Blackburnian Warbler | 2 |
| Black-capped Chickadee | 23 |
| **Black-crowned Night-Heron** | 2 |
| Blackpoll Warbler | 6 |
| Black-throated Blue Warbler | 1 |
| Blue Jay | 18 |
| **Bonaparte's Gull** | 190 |
| Brown Creeper | 2 |
| **Bufflehead** | 3 |
| **Canada Goose** | 15 |
| Cape May Warbler | 1 |
| **Caspian Tern** | 53 |
| Cedar Waxwing | 2 |
| Chestnut-sided Warbler | 2 |
| Chimney Swift | 3 |
| **Common Goldeneye** | 1 |
| Common Grackle | 2 |
| **Common Loon** | 35 |
| **Common Merganser** | 4 |
| Common Nighthawk | 2 |

| | |
|---|---|
| Common Yellowthroat | 3 |
| Dark-eyed Junco | 2 |
| **Double-crested Cormorant** | 310 |
| Downy Woodpecker | 5 |
| **duck sp.** | 9 |
| **Dunlin** | 9 |
| European Starling | 126 |
| **Forster's Tern** | 2 |
| **Gadwall** | 12 |
| Golden-crowned Kinglet | 9 |
| Gray Catbird | 2 |
| **Great Black-backed Gull** | 3 |
| **Great Blue Heron** | 22 |
| **Greater Scaup** | 57 |
| **Greater Yellowlegs** | 2 |
| **Greater/Lesser Scaup** | 20 |
| **Green Heron** | 2 |
| **Green-winged Teal** | 35 |
| **Herring Gull** | 233 |
| **Horned Grebe** | 1 |
| House Finch | 3 |
| House Sparrow | 44 |
| **Killdeer** | 8 |
| Least Flycatcher | 1 |
| **Lesser Scaup** | 48 |
| Lincoln's Sparrow | 1 |
| **Long-tailed Duck** | 87 |
| Magnolia Warbler | 6 |
| **Mallard** | 495 |
| Marsh Wren | 4 |
| **Merlin** | 2 |
| Mourning Dove | 6 |
| Mourning Warbler | 1 |
| **Mute Swan** | 91 |
| Nashville Warbler | 1 |
| Northern Cardinal | 8 |
| Northern Flicker | 1 |
| Northern Harrier | 1 |
| **Northern Pintail** | 2 |
| **Northern Shoveler** | 6 |
| **Osprey** | 2 |
| **Peregrine Falcon** | 1 |
| **Pied-billed Grebe** | 3 |

| | |
|---|---|
| Pine Siskin | 2 |
| Purple Martin | 175 |
| **Red Knot** | 1 |
| Red-bellied Woodpecker | 4 |
| **Red-breasted Merganser** | 35 |
| **Red-throated Loon** | 10 |
| Red-winged Blackbird | 9 |
| **Ring-billed Gull** | 738 |
| Rock Pigeon | 2 |
| Ruby-crowned Kinglet | 2 |
| Ruby-throated Hummingbird | 2 |
| **Ruddy Duck** | 17 |
| **Ruddy Turnstone** | 9 |
| Rusty Blackbird | 1 |
| **Sanderling** | 20 |
| **Savannah Sparrow** | 1 |
| **Semiaplmated Sandpiper** | 7 |
| **Semipalmated Plover** | 28 |
| **shorebird sp.** | 10 |
| **Snow Bunting** | 2 |
| **Solitary Sandpiper** | 2 |
| Song Sparrow | 20 |
| **Spotted Sandpiper** | 13 |
| **Surf Scoter** | 3 |
| Swamp Sparrow | 3 |
| Tennessee Warbler | 4 |
| Tree Swallow | 145 |
| Virginia Rail | 2 |
| Warbling Vireo | 3 |
| White-throated Sparrow | 21 |
| **White-winged Scoter** | 30 |
| Winter Wren | 1 |
| **Wood Duck** | 1 |
| Yellow Warbler | 3 |
| Yellow-rumped Warbler | 23 |

## Figures

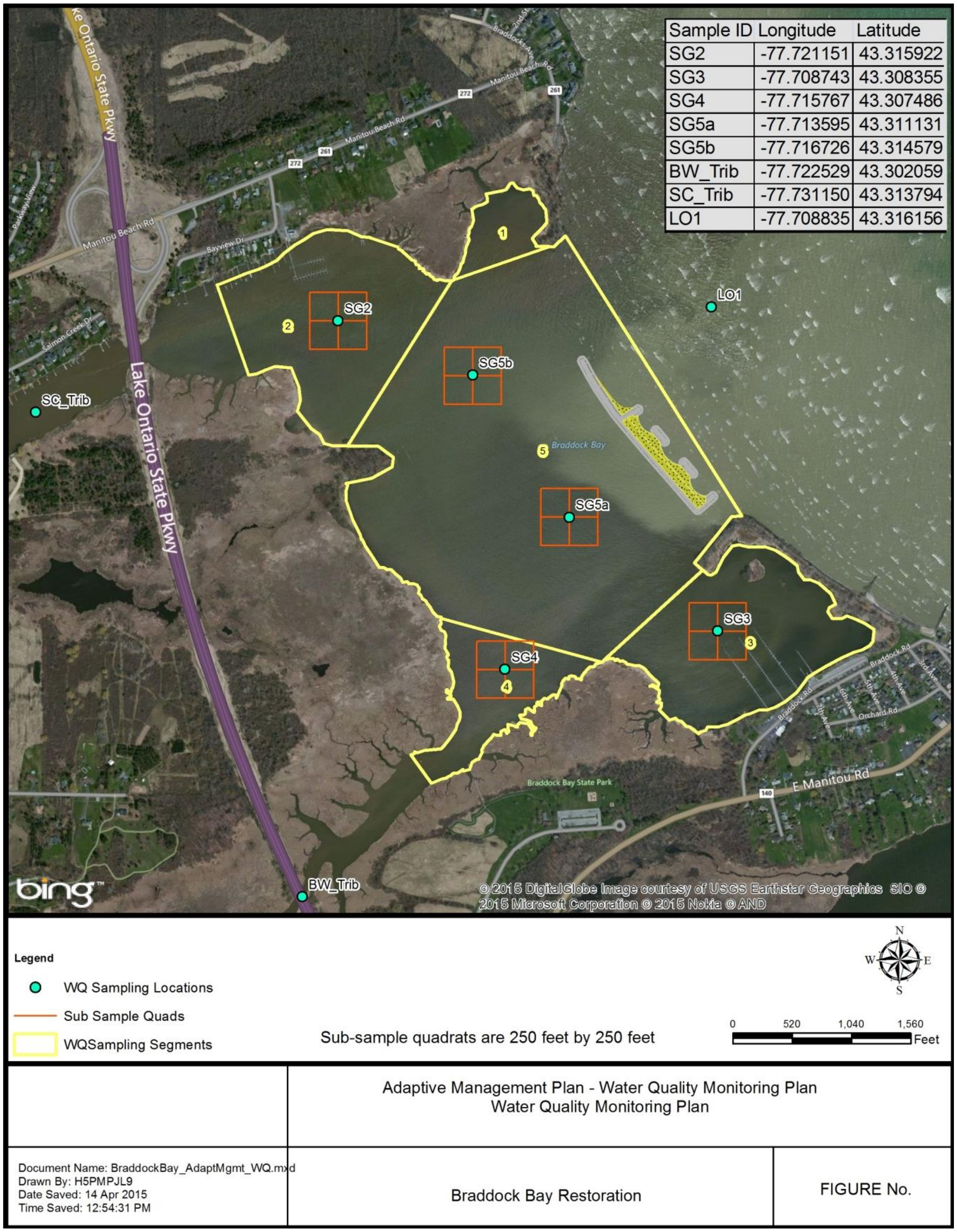



*Figure 1. Braddock Bay and Water Quality Monitoring Sites (Reproduced from USACE 2015), Braddock Bay Restoration: Monitoring and Adaptive Management Plan*

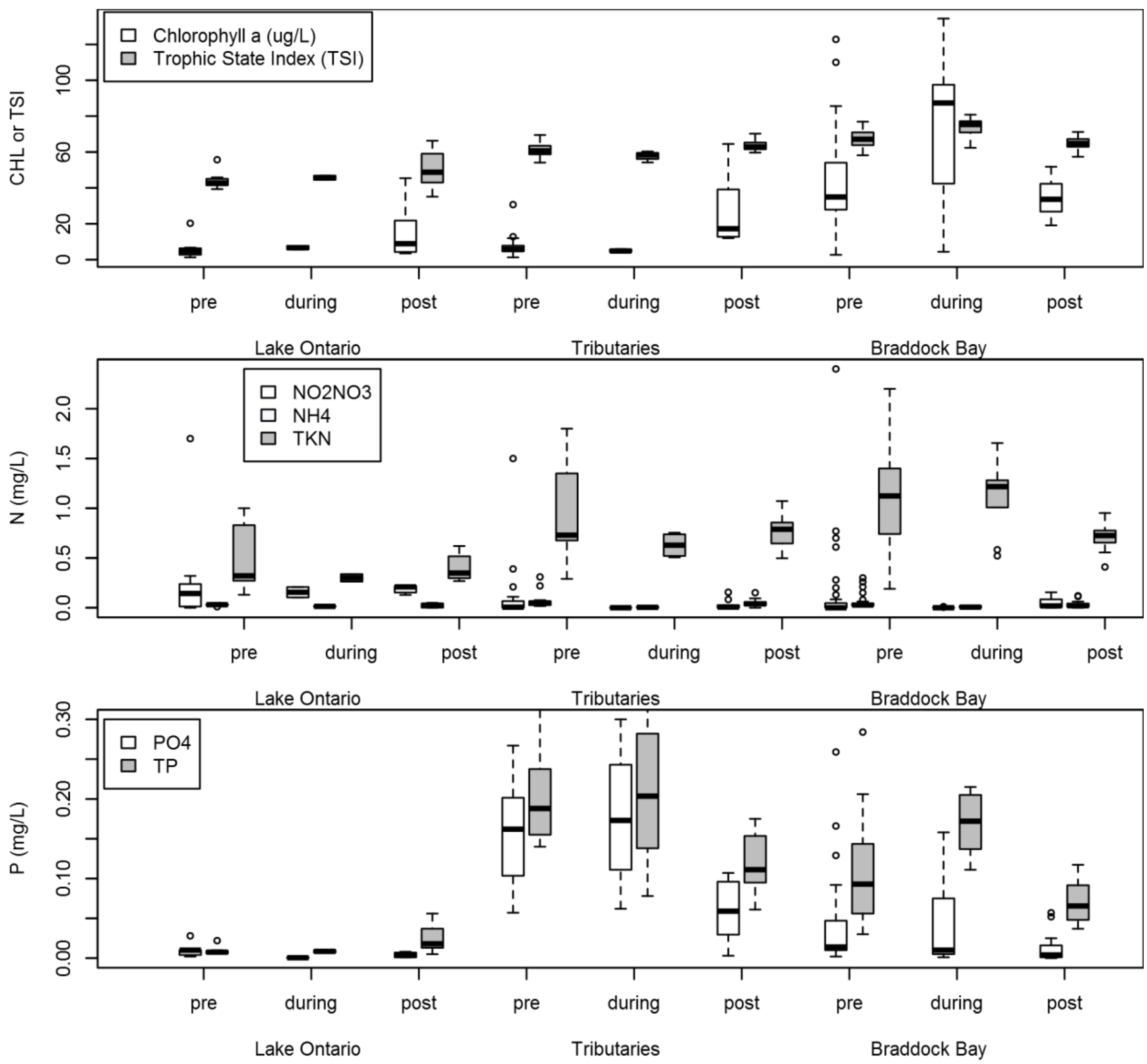



*Figure 2. Box and Whisker plots of water quality conditions pre, during, and post barrier construction for Lake Ontario near shore, Tributary, and Braddock Bay sampling sites. Whiskers are 95% confidence interval. Boxes are the interquartile range. Bars are average values.*

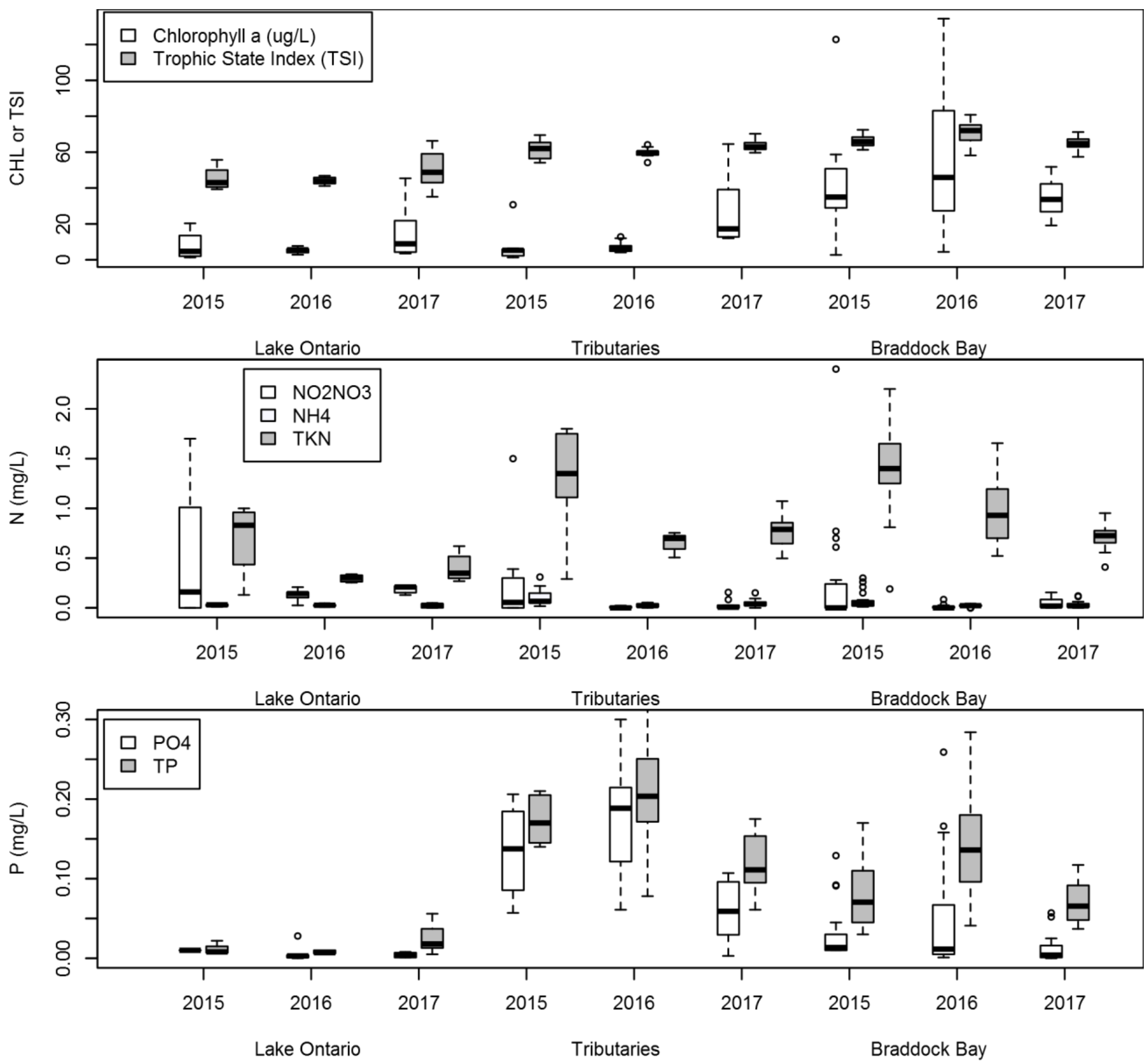



*Figure 3. Box and Whisker plots of water quality by year sampled for Lake Ontario near shore, Tributary, and Braddock Bay sampling sites. Whiskers are 95% confidence interval. Boxes are the interquartile range. Bars are average values.*

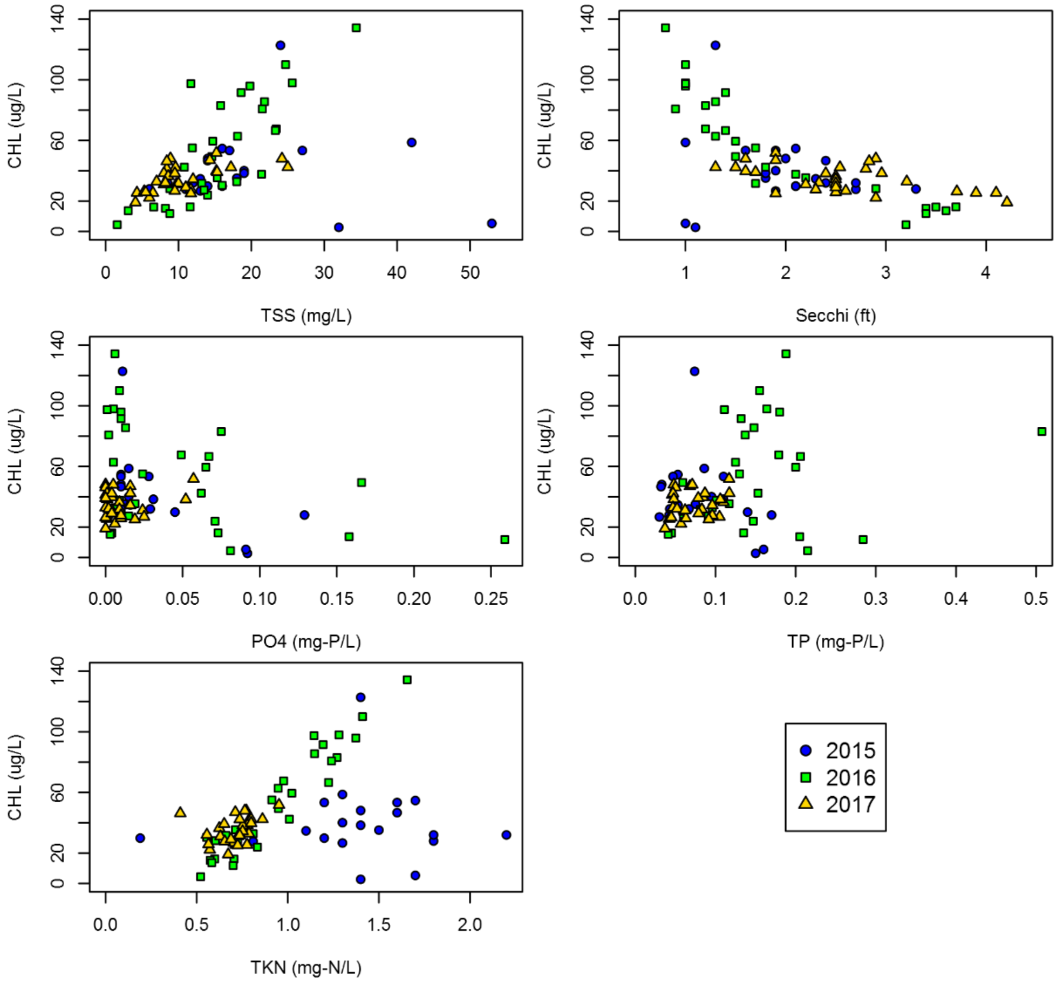



*Figure 4. For Braddock Bay sites only, relationship between phytoplankton biomass (CHL), TSS, Secchi depth, PO4, TP, and TKN. See Table 2 for correlation coefficients.*

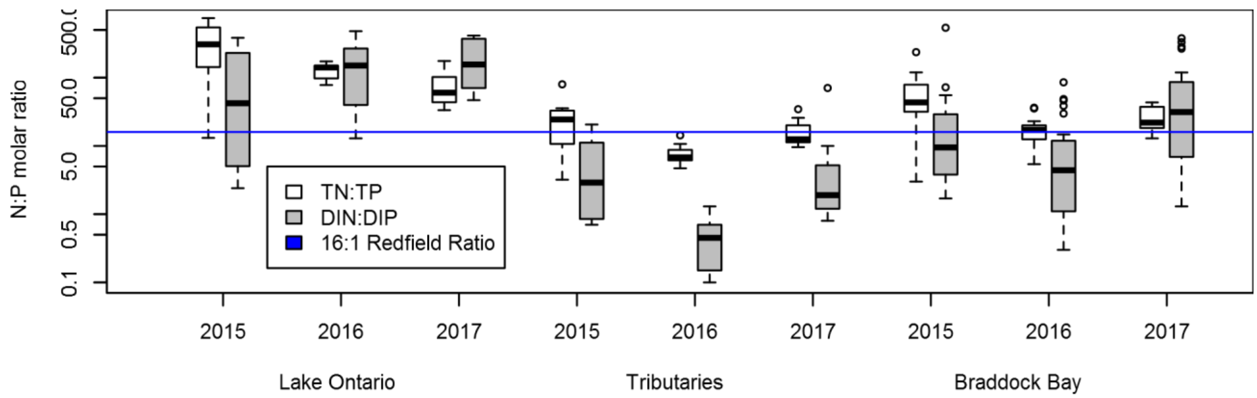



*Figure 5. Box and Whisker plots of nitrogen to phosphorus molar ratios by year for total and dissolved inorganic nutrients across Lake Ontario near shore, Tributary, and Braddock Bay sampling sites. Whiskers are 95% confidence interval. Boxes are the interquartile range. Bars are average values.*

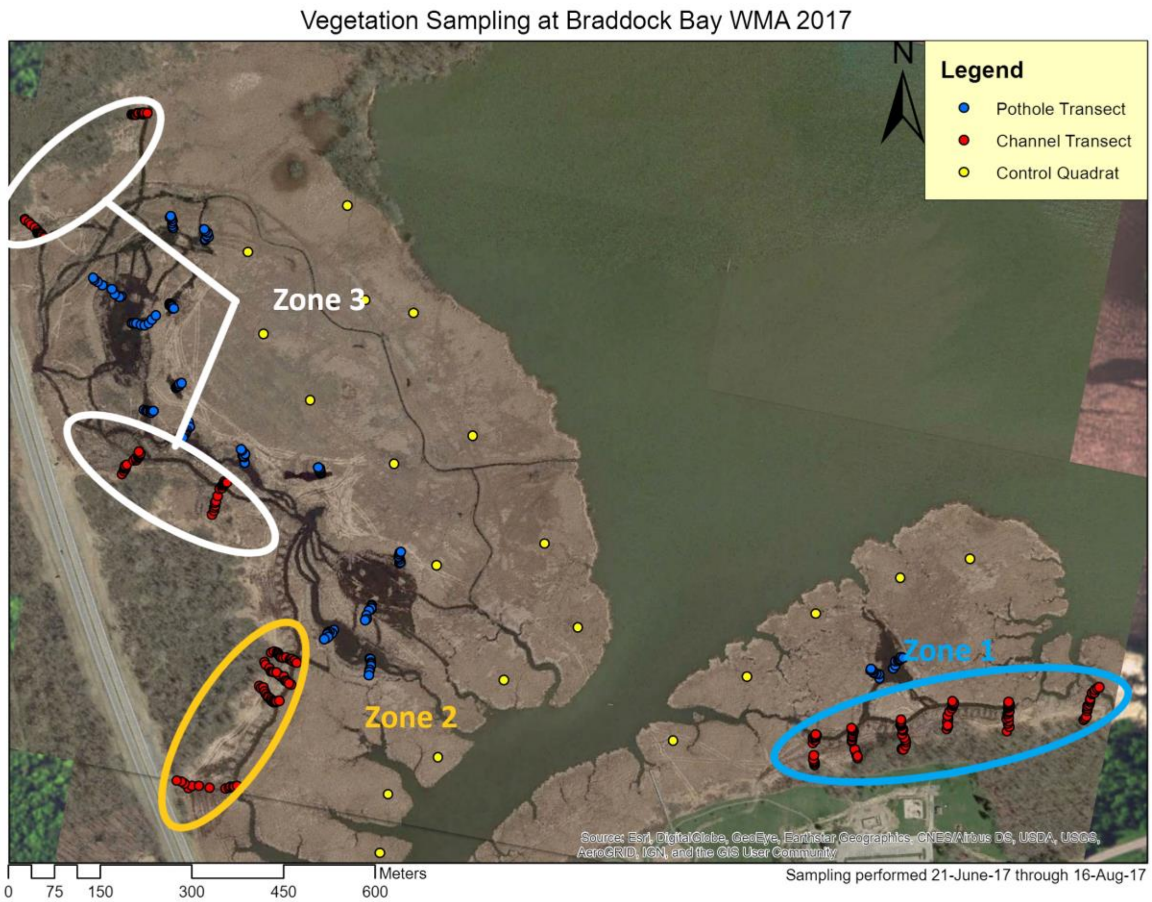



*Figure 6. Transect grouping for channel transects, with data presented in Table 2.*

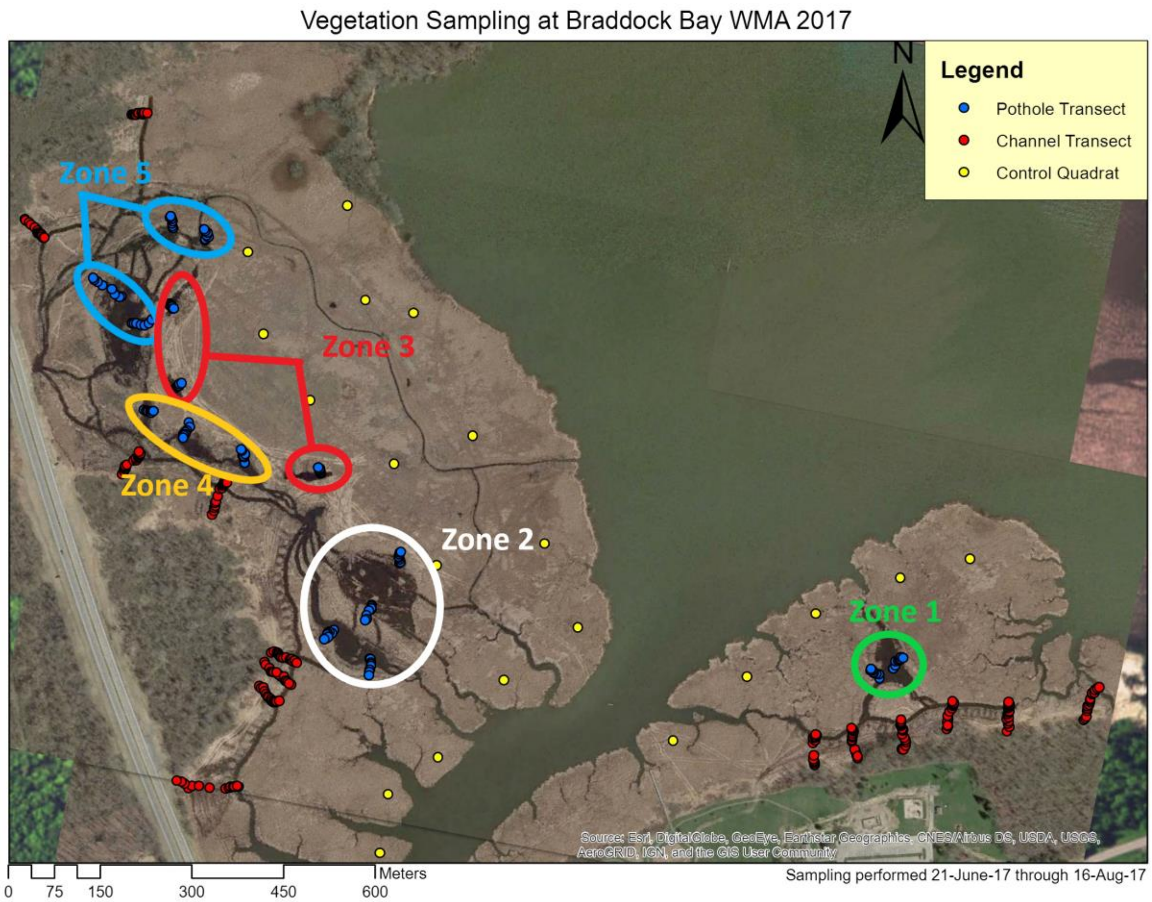



*Figure 7. Quadrat and transect grouping to calculate FQAI for the pothole and channel transect breakout, with data shown in Table 3.*

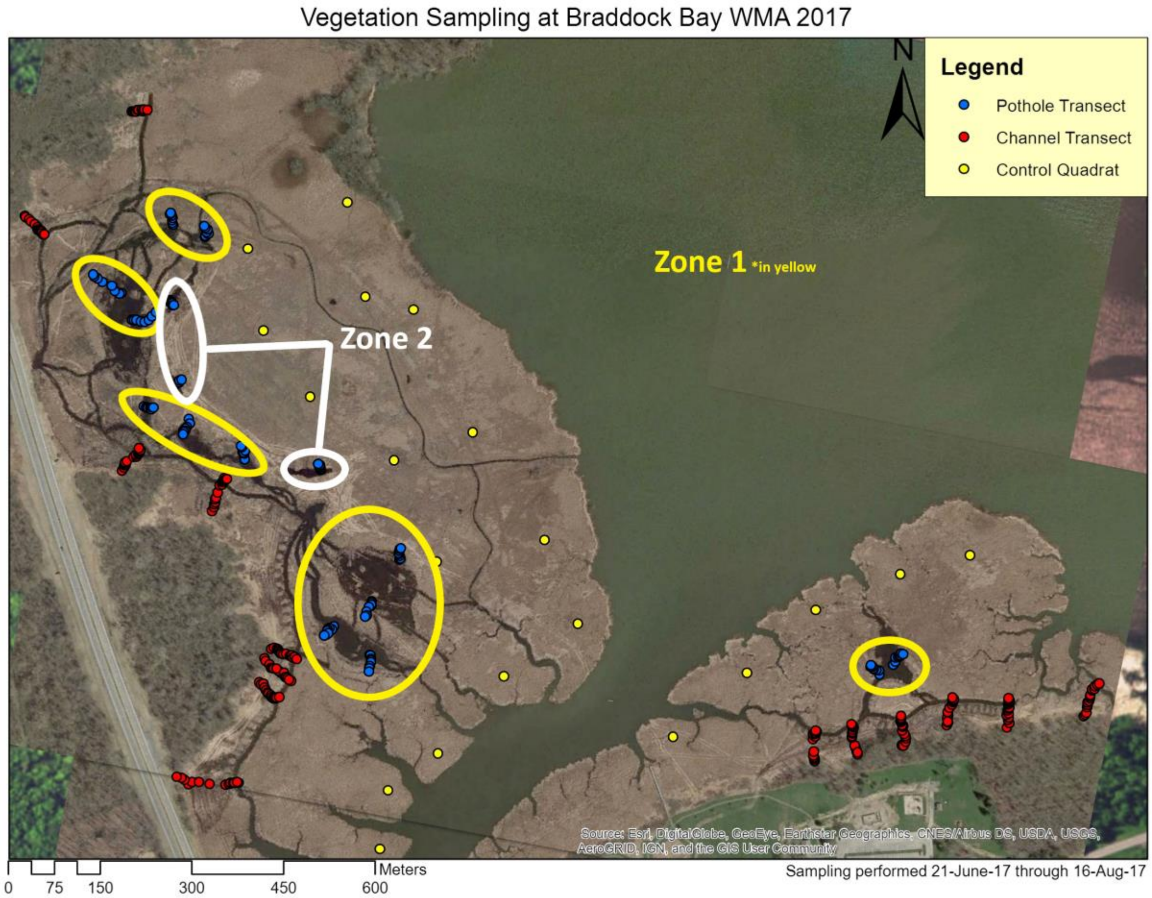



*Figure 8. Transect and quadrat grouping used to calculate FQAI for connected and isolated potholes, with data shown in Table 4.*


*Figure 9. Location of fyke net sets by project at Braddock Bay during 2017.*

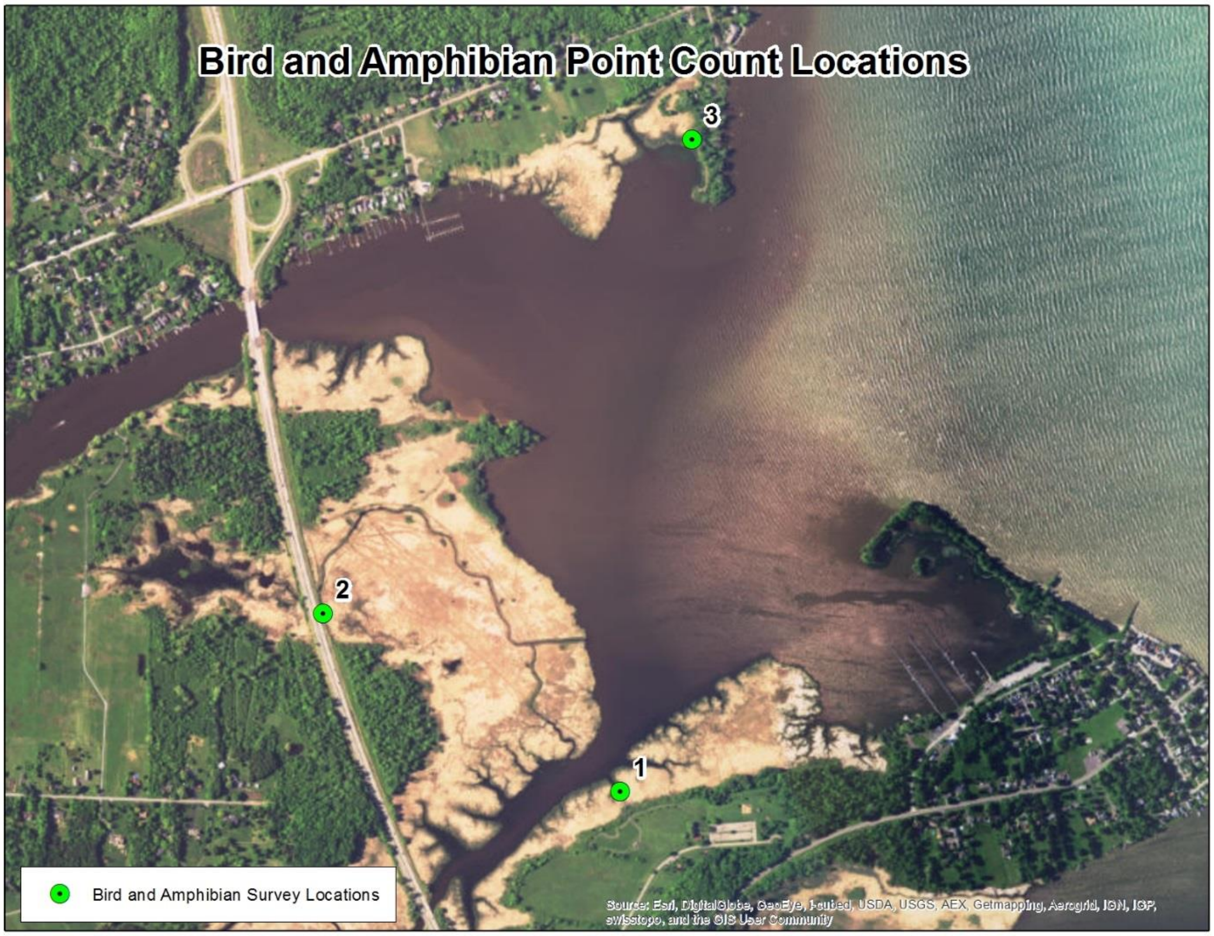



*Figure 10: Spring 2017 bird and anuran survey locations in Braddock Bay.*

Supplementary Materials:

Table S1. Summary water quality conditions (minimum, maximum, mean, and 95% confidence interval) for Lake Ontario, Braddock Bay, and its Tributaries for barrier pre-construction sampling events.

| | min | max | mean | 95% CI |
|---|---|---|---|---|
| Phosphate (PO4; mg/L) | | | | |
| Lake Ontario | 0.002 | 0.028 | 0.010 | 0.003 to 0.022 |
| Braddock Bay | 0.002 | 0.259 | 0.014 | 0.003 to 0.131 |
| Tributaries | 0.057 | 0.267 | 0.154 | 0.060 to 0.237 |
| Total Phosphorus (TP; mg/L) | | | | |
| Lake Ontario | 0.006 | 0.022 | 0.009 | 0.006 to 0.018 |
| Braddock Bay | 0.030 | 0.284 | 0.102 | 0.033 to 0.200 |
| Tributaries | 0.140 | 0.330 | 0.201 | 0.140 to 0.297 |
| Ammonia (NH4; mg/L) | | | | |
| Lake Ontario | 0.010 | 0.047 | 0.030 | 0.015 to 0.043 |
| Braddock Bay | 0.011 | 0.300 | 0.050 | 0.013 to 0.213 |
| Tributaries | 0.017 | 0.310 | 0.071 | 0.020 to 0.243 |
| Nitrate+Nitrite (NO2NO3; mg/L) | | | | |
| Lake Ontario | 0.000 | 1.700 | 0.311 | 0.000 to 1.217 |
| Braddock Bay | 0.000 | 2.400 | 0.136 | 0.000 to 0.704 |
| Tributaries | 0.000 | 1.500 | 0.142 | 0.000 to 0.668 |
| Total Kjeldahl Nitrogen (TKN; mg/L) | | | | |
| Lake Ontario | 0.130 | 1.000 | 0.497 | 0.173 to 0.972 |
| Braddock Bay | 0.190 | 2.200 | 1.123 | 0.573 to 1.800 |
| Tributaries | 0.290 | 7.200 | 1.334 | 0.487 to 3.150 |
| Chlorophyll a (CHL: µg/L) | | | | |
| Lake Ontario | 1.3 | 20.3 | 6.2 | 1.8 to 19.3 |
| Braddock Bay | 2.7 | 122.8 | 41.6 | 11.5 to 86.8 |
| Tributaries | 1.3 | 30.7 | 7.6 | 1.3 to 17.3 |
| Secchi Disc Depth (ft) | | | | |
| Lake Ontario | 3.7 | 6.8 | 5.8 | 4.0 to 6.6 |
| Braddock Bay | 1.0 | 3.7 | 1.9 | 1.0 to 3.4 |
| Tributaries | 1.1 | 8.0 | 5.0 | 1.7 to 7.7 |
| Trophic State Index (TSI) | | | | |
| Lake Ontario | 39 | 56 | 44 | 40 to 52 |
| Braddock Bay | 58 | 77 | 67 | 61 to 75 |
| Tributaries | 54 | 69 | 61 | 54 to 67 |

Table S2. Summary water quality conditions (minimum, maximum, mean, and 95% confidence interval) for Lake Ontario, Braddock Bay, and its Tributaries for barrier during construction sampling events.

| | min | max | mean | 95% CI |
|---|---|---|---|---|
| Phosphate (PO4; mg/L) | | | | |
| Lake Ontario | 0.000 | 0.001 | 0.001 | 0.000 to 0.001 |
| Braddock Bay | 0.001 | 0.158 | 0.041 | 0.001 to 0.123 |
| Tributaries | 0.062 | 0.300 | 0.177 | 0.077 to 0.283 |
| Total Phosphorus (TP; mg/L) | | | | |
| Lake Ontario | 0.007 | 0.010 | 0.009 | 0.007 to 0.010 |
| Braddock Bay | 0.111 | 0.507 | 0.199 | 0.120 to 0.376 |
| Tributaries | 0.078 | 0.355 | 0.210 | 0.096 to 0.333 |
| Ammonia (NH4; mg/L) | | | | |
| Lake Ontario | 0.009 | 0.018 | 0.008 | 0.009 to 0.176 |
| Braddock Bay | 0.000 | 0.018 | 0.008 | 0.000 to 0.018 |
| Tributaries | 0.000 | 0.012 | 0.005 | 0.000 to 0.011 |
| Nitrate + Nitrite (NO2NO3; mg/L) | | | | |
| Lake Ontario | 0.000 | 0.208 | 0.156 | 0.108 to 0.203 |
| Braddock Bay | 0.000 | 0.011 | 0.002 | 0.000 to 0.008 |
| Tributaries | 0.000 | 0.000 | 0.000 | 0.000 to 0.000 |
| Total Kjeldahl Nitrogen (TKN; mg/L) | | | | |
| Lake Ontario | 0.263 | 0.338 | 0.301 | 0.267 to 0.334 |
| Braddock Bay | 0.522 | 1.655 | 1.127 | 0.549 to 1.528 |
| Tributaries | 0.506 | 0.754 | 0.629 | 0.510 to 0.749 |
| Chlorophyll a (CHL: µg/L) | | | | |
| Lake Ontario | 5.7 | 7.7 | 6.7 | 5.8 to 7.6 |
| Braddock Bay | 4.4 | 134.4 | 74.2 | 8.6 to 118.0 |
| Tributaries | 4.3 | 5.9 | 5.0 | 4.3 to 5.8 |
| Secchi Disc Depth (ft) | | | | |
| Lake Ontario | 5.1 | 5.5 | 5.3 | 5.1 to 5.5 |
| Braddock Bay | 0.8 | 3.6 | 1.6 | 0.8 to 3.4 |
| Tributaries | 7.3 | 8.0 | 7.6 | 7.3 to 7.9 |
| Trophic State Index (TSI) | | | | |
| Lake Ontario | 45 | 47 | 46 | 45 to 47 |
| Braddock Bay | 62 | 81 | 74 | 64 to 80 |
| Tributaries | 54 | 60 | 58 | 55 to 60 |

Table S3. Summary water quality conditions (minimum, maximum, mean, and 95% confidence interval) for Lake Ontario, Braddock Bay, and its Tributaries for barrier post construction sampling events.

| | min | max | mean | 95% CI |
|---|---|---|---|---|
| Phosphate (PO4; mg/L) | | | | |
| Lake Ontario | 0.001 | 0.008 | 0.004 | 0.001 to 0.008 |
| Braddock Bay | 0.000 | 0.057 | 0.010 | 0.000 to 0.040 |
| Tributaries | 0.003 | 0.107 | 0.060 | 0.006 to 0.105 |
| Total Phosphorus (TP; mg/L) | | | | |
| Lake Ontario | 0.005 | 0.056 | 0.025 | 0.007 to 0.051 |
| Braddock Bay | 0.037 | 0.117 | 0.071 | 0.042 to 0.114 |
| Tributaries | 0.061 | 0.175 | 0.120 | 0.074 to 0.173 |
| Ammonia (NH4; mg/L) | | | | |
| Lake Ontario | 0.000 | 0.049 | 0.024 | 0.000 to 0.047 |
| Braddock Bay | 0.000 | 0.120 | 0.030 | 0.000 to 0.091 |
| Tributaries | 0.000 | 0.151 | 0.048 | 0.000 to 0.120 |
| Nitrate + Nitrite (NO2NO3; mg/L) | | | | |
| Lake Ontario | 0.129 | 0.221 | 0.190 | 0.135 to 0.221 |
| Braddock Bay | 0.000 | 0.155 | 0.042 | 0.000 to 0.146 |
| Tributaries | 0.000 | 0.156 | 0.026 | 0.000 to 0.116 |
| Total Kjeldahl Nitrogen (TKN; mg/L) | | | | |
| Lake Ontario | 0.268 | 0.620 | 0.400 | 0.275 to 0.594 |
| Braddock Bay | 0.410 | 0.952 | 0.712 | 0.560 to 0.833 |
| Tributaries | 0.497 | 1.072 | 0.773 | 0.568 to 0.976 |
| Chlorophyll a (CHL: µg/L) | | | | |
| Lake Ontario | 3.5 | 45.4 | 15.5 | 3.7 to 39.5 |
| Braddock Bay | 19.1 | 51.8 | 34.9 | 23.5 to 48.1 |
| Tributaries | 12.0 | 64.5 | 26.2 | 12.0 to 56.6 |
| Secchi Disc Depth (ft) | | | | |
| Lake Ontario | 1.8 | bottom | 4.0 | 1.9 to 6.5 |
| Braddock Bay | 1.3 | 4.2 | 2.5 | 1.5 to 4.0 |
| Tributaries | 2.5 | 6.0 | 4.0 | 2.8 to 5.4 |
| Trophic State Index (TSI) | | | | |
| Lake Ontario | 35 | 66 | 50 | 37 to 64 |
| Braddock Bay | 57 | 71 | 65 | 59 to 70 |
| Tributaries | 60 | 70 | 64 | 60 to 69 |

Appendix A. 2015 and 2016 pre-barrier data set.

| Site | date | CHL µg/L | PO4 mg-P/L | NH4 mg-N/L | NO2NO3 mg-N/L | TP mg-P/L | TSS mg/L | TKN mg/L |
|---|---|---|---|---|---|---|---|---|
| BW | 6/12/2015 | 5.3 | 0.081 | 0.310 | 0.210 | 0.140 | 8.0 | 1.700 |
| BW | 7/16/2015 | 5.3 | 0.206 | 0.076 | 0.000 | 0.330 | 2.0 | 1.300 |
| BW | 8/14/2015 | 3.2 | 0.156 | 0.062 | 0.000 | 0.200 | 2.0 | 0.290 |
| BW | 9/23/2015 | 1.3 | 0.201 | 0.056 | 0.390 | 0.210 | 2.0 | 7.200 |
| BW | 6/28/2016 | 12.0 | 0.126 | 0.028 | 0.000 | 0.186 | 6.2 | 0.683 |
| BW | 7/5/2016 | 8.6 | 0.195 | 0.042 | 0.015 | 0.244 | 6.6 | 0.713 |
| BW | 7/27/2016 | 6.1 | 0.202 | 0.053 | 0.017 | 0.231 | 2.6 | 0.719 |
| BW | 8/11/2016 | 7.0 | 0.227 | 0.021 | 0.000 | 0.257 | 1.0 | 0.729 |
| LO1 | 6/12/2015 | 2.7 | 0.010 | 0.027 | 0.320 | 0.008 | 8.0 | 0.920 |
| LO1 | 7/16/2015 | 1.3 | 0.010 | 0.010 | 0.000 | 0.006 | 0.0 | 0.740 |
| LO1 | 8/14/2015 | 20.3 | 0.010 | 0.034 | 0.000 | 0.022 | 7.0 | 0.130 |
| LO1 | 9/23/2015 | 6.7 | 0.010 | 0.035 | 1.700 | 0.008 | 2.0 | 1.000 |
| LO1 | 6/28/2016 | 6.0 | 0.004 | 0.023 | 0.156 | 0.006 | 3.3 | 0.314 |
| LO1 | 7/5/2016 | 5.4 | 0.004 | 0.047 | 0.025 | 0.010 | 3.4 | 0.328 |
| LO1 | 7/27/2016 | 4.0 | 0.028 | 0.031 | 0.133 | 0.007 | 1.6 | 0.289 |
| LO1 | 8/11/2016 | 2.8 | 0.002 | 0.030 | 0.153 | 0.006 | 1.7 | 0.254 |
| SC | 6/12/2015 | 5.3 | 0.090 | 0.220 | 0.110 | 0.140 | 22.0 | 1.300 |
| SC | 7/16/2015 | 30.7 | 0.057 | 0.017 | 0.000 | 0.150 | 10.0 | 1.800 |
| SC | 8/14/2015 | 6.4 | 0.119 | 0.047 | 0.000 | 0.160 | 6.0 | 0.920 |
| SC | 9/23/2015 | 1.3 | 0.168 | 0.069 | 1.500 | 0.180 | 0.0 | 1.400 |
| SC | 6/28/2016 | 12.8 | 0.061 | 0.024 | 0.011 | 0.153 | 7.2 | 0.730 |
| SC | 7/5/2016 | 4.1 | 0.117 | 0.048 | 0.000 | 0.157 | 6.0 | 0.669 |
| SC | 7/27/2016 | 6.1 | 0.267 | 0.036 | 0.023 | 0.286 | 2.3 | 0.630 |
| SC | 8/11/2016 | 5.3 | 0.191 | 0.021 | 0.000 | 0.190 | 1.1 | 0.553 |
| SG2 | 6/12/2015 | 2.7 | 0.092 | 0.300 | 0.770 | 0.150 | 32.0 | 1.400 |
| SG2 | 7/16/2015 | 53.4 | 0.028 | 0.021 | 0.000 | 0.110 | 27.0 | 1.200 |
| SG2 | 8/14/2015 | 29.9 | 0.045 | 0.080 | 0.000 | 0.140 | 14.0 | 0.190 |
| SG2 | 9/23/2015 | 28.0 | 0.129 | 0.063 | 0.610 | 0.170 | 6.0 | 1.800 |
| SG2 | 6/28/2016 | 35.5 | 0.019 | 0.023 | 0.026 | 0.117 | 15.3 | 0.713 |
| SG2 | 7/5/2016 | 24.0 | 0.071 | 0.041 | 0.000 | 0.147 | 14.0 | 0.833 |
| SG2 | 7/27/2016 | 49.4 | 0.166 | 0.028 | 0.000 | 0.059 | 14.6 | 0.949 |
| SG2 | 8/11/2016 | 11.8 | 0.259 | 0.030 | 0.016 | 0.284 | 8.8 | 0.700 |
| SG3 | 6/12/2015 | 122.8 | 0.011 | 0.038 | 0.000 | 0.074 | 24.0 | 1.400 |
| SG3 | 7/16/2015 | 54.7 | 0.010 | 0.022 | 0.000 | 0.053 | 16.0 | 1.700 |
| SG3 | 8/14/2015 | 35.2 | 0.012 | 0.060 | 0.000 | 0.075 | 18.0 | 1.500 |
| SG3 | 9/23/2015 | 32.0 | 0.010 | 0.038 | 2.400 | 0.043 | 8.5 | 2.200 |
| SG3 | 6/28/2016 | 31.7 | 0.005 | 0.021 | 0.006 | 0.081 | 13.2 | 0.661 |
| SG3 | 7/5/2016 | 27.3 | 0.015 | 0.029 | 0.000 | 0.091 | 13.5 | 0.725 |
| SG3 | 7/27/2016 | 55.1 | 0.024 | 0.027 | 0.000 | 0.130 | 11.9 | 0.912 |
| SG3 | 8/11/2016 | 85.6 | 0.013 | 0.022 | 0.013 | 0.148 | 21.8 | 1.147 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SG4 | 6/12/2015 | 40.1 | 0.015 | 0.210 | 0.280 | 0.095 | 19.0 | 1.300 |
| SG4 | 7/16/2015 | 53.4 | 0.010 | 0.011 | 0.000 | 0.047 | 17.0 | 1.600 |
| SG4 | 8/14/2015 | 38.4 | 0.031 | 0.050 | 0.000 | 0.110 | 19.0 | 1.400 |
| SG4 | 9/23/2015 | 32.0 | 0.029 | 0.027 | 0.700 | 0.067 | 12.0 | 1.800 |
| SG4 | 6/28/2016 | 37.7 | 0.009 | 0.024 | 0.023 | 0.101 | 21.4 | 0.757 |
| SG4 | 7/5/2016 | 16.2 | 0.073 | 0.038 | 0.000 | 0.135 | 11.6 | 0.599 |
| SG4 | 7/27/2016 | 67.7 | 0.049 | 0.023 | 0.000 | 0.179 | 23.4 | 0.977 |
| SG4 | 8/11/2016 | 66.6 | 0.067 | 0.024 | 0.014 | 0.206 | 23.3 | 1.224 |
| SG5a | 6/12/2015 | 58.7 | 0.015 | 0.150 | 0.200 | 0.086 | 42.0 | 1.300 |
| SG5a | 7/16/2015 | 48.1 | 0.010 | 0.011 | 0.000 | 0.033 | 14.0 | 1.400 |
| SG5a | 8/14/2015 | 29.9 | 0.010 | 0.027 | 0.000 | 0.059 | 16.0 | 1.200 |
| SG5a | 9/23/2015 | 46.7 | 0.010 | 0.017 | 0.130 | 0.032 | 14.0 | 1.600 |
| SG5a | 6/28/2016 | 28.2 | 0.002 | 0.023 | 0.012 | 0.060 | 8.8 | 0.603 |
| SG5a | 7/5/2016 | 32.8 | 0.006 | 0.039 | 0.000 | 0.096 | 18.0 | 0.810 |
| SG5a | 7/27/2016 | 62.8 | 0.005 | 0.022 | 0.000 | 0.125 | 18.1 | 0.947 |
| SG5a | 8/11/2016 | 110.0 | 0.009 | 0.017 | 0.000 | 0.155 | 24.7 | 1.410 |
| SG5b | 6/12/2015 | 5.3 | 0.091 | 0.260 | 0.059 | 0.160 | 53.0 | 1.700 |
| SG5b | 7/16/2015 | 26.7 | 0.010 | 0.013 | 0.000 | 0.030 | 13.0 | 1.300 |
| SG5b | 8/14/2015 | 27.8 | 0.010 | 0.055 | 0.000 | 0.042 | 11.0 | 0.810 |
| SG5b | 9/23/2015 | 34.7 | 0.016 | 0.020 | 0.078 | 0.053 | 13.0 | 1.100 |
| SG5b | 6/28/2016 | 16.1 | 0.004 | 0.020 | 0.034 | 0.045 | 6.6 | 0.705 |
| SG5b | 7/5/2016 | 30.4 | 0.002 | 0.043 | 0.000 | 0.059 | 16.0 | 0.555 |
| SG5b | 7/27/2016 | 15.3 | 0.003 | 0.032 | 0.084 | 0.041 | 8.2 | 0.574 |
| SG5b | 8/11/2016 | 59.5 | 0.065 | 0.018 | 0.000 | 0.200 | 14.7 | 1.022 |

ND = not determined

Values below detection limit are listed as 0

Appendix A. 2015 and 2016 pre-barrier data set continued.

| Site | Date | pH | DO | ORP | Conductivity | Turbidity | Secchi Depth |
|---|---|---|---|---|---|---|---|
| | | | mg/L | mV | µS/cm | NTU | ft |
| BW | 6/12/2015 | 7.39 | 3.7 | 210 | 0.744 | 33.9 | 2.3 |
| BW | 7/16/2015 | 6.78 | 2.8 | 176 | 0.830 | 1.2 | 3.4 |
| BW | 8/14/2015 | 7.15 | 5.8 | 176 | 0.788 | 3.9 | 5.2 |
| BW | 9/23/2015 | 7.48 | 7.4 | 179 | 0.722 | 3.3 | 7.5 |
| BW | 6/28/2016 | 7.15 | 5.6 | 142 | 0.524 | 3.6 | 3.8 |
| BW | 7/5/2016 | 7.16 | 5.1 | 74 | 0.574 | 0.0 | ND |
| BW | 7/27/2016 | 7.12 | 4.7 | 176 | 0.527 | 1.9 | 7.4 |
| BW | 8/11/2016 | 7.18 | 5.3 | 131 | 0.558 | 1.6 | 8.0 |
| LO1 | 6/12/2015 | 8.30 | 7.1 | 222 | 0.456 | 4.4 | 6.2 |
| LO1 | 7/16/2015 | 7.99 | 5.8 | 210 | 0.446 | 18.5 | 4.7 |
| LO1 | 8/14/2015 | 8.49 | 9.7 | 164 | 0.049 | 10.4 | 3.7 |
| LO1 | 9/23/2015 | 8.36 | 9.4 | 179 | 0.465 | 3.5 | 6.8 |
| LO1 | 6/28/2016 | 8.15 | 10.7 | 66 | 0.299 | 1.0 | 6.2 |
| LO1 | 7/5/2016 | 8.37 | 9.6 | 139 | 0.301 | 0.0 | 5.3 |
| LO1 | 7/27/2016 | 8.20 | 9.4 | 155 | 0.310 | 1.4 | 6.1 |
| LO1 | 8/11/2016 | 8.16 | 10.0 | 50 | 0.301 | 1.2 | 5.4 |
| SC | 6/12/2015 | 6.83 | 5.3 | 184 | 0.835 | 86.8 | 1.1 |
| SC | 7/16/2015 | 7.57 | 6.8 | 185 | 0.966 | 36.2 | 1.9 |
| SC | 8/14/2015 | 7.57 | 10.0 | 187 | 0.984 | 12.0 | 3.7 |
| SC | 9/23/2015 | 6.85 | 10.5 | 196 | 0.800 | 3.8 | 6.5 |
| SC | 6/28/2016 | 8.06 | 8.3 | 120 | 0.691 | 2.6 | 4.2 |
| SC | 7/5/2016 | 8.24 | 9.3 | 129 | 0.682 | 0.0 | 5.4 |
| SC | 7/27/2016 | 8.28 | 7.3 | 151 | 0.542 | 1.5 | 7.6 |
| SC | 8/11/2016 | 7.93 | 6.5 | 100 | 0.441 | 0.6 | 6.7 |
| SG2 | 6/12/2015 | 7.41 | 4.9 | 202 | 0.744 | 111.0 | 1.1 |
| SG2 | 7/16/2015 | 7.73 | 5.3 | 183 | 0.736 | 53.9 | 1.6 |
| SG2 | 8/14/2015 | 7.77 | 8.6 | 182 | 0.855 | 37.0 | 2.1 |
| SG2 | 9/23/2015 | 7.79 | 9.3 | 202 | 0.680 | 24.6 | 3.3 |
| SG2 | 6/28/2016 | 7.90 | 7.9 | 81 | 0.470 | 2.6 | 2.2 |
| SG2 | 7/5/2016 | 8.13 | 7.2 | 129 | 0.605 | 2.0 | ND |
| SG2 | 7/27/2016 | 8.17 | 8.2 | 152 | 0.576 | 17.0 | 1.5 |
| SG2 | 8/11/2016 | 8.28 | 8.1 | 75 | 0.466 | 5.8 | 3.4 |
| SG3 | 6/12/2015 | 8.21 | 5.9 | 220 | 0.680 | 67.8 | 1.3 |
| SG3 | 7/16/2015 | 8.41 | 7.2 | 194 | 0.509 | 80.2 | 2.1 |
| SG3 | 8/14/2015 | 8.23 | 9.6 | 149 | 0.549 | 44.0 | 1.8 |
| SG3 | 9/23/2015 | 8.49 | 11.6 | 137 | 0.529 | 26.9 | 2.4 |
| SG3 | 6/28/2016 | 8.00 | 8.8 | 133 | 0.359 | 9.6 | 1.7 |
| SG3 | 7/5/2016 | 8.02 | 7.3 | 84 | 0.358 | 1.0 | ND |
| SG3 | 7/27/2016 | 8.21 | 8.8 | 116 | 0.354 | 16.3 | 1.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SG3 | 8/11/2016 | 8.28 | 9.6 | 110 | 0.334 | 18.2 | 1.3 |
| SG4 | 6/12/2015 | 7.76 | 5.2 | 200 | 0.694 | 58.9 | 1.9 |
| SG4 | 7/16/2015 | 7.79 | 5.6 | 233 | 0.520 | 52.2 | 1.9 |
| SG4 | 8/14/2015 | 7.87 | 8.3 | 188 | 0.562 | 55.1 | 1.8 |
| SG4 | 9/23/2015 | 8.13 | 9.5 | 168 | 0.579 | 33.5 | 2.7 |
| SG4 | 6/28/2016 | 8.16 | 8.4 | 115 | 0.365 | 14.4 | 2.1 |
| SG4 | 7/5/2016 | 7.98 | 7.7 | 148 | 0.403 | 1.1 | 3.7 |
| SG4 | 7/27/2016 | 8.36 | 10.1 | 149 | 0.380 | 18.7 | 1.2 |
| SG4 | 8/11/2016 | 8.50 | 10.8 | 94 | 0.360 | 17.4 | 1.4 |
| SG5a | 6/12/2015 | 7.45 | 4.6 | 219 | 0.777 | 132.0 | 1.0 |
| SG5a | 7/16/2015 | 8.09 | 6.9 | 197 | 0.495 | 59.5 | 2.0 |
| SG5a | 8/14/2015 | 8.40 | 9.3 | 184 | 0.550 | 45.1 | 2.1 |
| SG5a | 9/23/2015 | 8.50 | 10.1 | 165 | 0.526 | 36.4 | 2.4 |
| SG5a | 6/28/2016 | 8.03 | 8.9 | 140 | 0.355 | 8.8 | 2.9 |
| SG5a | 7/5/2016 | 7.95 | 7.3 | 116 | 0.367 | 2.7 | ND |
| SG5a | 7/27/2016 | 8.36 | 9.5 | 147 | 0.392 | 18.5 | 1.3 |
| SG5a | 8/11/2016 | 7.83 | 8.4 | 126 | 0.348 | 27.3 | 1.0 |
| SG5b | 6/12/2015 | 7.55 | 4.4 | 212 | 0.755 | 162.0 | 1.0 |
| SG5b | 7/16/2015 | 8.05 | 8.1 | 183 | 0.507 | 43.8 | 1.9 |
| SG5b | 8/14/2015 | 8.50 | 9.8 | 157 | 0.525 | 26.9 | 2.7 |
| SG5b | 9/23/2015 | 8.35 | 9.8 | 176 | 0.580 | 37.8 | 2.3 |
| SG5b | 6/28/2016 | 8.00 | 9.2 | 109 | 0.343 | 6.0 | 3.5 |
| SG5b | 7/5/2016 | 8.01 | 7.6 | 129 | 0.367 | 1.1 | ND |
| SG5b | 7/27/2016 | 7.86 | 7.7 | 160 | 0.333 | 8.1 | 3.4 |
| SG5b | 8/11/2016 | 8.25 | 8.8 | 96 | 0.395 | 17.9 | 1.5 |

ND = not determined

Values below detection limit are listed as 0

Appendix B. 2016 during barrier construction data set.

| Site | date | CHL µg/L | PO4 mg-P/L | NH4 mg-N/L | NO2NO3 mg-N/L | TP mg-P/L | TSS mg/L | TKN mg/L |
|---|---|---|---|---|---|---|---|---|
| BW | 8/30/2016 | 4.3 | 0.300 | 0.012 | 0.000 | 0.355 | 1.5 | 0.754 |
| BW | 9/18/2016 | 4.3 | 0.186 | 0.000 | 0.000 | 0.209 | 0.4 | 0.722 |
| LO1 | 8/30/2016 | 7.7 | 0.001 | 0.018 | 0.103 | 0.010 | 2.1 | 0.338 |
| LO1 | 9/18/2016 | 5.7 | 0.000 | 0.009 | 0.208 | 0.007 | 0.0 | 0.263 |
| SC | 8/30/2016 | 5.9 | 0.160 | 0.008 | 0.000 | 0.198 | 1.6 | 0.535 |
| SC | 9/18/2016 | 5.4 | 0.062 | 0.000 | 0.000 | 0.078 | 1.0 | 0.506 |
| SG2 | 8/30/2016 | 13.7 | 0.158 | 0.015 | 0.005 | 0.205 | 3.1 | 0.583 |
| SG2 | 9/18/2016 | 4.4 | 0.081 | 0.000 | 0.000 | 0.215 | 1.6 | 0.522 |
| SG3 | 8/30/2016 | 95.9 | 0.010 | 0.018 | 0.000 | 0.180 | 19.8 | 1.373 |
| SG3 | 9/18/2016 | 91.6 | 0.010 | 0.000 | 0.000 | 0.132 | 18.6 | 1.194 |
| SG4 | 8/30/2016 | 83.1 | 0.075 | 0.018 | 0.000 | 0.507 | 15.8 | 1.270 |
| SG4 | 9/18/2016 | 42.4 | 0.062 | 0.000 | 0.000 | 0.153 | 10.8 | 1.008 |
| SG5a | 8/30/2016 | 134.4 | 0.006 | 0.012 | 0.000 | 0.188 | 34.4 | 1.655 |
| SG5a | 9/18/2016 | 80.8 | 0.002 | 0.000 | 0.000 | 0.137 | 21.5 | 1.240 |
| SG5b | 8/30/2016 | 98.0 | 0.005 | 0.018 | 0.000 | 0.164 | 25.6 | 1.281 |
| SG5b | 9/18/2016 | 97.5 | 0.001 | 0.000 | 0.011 | 0.111 | 11.7 | 1.144 |

ND = not determined

Values below detection limit are listed as 0

Appendix B 2016 during barrier construction data set continued.

| Site | Date | pH | DO | ORP | Conductivity | Turbidity | Secchi Depth |
|---|---|---|---|---|---|---|---|
| | | | mg/L | mV | µS/cm | NTU | ft |
| BW | 8/30/2016 | 7.08 | ND | 230 | 0.542 | 1.4 | 8.0 |
| BW | 9/18/2016 | 7.11 | ND | 72 | 0.540 | 1.1 | 7.5 |
| LO1 | 8/30/2016 | 7.96 | ND | 205 | 0.309 | 2.5 | 5.5 |
| LO1 | 9/18/2016 | 7.96 | ND | 143 | 0.314 | 2.2 | 5.1 |
| SC | 8/30/2016 | 7.05 | ND | 232 | 0.443 | 1.2 | 7.6 |
| SC | 9/18/2016 | 7.39 | ND | 109 | 0.500 | 1.1 | 7.3 |
| SG2 | 8/30/2016 | 7.88 | ND | 214 | 0.443 | 4.1 | 3.6 |
| SG2 | 9/18/2016 | 7.7 | ND | 133 | 0.456 | 2.0 | 3.2 |
| SG3 | 8/30/2016 | 7.88 | ND | 175 | 0.332 | 22.0 | 1.0 |
| SG3 | 9/18/2016 | 8.17 | ND | 131 | 0.343 | 18.4 | 1.4 |
| SG4 | 8/30/2016 | 8.31 | ND | 201 | 0.381 | 18.3 | 1.2 |
| SG4 | 9/18/2016 | 8.21 | ND | 79 | 0.414 | 12.9 | 1.8 |
| SG5a | 8/30/2016 | 8.06 | ND | 202 | 0.343 | 34.5 | 0.8 |
| SG5a | 9/18/2016 | 8.31 | ND | 114 | 0.362 | 24.4 | 0.9 |
| SG5b | 8/30/2016 | 8.32 | ND | 184 | 0.370 | 22.1 | 1.0 |
| SG5b | 9/18/2016 | 8.29 | ND | 128 | 0.357 | 21.7 | 1.0 |

ND = not determined

Values below detection limit are listed as 0

Appendix C. 2017 post barrier construction data set.

| Site | date | CHL µg/L | PO4 mg-P/L | NH4 mg-N/L | NO2NO3 mg-N/L | TP mg-P/L | TSS mg/L | TKN mg/L |
|---|---|---|---|---|---|---|---|---|
| BW | 5/16/2017 | 22.8 | 0.028 | 0.000 | 0.000 | 0.085 | 7.1 | 0.806 |
| BW | 6/13/2017 | 14.6 | 0.047 | 0.037 | 0.000 | 0.105 | 3.2 | 0.755 |
| BW | 7/6/2017 | 17.1 | 0.045 | 0.040 | 0.025 | 0.098 | 4.1 | 0.497 |
| BW | 7/24/2017 | 12.6 | 0.098 | 0.094 | 0.007 | 0.175 | 3.7 | 0.851 |
| BW | 8/14/2017 | 12.0 | 0.107 | 0.062 | 0.008 | 0.155 | 4.3 | 0.665 |
| BW | 9/2/2017 | 12.0 | 0.071 | 0.034 | 0.000 | 0.117 | 3.6 | 0.627 |
| LO1 | 5/16/2017 | 21.8 | 0.002 | 0.000 | 0.208 | 0.037 | 7.9 | 0.517 |
| LO1 | 6/13/2017 | 4.3 | 0.001 | 0.014 | 0.219 | 0.013 | 0.6 | 0.381 |
| LO1 | 7/6/2017 | 7.2 | 0.001 | 0.037 | 0.211 | 0.018 | 2.6 | 0.316 |
| LO1 | 7/24/2017 | 45.4 | 0.008 | 0.042 | 0.221 | 0.056 | 19.5 | 0.620 |
| LO1 | 8/14/2017 | 10.6 | 0.005 | 0.049 | 0.153 | 0.018 | 2.9 | 0.297 |
| LO1 | 9/2/2017 | 3.5 | 0.007 | 0.001 | 0.129 | 0.005 | 2.9 | 0.268 |
| SC | 5/16/2017 | 64.5 | 0.003 | 0.000 | 0.083 | 0.061 | 8.9 | 0.862 |
| SC | 6/13/2017 | 50.2 | 0.008 | 0.036 | 0.000 | 0.092 | 8.8 | 1.072 |
| SC | 7/6/2017 | 47.7 | 0.081 | 0.049 | 0.025 | 0.171 | 9.1 | 0.850 |
| SC | 7/24/2017 | 17.4 | 0.094 | 0.151 | 0.156 | 0.122 | 5.1 | 0.898 |
| SC | 8/14/2017 | 30.6 | 0.104 | 0.054 | 0.006 | 0.152 | 5.7 | 0.771 |
| SC | 9/2/2017 | 12.9 | 0.031 | 0.013 | 0.000 | 0.105 | 4.9 | 0.626 |
| SG2 | 5/16/2017 | 48.1 | 0.000 | 0.000 | 0.119 | 0.048 | 8.9 | 0.772 |
| SG2 | 6/13/2017 | 25.5 | 0.001 | 0.019 | 0.028 | 0.042 | 4.3 | 0.715 |
| SG2 | 7/6/2017 | 36.5 | 0.009 | 0.027 | 0.017 | 0.110 | 8.6 | 0.624 |
| SG2 | 7/24/2017 | 51.8 | 0.057 | 0.120 | 0.084 | 0.117 | 15.2 | 0.952 |
| SG2 | 8/14/2017 | 34.4 | 0.016 | 0.056 | 0.020 | 0.096 | 12.0 | 0.752 |
| SG2 | 9/2/2017 | 42.4 | 0.016 | 0.009 | 0.000 | 0.117 | 25.0 | 0.861 |
| SG3 | 5/16/2017 | 41.3 | 0.000 | 0.000 | 0.110 | 0.046 | 8.4 | 0.784 |
| SG3 | 6/13/2017 | 25.5 | 0.001 | 0.021 | 0.000 | 0.042 | 6.5 | 0.776 |
| SG3 | 7/6/2017 | 22.2 | 0.006 | 0.014 | 0.017 | 0.057 | 6.0 | 0.572 |
| SG3 | 7/24/2017 | 31.1 | 0.024 | 0.114 | 0.155 | 0.062 | 9.7 | 0.726 |
| SG3 | 8/14/2017 | 31.7 | 0.009 | 0.018 | 0.007 | 0.083 | 10.0 | 0.736 |
| SG3 | 9/2/2017 | 39.8 | 0.004 | 0.012 | 0.000 | 0.084 | 15.2 | 0.799 |
| SG4 | 5/16/2017 | 46.3 | 0.000 | 0.000 | 0.044 | 0.050 | 8.4 | 0.410 |
| SG4 | 6/13/2017 | 32.9 | 0.000 | 0.031 | 0.008 | 0.047 | 7.0 | 0.787 |
| SG4 | 7/6/2017 | 25.8 | 0.010 | 0.008 | 0.017 | 0.063 | 5.5 | 0.565 |
| SG4 | 7/24/2017 | 38.3 | 0.052 | 0.062 | 0.029 | 0.106 | 9.5 | 0.753 |
| SG4 | 8/14/2017 | 26.8 | 0.025 | 0.040 | 0.009 | 0.105 | 9.5 | 0.703 |
| SG4 | 9/2/2017 | 25.1 | 0.019 | 0.010 | 0.000 | 0.092 | 11.7 | 0.725 |
| SG5a | 5/16/2017 | 42.3 | 0.001 | 0.000 | 0.108 | 0.047 | 9.6 | 0.799 |
| SG5a | 6/13/2017 | 26.4 | 0.000 | 0.019 | 0.005 | 0.045 | 5.3 | 0.716 |
| SG5a | 7/6/2017 | 31.0 | 0.004 | 0.039 | 0.025 | 0.062 | 8.0 | 0.630 |
| SG5a | 7/24/2017 | 47.0 | 0.016 | 0.051 | 0.151 | 0.068 | 14.3 | 0.712 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SG5a | 8/14/2017 | 27.7 | 0.010 | 0.050 | 0.011 | 0.096 | 11.7 | 0.654 |
| SG5a | 9/2/2017 | 42.3 | 0.004 | 0.009 | 0.000 | 0.087 | 17.2 | 0.736 |
| SG5b | 5/16/2017 | 38.4 | 0.001 | 0.000 | 0.094 | 0.048 | 8.0 | 0.778 |
| SG5b | 6/13/2017 | 19.1 | 0.000 | 0.018 | 0.026 | 0.037 | 4.1 | 0.673 |
| SG5b | 7/6/2017 | 32.2 | 0.002 | 0.042 | 0.025 | 0.052 | 8.2 | 0.556 |
| SG5b | 7/24/2017 | 48.0 | 0.005 | 0.042 | 0.140 | 0.071 | 24.2 | 0.764 |
| SG5b | 8/14/2017 | 29.1 | 0.004 | 0.055 | 0.008 | 0.079 | 11.0 | 0.688 |
| SG5b | 9/2/2017 | 39.2 | 0.000 | 0.021 | 0.000 | 0.078 | 15.3 | 0.651 |

ND = not determined

Values below detection limit are listed as 0

Appendix C. 2017 post barrier data set continued.

| Site | Date | pH | DO | ORP | Conductivity | Turbidity | Secchi Depth |
|---|---|---|---|---|---|---|---|
| | | | mg/L | mV | µS/cm | NTU | ft |
| BW | 5/16/2017 | 6.9 | 7.4 | 68 | 0.385 | 8.7 | 3.4 |
| BW | 6/13/2017 | 6.6 | 2.0 | 79 | 0.429 | 3.2 | 5.0 |
| BW | 7/6/2017 | 6.6 | 3.6 | 116 | 0.411 | 3.2 | 4.1 |
| BW | 7/24/2017 | 6.48 | ND | 108 | 0.501 | 3.6 | 3.8 |
| BW | 8/14/2017 | 6.45 | 1.4 | 110 | 0.523 | 2.1 | 4.5 |
| BW | 9/2/2017 | 6.54 | 1.9 | 111 | 0.872 | 3.5 | 6.0 |
| LO1 | 5/16/2017 | 7.9 | 12.6 | 120 | 0.341 | 8.3 | 3.3 |
| LO1 | 6/13/2017 | 7.7 | 10.6 | 25 | 0.317 | 1.7 | Bottom |
| LO1 | 7/6/2017 | 8.0 | 9.7 | 40 | 0.314 | 2.9 | Bottom |
| LO1 | 7/24/2017 | 7.60 | 7.8 | 104 | 0.382 | 20.4 | 1.8 |
| LO1 | 8/14/2017 | 7.98 | 9.4 | 83 | 0.320 | 3.2 | 6.9 |
| LO1 | 9/2/2017 | 7.80 | 10.2 | 88 | 0.491 | 3.1 | Bottom |
| SC | 5/16/2017 | 7.9 | 13.1 | 100 | 0.494 | 7.4 | 3.3 |
| SC | 6/13/2017 | 7.5 | 8.3 | 51 | 0.480 | 11.3 | 3.7 |
| SC | 7/6/2017 | 7.2 | 7.7 | 87 | 0.596 | 8.7 | 2.5 |
| SC | 7/24/2017 | 6.99 | 3.9 | 119 | 0.595 | 5.5 | 4.2 |
| SC | 8/14/2017 | 7.14 | 7.1 | 103 | 0.631 | 4.4 | 3.1 |
| SC | 9/2/2017 | 7.28 | 8.1 | 102 | 0.947 | 4.8 | 4.1 |
| SG2 | 5/16/2017 | 8.0 | 13.1 | 116 | 0.396 | 8.1 | 2.9 |
| SG2 | 6/13/2017 | 7.7 | 9.5 | 10 | 0.377 | 6.6 | 4.1 |
| SG2 | 7/6/2017 | 7.7 | 8.9 | 64 | 0.403 | 7.9 | 2.5 |
| SG2 | 7/24/2017 | 7.12 | 4.8 | 114 | 0.546 | 15.2 | 1.9 |
| SG2 | 8/14/2017 | 7.44 | 8.2 | 92 | 0.516 | 11.6 | 2.5 |
| SG2 | 9/2/2017 | 7.38 | 8.1 | 96 | 0.804 | 21.9 | 1.3 |
| SG3 | 5/16/2017 | 7.9 | 12.2 | 75 | 0.363 | 9.8 | 2.8 |
| SG3 | 6/13/2017 | 7.6 | 8.9 | 88 | 0.352 | 6.2 | 3.9 |
| SG3 | 7/6/2017 | 7.6 | 9.3 | 75 | 0.348 | 5.6 | 2.9 |
| SG3 | 7/24/2017 | 7.28 | 6.2 | 96 | 0.396 | 12.8 | 2.2 |
| SG3 | 8/14/2017 | 7.76 | 9.3 | 86 | 0.432 | 10.8 | 2.5 |
| SG3 | 9/2/2017 | 7.81 | 10.3 | 88 | 0.674 | 15.3 | 1.6 |
| SG4 | 5/16/2017 | 7.9 | 12.2 | 92 | 0.365 | 11.0 | 2.8 |
| SG4 | 6/13/2017 | 7.5 | 8.3 | 48 | 0.354 | 10.5 | 3.2 |
| SG4 | 7/6/2017 | 7.5 | 9.2 | 81 | 0.364 | 5.2 | 2.5 |
| SG4 | 7/24/2017 | 6.88 | 4.3 | 121 | 0.447 | 11.8 | 2.4 |
| SG4 | 8/14/2017 | 7.24 | 8.0 | 97 | 0.454 | 10.5 | 2.6 |
| SG4 | 9/2/2017 | 7.20 | 8.8 | 98 | 0.780 | 13.7 | 1.9 |
| SG5a | 5/16/2017 | 7.9 | 12.2 | 108 | 0.366 | 9.5 | 2.5 |
| SG5a | 6/13/2017 | 7.7 | 9.2 | 10 | 0.353 | 5.4 | 3.7 |
| SG5a | 7/6/2017 | 7.6 | 8.9 | 72 | 0.360 | 7.5 | 2.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SG5a | 7/24/2017 | 7.42 | 6.8 | 105 | 0.405 | 17.2 | 1.9 |
| SG5a | 8/14/2017 | 7.64 | 9.2 | 87 | 0.444 | 9.7 | 2.3 |
| SG5a | 9/2/2017 | 7.65 | 9.8 | 95 | 0.698 | 16.8 | 1.5 |
| SG5b | 5/16/2017 | 8.0 | 12.8 | 114 | 0.366 | 8.7 | 3.0 |
| SG5b | 6/13/2017 | 7.7 | 9.5 | 1 | 0.367 | 5.9 | 4.2 |
| SG5b | 7/6/2017 | 7.8 | 9.5 | 67 | 0.353 | 7.1 | 2.3 |
| SG5b | 7/24/2017 | 7.44 | 6.6 | 106 | 0.396 | 23.1 | 1.6 |
| SG5b | 8/14/2017 | 7.76 | 9.5 | 88 | 0.452 | 7.6 | 2.5 |
| SG5b | 9/2/2017 | 7.82 | 10.7 | 90 | 0.663 | 15.2 | 1.7 |

ND = not determined

Values below detection limit are listed as 0

Appendix D: Description of the anuran call codes.

| Call Code | |
|---|---|
| 1 | Calls not simultaneous, number of individuals can be accurately counted. |
| 2 | Some calls simultaneous, number of individuals can be reliably estimated. |
| 3 | Full chorus, calls continuous and overlapping, number of individuals cannot be estimated. |

**References**

Carlson, R. E. 1977. A trophic state index for lakes. Limnology and Oceanography, 22(2):361-369.

Harpole, W.S. and others. 2011. Nutrient co-limitation of primary producer communities. Ecology Letters, 14:852-862.

Redfield, A.C. 1958. The biological control of chemical factors in the environment. American Scientist 46:205–221.

U.S. Army Corps of Engineers (USACE). 2015. Braddock Bay Restoration: Monitoring and Adaptive Management Plan. Buffalo District.

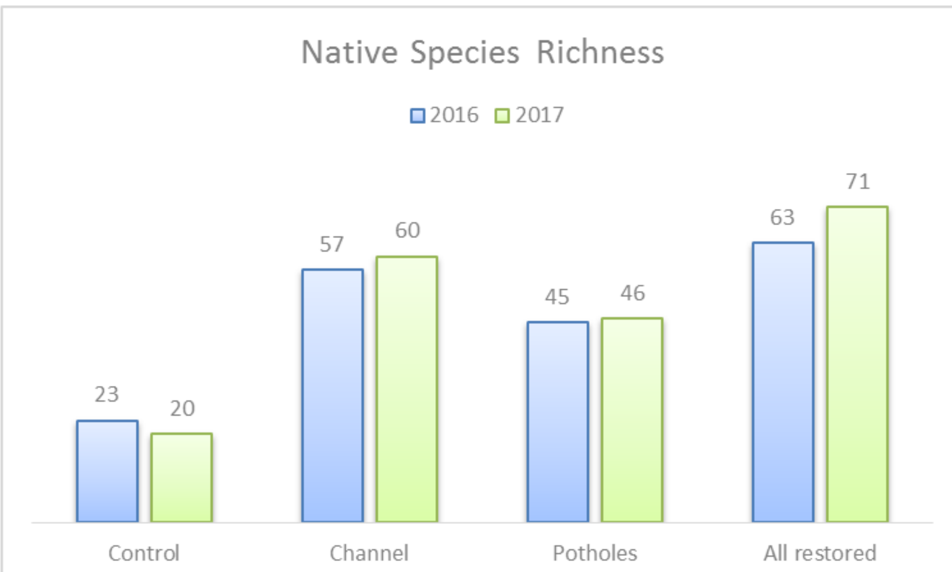
U.S. Army Corps of Engineers (USACE). 2016. Braddock Bay Restoration: 2015 Water Quality Monitoring. Buffalo District.

# APPENDIX C: USACE VEGETATION ANALYSIS AND NORTHERN PIKE SURVEY DATA

## Appendix C-1: 2016 and 2017 Wetland Survey Species List and FQAI Analysis

Vegetation Monitoring

| | 2016 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Control (n =30) | Channel (n=184) | Potholes (n=128) | All restored (n=312) | Control (n =20) | Channel (n=179) | Potholes (n=124) | All restored (n=303) |
| Total # of Species | 27 | 68 | 52 | 74 | 23 | 70 | 51 | 81 |
| # of Native Species | 23 | 57 | 45 | 63 | 20 | 60 | 46 | 71 |
| Mean C | 3.6 | 3.5 | 3.57115 | 3.6 | 3.7 | 3.6 | 3.8 | 3.7 |
| **FQAI** | **18.9** | **28.6** | **25.8** | **31.1** | **17.5** | **30.1** | **26.8** | **33.3** |
| % natives | 85% | 84% | 87% | 85% | 87% | 86% | 90% | 88% |




| Vegetative Cover | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CHANNEL TRANSECTS | | | | | | POTHOLE TRANSECTS | | | |
| **Year** | **M** | | **SB** | | **IB** | | **B** | | **M** | |
| | Average % | Range % | Average % | Range % | Average % | Range % | Average % | Range % | Average % | Range % |
| 2016 | 62.95 | 10-100 | 66.61 | 30-100 | 68.93 | 25-100 | 48.28 | <5 -100 | 68.54 | 25-100 |
| 2017 | 61.90 | 20-100 | 49.50 | 9.5-98.5 | 36.80 | 13-88 | 48.70 | 10-100 | 69.70 | 10-100 |

2016 Vegetation Survey Data: Control and Restored (Channel and Pothole) Areas

| Control Quadrats 2016 Survey n=30 | COC | |
|---|---|---|
| Bidens frondosa | 2.00 | |
| Calystegia sepium | 2.00 | |
| Cicuta bulbifera | 5.00 | |
| Decodon verticillatus | 7.50 | |
| Galium trifidum | 5.00 | |
| Hibiscus moscheutos | 7.00 | |
| Hydrocharis morsus-ranae | **0.00** | |
| Impatiens capensis | 2.00 | |
| Juncus canadensis | 5.50 | |
| Lathyrus palustris | 6.00 | |
| Lemna minor | 2.00 | |
| Lycopus virginicus | 4.50 | |
| Lythrum salicaria | **0.00** | |
| Mentha arvense | 3.50 | |
| Onoclea sensibilis | 2.00 | |
| Persicaria amphibia | 6.00 | |
| Persicaria hydropiper | 1.00 | |
| Persicaria hydropiperoides | 4.00 | |
| Phragmites australis | **0.00** | |
| Sagittaria latifolia | 4.00 | |
| Scirpus fluviatilis | 6.00 | |
| Scutellaria galericulata | 5.00 | |
| Solanum dulcamara | 2.00 | |
| Thelyptris palustris | 6.00 | |
| Triadenum fraseri | 6.00 | |
| Typha x glauca | **0.00** | |
| Verbena hastata | 4.00 | |
| Total Richness | 27 | |
| Native Richness | 23 | |
| Average C | 3.63 | |
| FQI | 18.86 | |
| % natives | 85% | |
| Sedge Grass Meadow Species Removed, only species of restored area kept | | |
| Unknowns removed | | |
| Plants identified to genus, removed if another of same species was present, other wise kept and assigned COC based on likely occurrence | | |
| | | |
| FQI calculated based on Wilhelm and Swink (1997) using all species (Native and nonnative). : FQI=AvgC * SQRT(Species richness) | | |

| Restored Areas Quadrats 2016 Survey n=312 | COC |
|---|---|
| Acer saccharinum | 3.50 |
| Alisma triviale | 3.50 |
| Apios americana | 3.50 |
| Asclepias incarnata | 4.00 |
| Azolla caroliniana | 3.00 |
| Bidens cernua | 4.00 |
| Bidens frondosa | 2.00 |
| Butomus umbellatus | **0.00** |
| Calamagrostis canadensis | 5.00 |
| Calystegia sepium | 2.00 |
| Carex comosa | 4.50 |
| Carex lacustris | 6.50 |
| Carex stricta | 3.00 |
| Cephalanthus occidentalis | 6.50 |
| Ceratophyllum demersum | 2.50 |
| Chamerion angustifolium | 3.00 |
| Cicuta bulbifera | 5.00 |
| Cirsium arvense | **0.00** |
| Comarum palustre | 6.50 |
| Cuscuta spp. | 4.00 |
| Cyperus esculentus | 1.00 |
| Cyperus fuscus | **0.00** |
| Cyperus odoratus | 7.00 |
| Decodon verticillatus | 7.50 |
| Dichanthelium clandestinum | 3.00 |
| Eleocharis obtusa | 3.50 |
| Elodea canadensis | 3.00 |
| Elymus virginicus | 6.70 |
| Eupatorium spp. | - |
| Galium trifidum | 5.00 |
| Gallium trifidum | 5.00 |
| Hibiscus moscheutos | 7.00 |
| Hydrocharis morsus-ranae | **0.00** |
| Impatiens capensis | 2.00 |
| Iris spp. | 5.00 |
| Juncus canadensis | 5.50 |
| Juncus effusus | 2.00 |
| Lathyrus palustris | 6.00 |
| Lemna minor | 2.00 |
| Lemna trisulca | 5.00 |
| Lycopus americanus | 3.00 |
| Lycopus virginicus | 4.50 |
| Lythrum salicaria | **0.00** |
| Mentha arvensis | 3.50 |
| Myosotis scorpiodes | **0.00** |
| Myriophyllum spicatum | **0.00** |
| Najas flexilis | 4.00 |
| Najas minor | **0.00** |
| Nymphaea odorata | 4.50 |
| Oxybasis glauca | 3.00 |
| Persicaria amphibia | 6.00 |
| Persicaria hydropiper | 1.00 |
| Persicaria hydropiperoides | 4.00 |
| Persicaria lapathifolia | **0.00** |
| Persicaria maculosa | 6.00 |
| Persicaria sagittata | 4.00 |
| Pontederia cordata | 5.50 |
| Potamogeton crispus | **0.00** |
| Potamogeton foliosus | 4.00 |
| Ranunculus aquatilis | 5.00 |
| Rhus typhina | 2.00 |
| Rorippa palustris | 4.00 |
| Rumex orbiculatus | 4.50 |
| Sagittaria latifolia | 4.00 |
| Schoenoplectus tabernaemontani | 5.00 |
| Scirpus fluviatilis | 6.00 |
| Scutellaria galericulata | 5.00 |
| Solanum dulcamara | 2.00 |
| Sparganium spp. | 5.00 |
| Stuckenia pectinata | 5.50 |
| Thelyptris palustris | 6.00 |
| Typha x glauca | **0.00** |
| Utricularia vulgaris | 6.00 |
| Verbena hastata | 4.00 |
| Vitis spp. | 2.50 |
| Total Richness | 74 |
| Native Richness | 63 |
| Average C | 3.62 |
| FQI | 31.12 |
| % natives | 85% |

2017 Vegetation Survey Data: Control and Restored(Channel and Pothole) Areas

| Control Quadrats 2017 Survey n=20 | COC | |
|---|---|---|
| Bidens frondosa | 2.00 | |
| Boehmeria cylindrica | 4.00 | |
| Bolboschoenus fluviatilis | 6.00 | |
| Calystegia sepium | 2.00 | |
| Cicuta bulbifera | 5.00 | |
| Decodon verticillatus | 7.50 | |
| Gallium trifidum | 5.00 | |
| Hibiscus moscheutos | 7.00 | |
| Hydrocharis morsus-ranae | **0.00** | |
| Impatiens capensis | 2.00 | |
| Lemna minor | 2.00 | |
| Lemna trisulca | 5.00 | |
| Lythrum salicaria | **0.00** | |
| Nymphaceae spp. | 4.50 | |
| Onoclea sensibilis | 2.00 | |
| Pontedaria cordata | 5.50 | |
| Scutellaria galericulata | 5.00 | |
| Solanum dulcamara | 2.00 | |
| Spirodela polyrrhiza | 3.00 | |
| Thelyptris palustris | 6.00 | |
| Triadenum fraseri | 6.00 | |
| Typha x glauca | **0.00** | |
| Vitis riparia | 2.50 | |
| | | |
| | | |
| | | |
| | | |
| Total Richness | 23 | |
| Native Richness | 20 | |
| Average C | 3.65 | |
| FQI | 17.52 | |
| % natives | 87% | |
| Sedge Grass Meadow Species Removed, only species of restored area kept | | |
| Unknowns removed | | |
| Plants identified to genus, removed if another of same species was present, other wise kept and assigned COC based on likely occurrence | | |
| | | |
| FQI calculated based on Wilhelm and Swink (1997) using all species (Native and nonnative). : FQI=AvgC * SQRT(Species richness) | | |

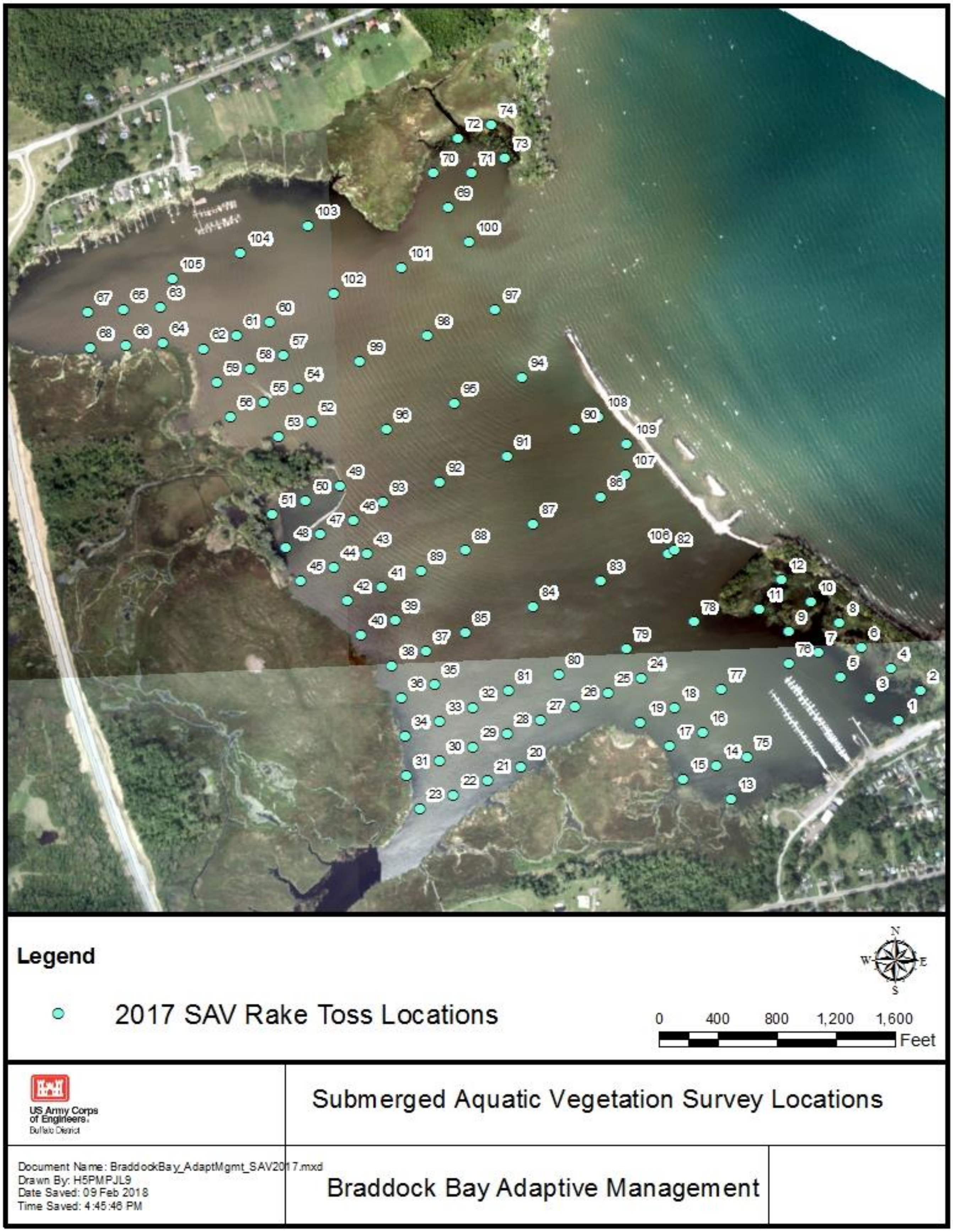
| Restored Areas Quadrats 2017 Survey n=303 | COC |
|---|---|
| Acer spp. | 3.50 |
| Agrostis stolonifera | 0.00 |
| Asclepias incarnata | 4.00 |
| Azolla caroliniana | 3.00 |
| Bidens cernua | 4.00 |
| Bidens frondosa | 2.00 |
| Boehmeria cylindrica | 4.00 |
| Bolboschoenus fluviatilis | 6.00 |
| Butomus umbellatus | 0.00 |
| Calamagrostis canadensis | 5.00 |
| Calystegia sepium | 2.00 |
| Carex hystericina | 5.00 |
| Carex lacustris | 6.50 |
| Carex spp. | - |
| Cephalanthus occidentalis | 6.50 |
| Ceratophyllum demersum | 2.50 |
| Chara spp. | - |
| Chenopodium glauca | 3.00 |
| Cicuta bulbifera | 5.00 |
| Cirsium arvense | 0.00 |
| Cornus sericea | 4.00 |
| Cuscuta spp. | 4.00 |
| Cyperus odoratus | 7.00 |
| Cyperus spp. | - |
| Decodon verticillatus | 7.50 |
| Dichanthelium clandestinum | 3.00 |
| Eleocharis obtusa | 3.50 |
| Elodea canadensis | 3.00 |
| Elymus virginicus | 6.70 |
| Erichtites hieracifolia | 2.00 |
| Fragaria spp. | - |
| Fraxinus pennyslvanica | 5.50 |
| Gallium trifidum | 5.00 |
| Hibiscus moscheutos | 7.00 |
| Hydrocharis morsus-ranae | 0.00 |
| Impatiens capensis | 2.00 |
| Iris spp. | 5.00 |
| Juncus effusus | 2.00 |
| Lathyrus palustris | 6.00 |
| Leersia oryzoides | 3.00 |
| Lemna minor | 2.00 |
| Lemna trisulca | 5.00 |
| Lycopus americanus | 3.00 |
| Lycopus spp. | - |
| Lythrum salicaria | 0.00 |
| Mentha arvense | 3.50 |
| Myosotis scorpiodes | 0.00 |
| Myriophyllum spicatum | 0.00 |
| Nymphaceae spp. | 4.50 |
| Nymphaea odorata | 4.50 |
| Onoclea sensibilis | 2.00 |
| Persicaria amphibia | 6.00 |
| Persicaria hydropiper | 1.00 |
| Persicaria hydropiperoides | 4.00 |
| Persicaria lapathifolium | 0.00 |
| Persicaria maculosa | 6.00 |
| Persicaria sagittata | 4.00 |
| Pontedaria cordata | 5.50 |
| Populus tremuloides | 2.50 |
| Potamogeton foliosus | 4.00 |
| Potentilla spp. | 2.00 |
| Rhus typhina | 2.00 |
| Ricciocarpus natans | 2.00 |
| Rorippa palustris | 4.00 |
| Rumex orbiculatus | 4.50 |
| Rumex spp. | 4.00 |
| Sagittaria latifolia | 4.00 |
| Schoenoplectus tabernaemontanii | 5.00 |
| Scutellaria galericulata | 5.00 |
| Sium suave | 4.00 |
| Solanum dulcamara | 2.00 |
| Sparganium eurycarpum | 5.00 |
| Sparganium spp. | 5.00 |
| Spirodela polyrrhiza | 3.00 |
| Stachys tenuifollium | 6.00 |
| Stuckenia filiformis | 8.00 |
| Stuckenia pectinatus | 5.50 |
| Taraxacum officinale | 0.00 |
| Thelyptris palustris | 6.00 |
| Triadenum fraseri | 6.00 |
| Typha x glauca | 0.00 |
| Utricularia vulgaris | 6.00 |
| Vallisneria americana | 4.50 |
| Verbena hastata | 4.00 |
| Vernonia noveboracensis | 4.00 |
| Vitis riparia | 2.50 |
| Total Richness | 81 |
| Native Richness | 71 |
| Average C | 3.70 |
| FQI | 33.30 |
| % natives | 88% |

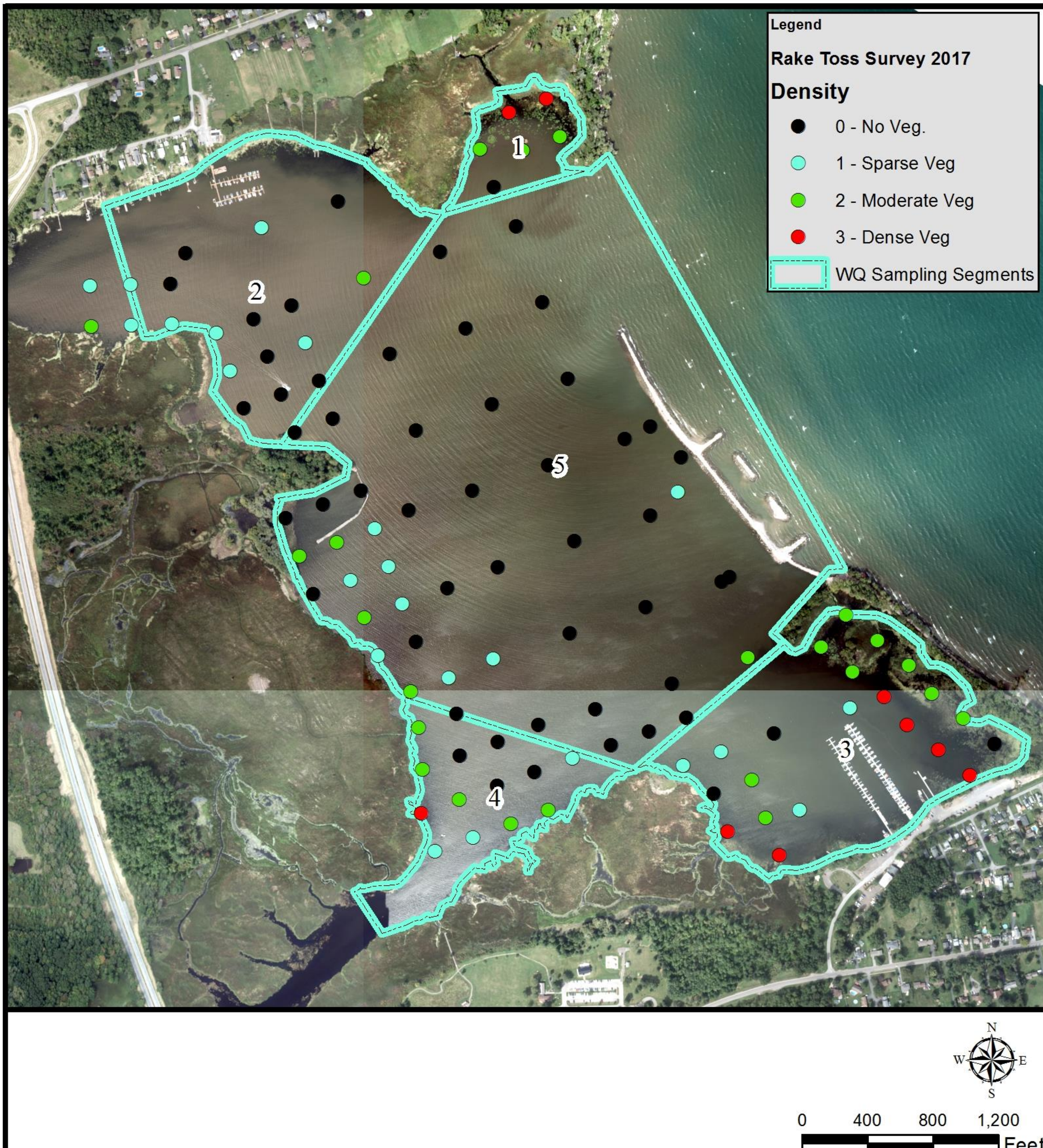
2016 and 2017 Sedge Grass Meadow Quadrats

| Sedge Grass Meadow Quadrats 2016 Survey n=30 | COC |
|---|---|
| Acer saccharinum | 3.50 |
| Apios americana | 3.50 |
| Bidens frondosa | 2.00 |
| Calamagrostis canadensis | 5.00 |
| Calystegia sepium | 2.00 |
| Carex lacustris | 6.50 |
| Cirsium arvense | **0.00** |
| Cornus spp. | 5.00 |
| Dichanthelium clandestinum | 3.00 |
| Elymus virginicus | 6.70 |
| Equisetum arvense | 2.00 |
| Fraxinus pennsylvanica | 5.50 |
| Galium trifidum | 5.00 |
| Impatiens capensis | 2.00 |
| Iris spp. | 5.00 |
| Juncus effusus | 2.00 |
| Lathyrus palustris | 6.00 |
| Lycopus americanus | 3.00 |
| Lycopus virginicus | 4.50 |
| Lythrum salicaria | **0.00** |
| Mentha arvensis | 3.50 |
| Onoclea sensibilis | 2.00 |
| Persicaria hydropiper | 1.00 |
| Persicaria hydropiperoides | 4.00 |
| Persicaria lapathifolia | **0.00** |
| Persicaria maculosa | 6.00 |
| Persicaria sagittata | 4.00 |
| Populus tremuloides | 2.50 |
| Ranunculus spp. | - |
| Salix fragilis | **0.00** |
| Scirpus fluviatilis | 6.00 |
| Scutellaria galericulata | 5.00 |
| Sparganium spp. | 5.00 |
| Spiraea latifolia | 4.00 |
| Thelyptris palustris | 6.00 |
| Typha x glauca | **0.00** |
| Verbena hastata | 4.00 |
| Vitis riparia | 2.50 |
| Total Richness | 37 |
| Native Richness | 32 |
| Average C | 3.45 |
| FQI | 20.99 |
| % natives | 86% |

| Sedge Grass Meadow Quadrats 2017 Survey n=30 | |
|---|---|
| Azolla caroliniana | 3.00 |
| Bidens frondosa | 2.00 |
| Calamagrostis canadensis | 5.00 |
| Carex hystericina | 5.00 |
| Carex lacustris | 6.50 |
| Ceratophyllum demersum | 2.50 |
| Cephalanthus occidentalis | 6.50 |
| Cicuta bulbifera | 5.00 |
| Cornus amomum | 4.50 |
| Cornus sericea | 4.00 |
| Fraxinus pennyslvanica | 5.50 |
| Hydrocharis morsus-ranae | **0.00** |
| Lemna trisulca | 5.00 |
| Lemna minor | 2.00 |
| Lycopus americanus | 3.00 |
| Lythrum salicaria | **0.00** |
| Onoclea sensibilis | 2.00 |
| Persicaria amphibia | 6.00 |
| Pontedaria cordata | 5.50 |
| Populus tremuloides | 2.50 |
| Ricciocarpus natans | 2.00 |
| Salix fragilis | **0.00** |
| Schoenoplectus tabernaemontanii | 5.00 |
| Sparganium eurycarpum | 5.00 |
| Spiraea alba var. latifolia | 5.00 |
| Spirodela polyrrhiza | 3.00 |
| Typha x glauca | **0.00** |
| Utricularia vulgaris | 6.00 |
| Vitis riparia | 2.50 |
| Total Richness | 29 |
| Native Richness | 25 |
| Average C | 3.59 |
| FQI | 19.31 |
| % natives | 86% |

## Appendix C-2: 2016 and 2017 Aquatic Vegetation Survey Data






US Army Corps of Engineers
Buffalo District

2017 Aquatic Vegetation Survey - Sample Locations

Document Name: BiovolumeSurvey_2017.mxd
Drawn By: H5PMPJL9
Date Saved: 23 Feb 2018
Time Saved: 10:56:23 AM

Braddock Bay Adaptive Management

| 2017 Species Observed | # of times observed | % of all sample points | % of vegetated sample points | Dominant species sample points |
|---|---|---|---|---|
| Vallisneria americana | 39 | 37% | 76% | 23% |
| Ceratophyllum demersum | 35 | 33% | 69% | 27% |
| Elodea canadensis | 15 | 14% | 29% | 3% |
| Myriophyllum spicatum* | 15 | 14% | 29% | 8% |
| Heteranthera dubia (Zosteralla) | 9 | 8% | 18% | 4% |
| Najas minor* | 8 | 8% | 16% | 2% |
| Stuckenia pectinata | 6 | 6% | 12% | 2% |
| Nitella obtusa* | 4 | 4% | 8% | 1% |
| Nymphea odorata | 3 | 3% | 6% | - |
| Myriophyllum simbricum | 3 | 3% | 6% | - |
| Unk. Potamogeton | 3 | 3% | 6% | - |
| Chara sp. | 2 | 2% | 4% | - |
| Najas flexilis | 3 | 3% | 6% | - |
| Lemna truscala | 2 | 2% | 4% | - |
| Trapa natans* | 2 | 2% | 4% | - |
| Utricularia vulgaris | 1 | 1% | 2% | - |
| **Species richness (vascular only)** | 14 | | | |
| **Total Sample Points** | 106 | | | |
| **Sample points with no veg** | 51 | 49% | | |
| **Points with nutrient enrichment tolerant species** | 40 | 38% | | |
| | | | | |
| *** non-native species** | **Nutrient Enrichment Tolerant Species** | | | |

| **Entire Bay** | 2016 | | 2017 | |
|---|---|---|---|---|
| **Native Species richness (vascular only)** | 12 | | 11 | |
| **Total Sample Points** | 104 | | 106 | |
| **Sample points with no veg** | 18 | 17% | 51 | 48% |
| **Points with NET species** | 48 | 46% | 40 | 38% |
| **Nutrient Enrichment Tolerant Species Analysis Segments 3,4,5 only** | 2016 | | 2017 | |
| **Total Sample Points** | 84 | | 84 | |
| **Points with NET species** | 31 | 37% | 31 | 37% |
| **Points with NET species as dominants** | 21 | 25% | 29 | 35% |

*NET - Nutrient Enrichment Tolerant

| 2017 All Vascular Species Observed all segments | C Score |
|---|---|
| Ceratophyllum demersum | 2.5 |
| Elodea canadensis | 3 |
| Heteranthera dubia | 5.5 |
| Lemna truscala | 5 |
| Myriophyllum simbricum | 4.5 |
| Myriophyllum spicatum* | 0 |
| Najas flexilis | 4 |
| Najas minor* | 0 |
| Nymphea odorata | 4.5 |
| Potamogeton spp. | 4.5 |
| Stuckenia pectinata | 5.5 |
| Trapa natans* | 0 |
| Utricularia vulgaris | 6 |
| Vallisneria americana | 4.5 |
| **Total Richness** | 14 |
| **Native Richness** | 11 |
| **Average C-Score** | 3.54 |
| **FQAI** | 13.23 |

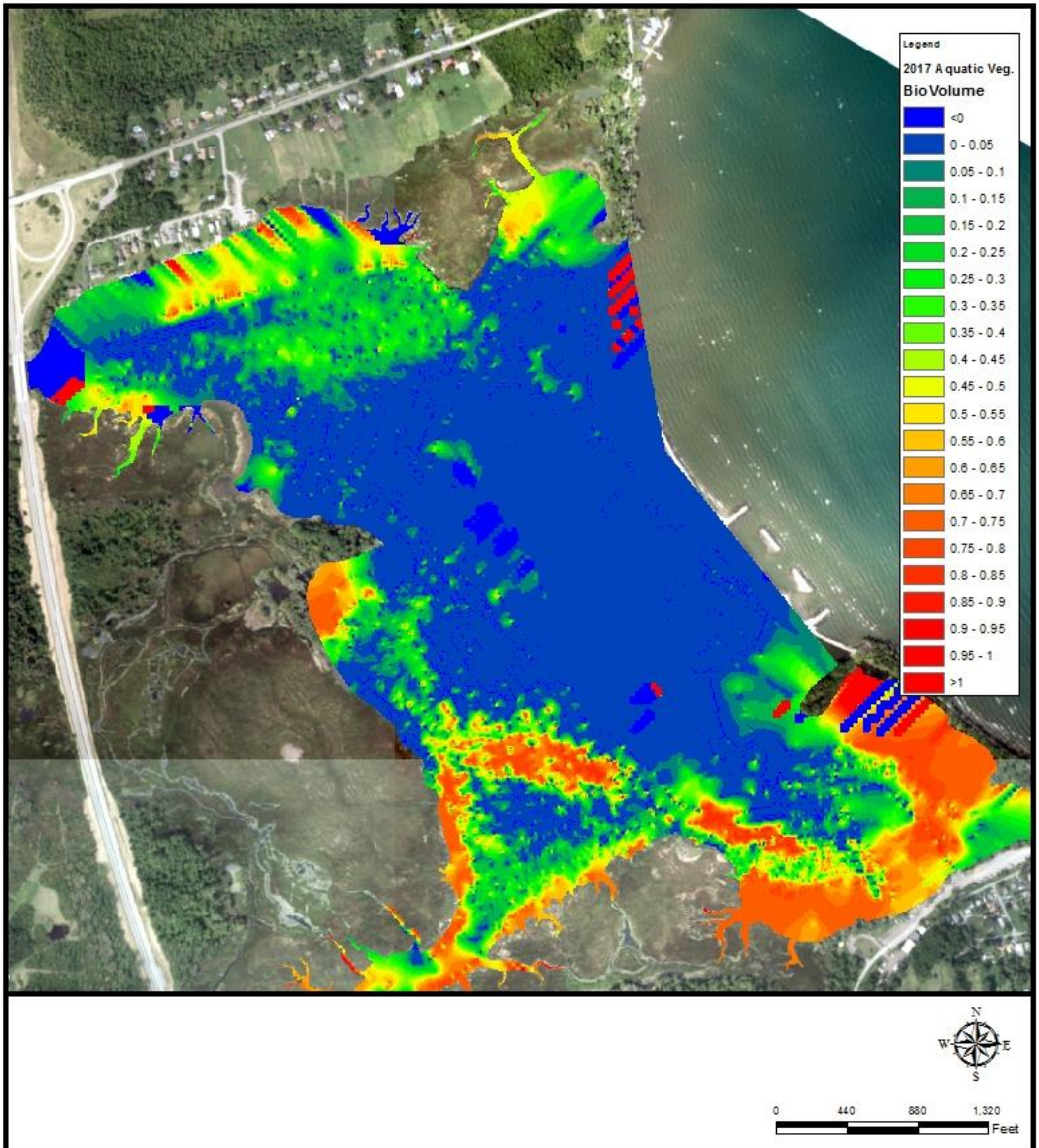
*** non-native species**

| 2016 All Species Observed segments 4 and 5 | C Score |
|---|---|
| Ceratophyllum demersum | 2.5 |
| Elodea canadensis | 3 |
| Heteranthera dubia | 5.5 |
| Lemna truscala | 5 |
| Myriophyllum spicatum* | 0 |
| Myriophyllum verticillatum | 4.5 |
| Najas flexilis | 4 |
| Najas minor* | 0 |
| Nymphea odorata | 4.5 |
| Potamogeton pusillus | 4 |
| Potamogeton richardsonii | 4.5 |
| Potamogeton robinnsii | 4.5 |
| Stuckenia pectinata | 5.5 |
| Vallisneria americana | 4.5 |
| **Total Richness** | 14 |
| **Native Richness** | 12 |
| **Average C-Score** | 3.71 |
| **FQAI** | 13.90 |

*** non-native species**

| 2017 All Vascular Species Observed (segments 4 and 5 Only) | C Score |
|---|---|
| Ceratophyllum demersum | 2.5 |
| Elodea canadensis | 3 |
| Stuckenia pectinata | 5.5 |
| Myriophyllum spicatum* | 0 |
| Najas minor | 0 |
| Vallisneria americana | 4.5 |
| Heteranthera dubia (Zosteralla) | 5.5 |
| Najas flexilis | 4 |
| Unk. Potamogeton | 4.5 |
| **Total Richness** | 9 |
| **Native Richness** | 8 |
| **Average C-Score** | 3.28 |
| **FQAI** | 9.83 |

*** non-native species**

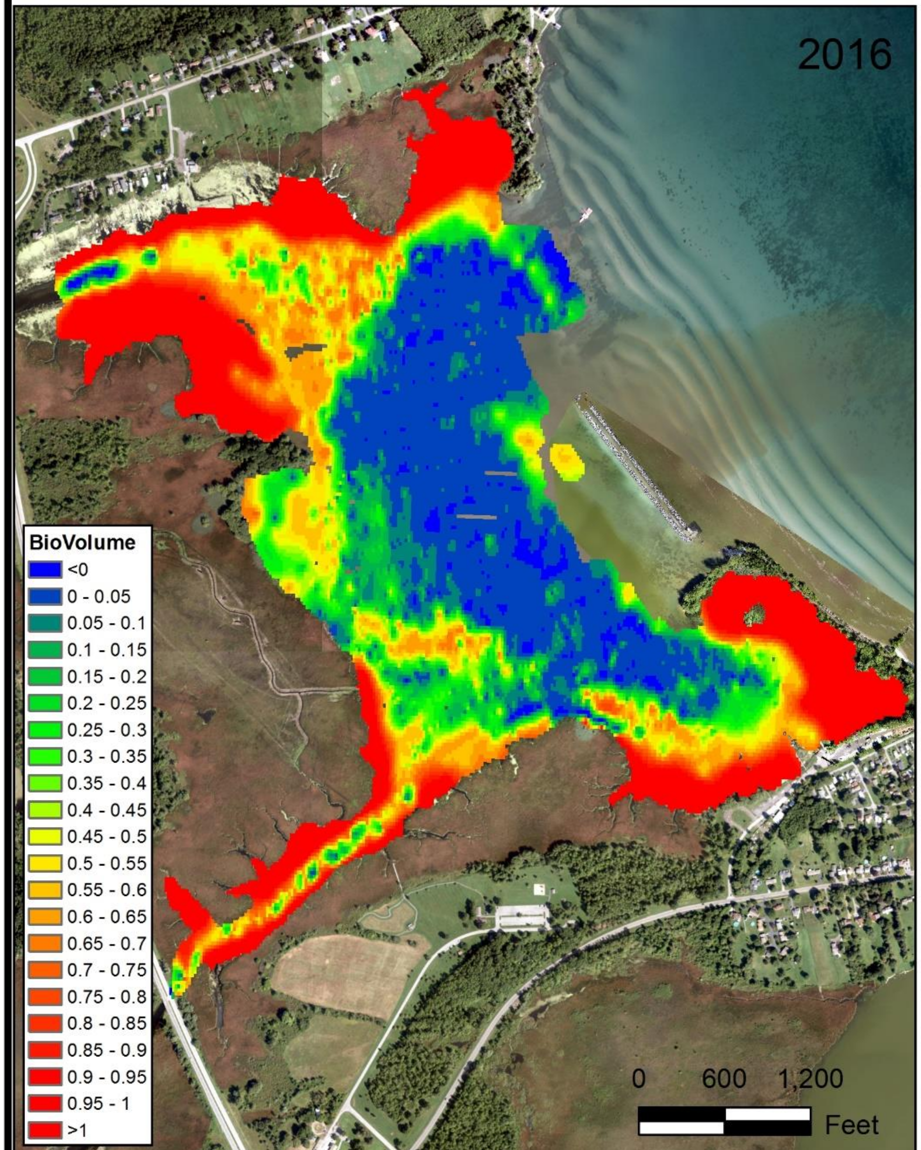


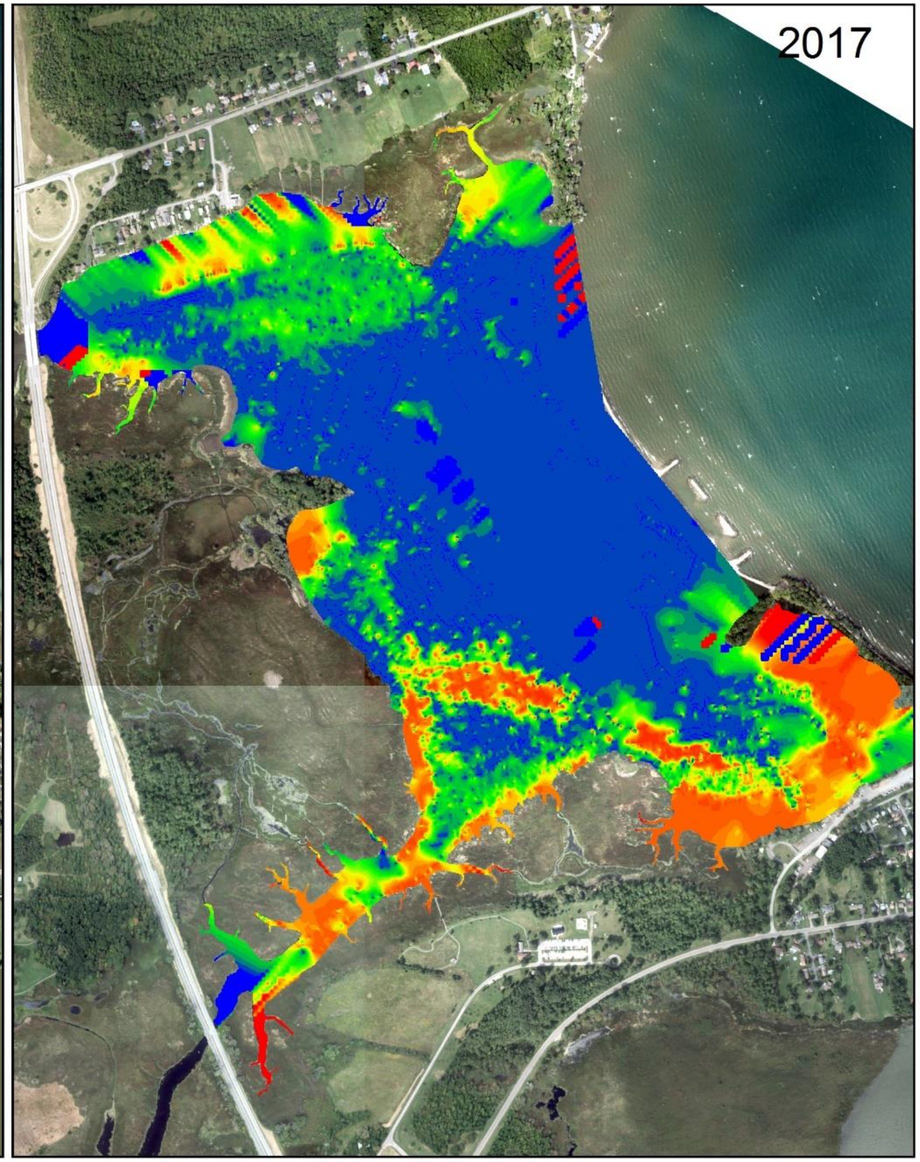

US Army Corps of Engineers
Buffalo District

# 2017 Submerged Aquatic Vegetation Survey

Document Name: BraddockBay_AdaptMgmt_SAV2017.mxd
Drawn By: H5PMPJL9
Date Saved: 09 Feb 2018
Time Saved: 5:07:36 PM

## Braddock Bay Adaptive Managment




N W E S

US Army Corps of Engineers®
Buffalo District

Drawn By: H5PMPJL9
Date Saved: 26 Mar 2018
Time Saved: 3:59:35 PM

Aquatic Vegetation Biovolume Survey 2016 vs. 2017

Braddock Bay Adaptive Managment

Document Path: Z:\LRB_Projects\BraddockBay_395893\MXD\Adaptive Management\SAV\BiovolumeSurvey_2016v2017.mxd

# Appendix C-3:  Northern Pike Surveys

| | Date Set | Time Set | Date Retrieved | Water Depth Ft | DO mg/L | DO % | Temp | YOY Pike | mud minnow | Marginal mad tom | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Net | | | | | | | | | | | |
| 1 | 2-Aug | 1005 | 3-Aug | 6.00 | - | - | - | 0 | 0 | 0 | |
| 2 | 2-Aug | 1036 | 3-Aug | 6.00 | - | - | - | 0 | 0 | 0 | |
| 3 | 2-Aug | 1105 | 3-Aug | 3.50 | 6.40 | 79% | 79.30 | 1 | 1 | 0 | |
| 4 | 2-Aug | 1225 | 3-Aug | 5.00 | 4.12 | 51% | 77.20 | 0 | 0 | 0 | |
| 5 | 2-Aug | 1147 | 3-Aug | 4.50 | 4.09 | 51% | 78.90 | 0 | 0 | 0 | |
| 6 | 2-Aug | 1300 | 3-Aug | 5.00 | 4.71 | 60% | 79.00 | 0 | 0 | 0 | |
| 1 | 15-Aug | - | 16-Aug | 5.00 | 6.35 | - | 73.90 | 0 | 0 | 2 | Minnow nets set at bottom of channel |
| 2 | 15-Aug | - | 16-Aug | 5.00 | 7.67 | 90% | 73.40 | 0 | 0 | 0 | Minnow nets set at bottom of channel |
| 3 | 15-Aug | - | 16-Aug | 3.50 | 9.38 | 108% | 73.10 | 0 | 1 | 0 | Minnow nets set at bottom of channel. Banded Killifish observed nearby |
| 4 | 15-Aug | - | 16-Aug | 5.50 | 7.49 | 89% | 72.40 | 0 | 0 | 0 | Minnow nets set at bottom of channel |
| 5 | 15-Aug | - | 16-Aug | 5.50 | 6.19 | 72% | 73.60 | 0 | 0 | 0 | Minnow nets set at bottom of channel |
| 6 | 15-Aug | - | 16-Aug | 5.50 | 11.68 | 141% | 74.20 | 0 | 0 | 0 | Minnow nets set at bottom of channel |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

* Sampling was conducted using Fyke Nets. Fyke nets consisted of 4 - 2Ft diameter hoops with 1 inch throat and 10 foot mesh wings made of 1/16" mesh.


**Legend**

2017 N.Pike YOY

N
W
E
S

0 220 440 660 Feet

US Army Corps of Engineers. Buffalo District

2017 N. Pike Young of the Year Sampling Locations

Document Name: BraddockBay_AdaptMgmt_2017NortherPike.mxd
Drawn By: H5PMPJL9
Date Saved: 01 Feb 2018
Time Saved: 4:29:50 PM

Braddock Bay Adaptive Management

# APPENDIX D: COASTAL ASSESSMENT

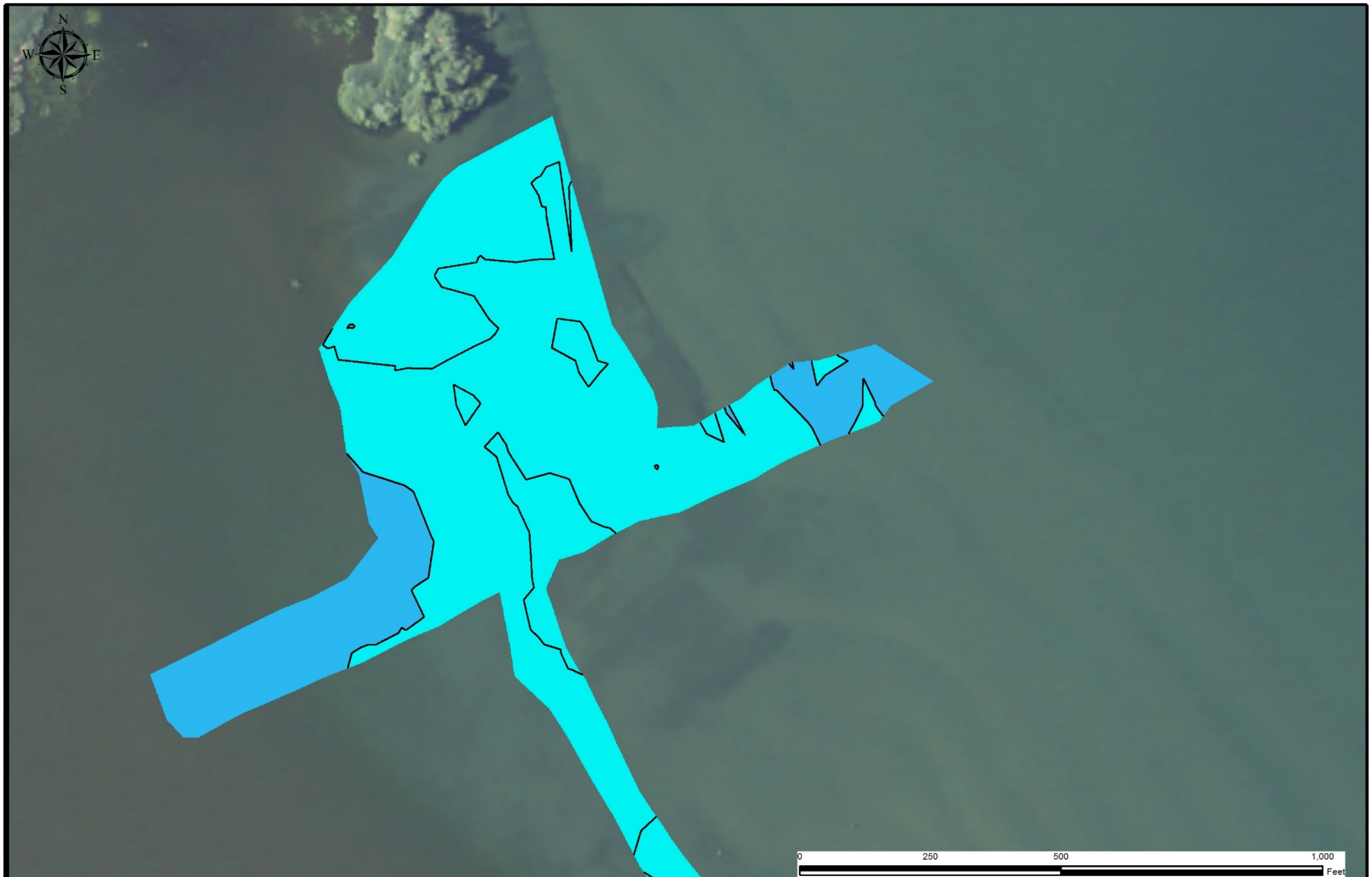
US Army Corps of Engineers®
Buffalo District


**Illustration 1. Oblique Photo of the Spine Breakwater at Braddock Bay looking west, 17 November 2016**

Construction of the Spine and Headland Breakwaters at Braddock Bay commenced in August, 2016. The construction was largely complete by the time a high water event occurred on Lake Ontario, with only a couple of access sections to complete. Because of technical problems and complications created by the high water, placement of the prefill sand and complete dredging of the navigation channel and borrow area were unable to be completed. These areas are scheduled for completion in 2018. As an interim assessment of the impacts to the littoral system, a data analysis was completed using available survey data and aerial imagery covering the period of construction.

The contractor performed surveys of the work locations before beginning construction on 9 August 2016, followed up by surveys on 13 April 2017 and 4 August 2017 after completing some of the dredging. Digital Elevation Models (DEMs) generated from these data collections are presented in Figures 1-3. Determination of the volumetric change between subsequent surveys is inconclusive as to patterns of deposition in the dredge area due to incomplete dredging, and no conclusions as to littoral patterns around the breakwaters can be drawn as post construction surveys are not available at this time. The elevation change from pre-construction to August of 2017 is shown in Figure 4. The areas of heavier erosion and accretion at the southern corner of the borrow area are attributable to the sidecasting of the dredge material.

Some evidence of trends in littoral patters can be determined from observation of aerial imagery for the site. DigitalGlobe has imagery available covering Braddock Bay on 4 August 2016 (pre-construction, Figure 5), 3 September 2016 (beginning of construction, Figure 6) 12 October (Breakwater construction nearly complete, Figure 7), 3 June 2017 (during high water, Figure 8), and 17 September 2017 (returning to normal water levels, Figure 9). Figure 9 shows that the shore parallel bar system fronting the mouth of Braddock Bay has remained strong with the completion of the project, indicating that the breakwaters have not had a negative impact to the littoral system. Additional observation and data collection to include high resolution survey data both within the footprint of the project and immediately updrift and downdrift will be required once the project is completed to fully qualify and quantify the impacts of the project.




Elevation

| | |
|---|---|
| > 8 (FEET) | -4 - -2 |
| 4 - 8 | -8 - -4 |
| 2- -4 | -16 - -8 |
| 0 - 2 | < -16 |
| -2 - 0 | |


US Army Corps of Engineers
Buffalo District

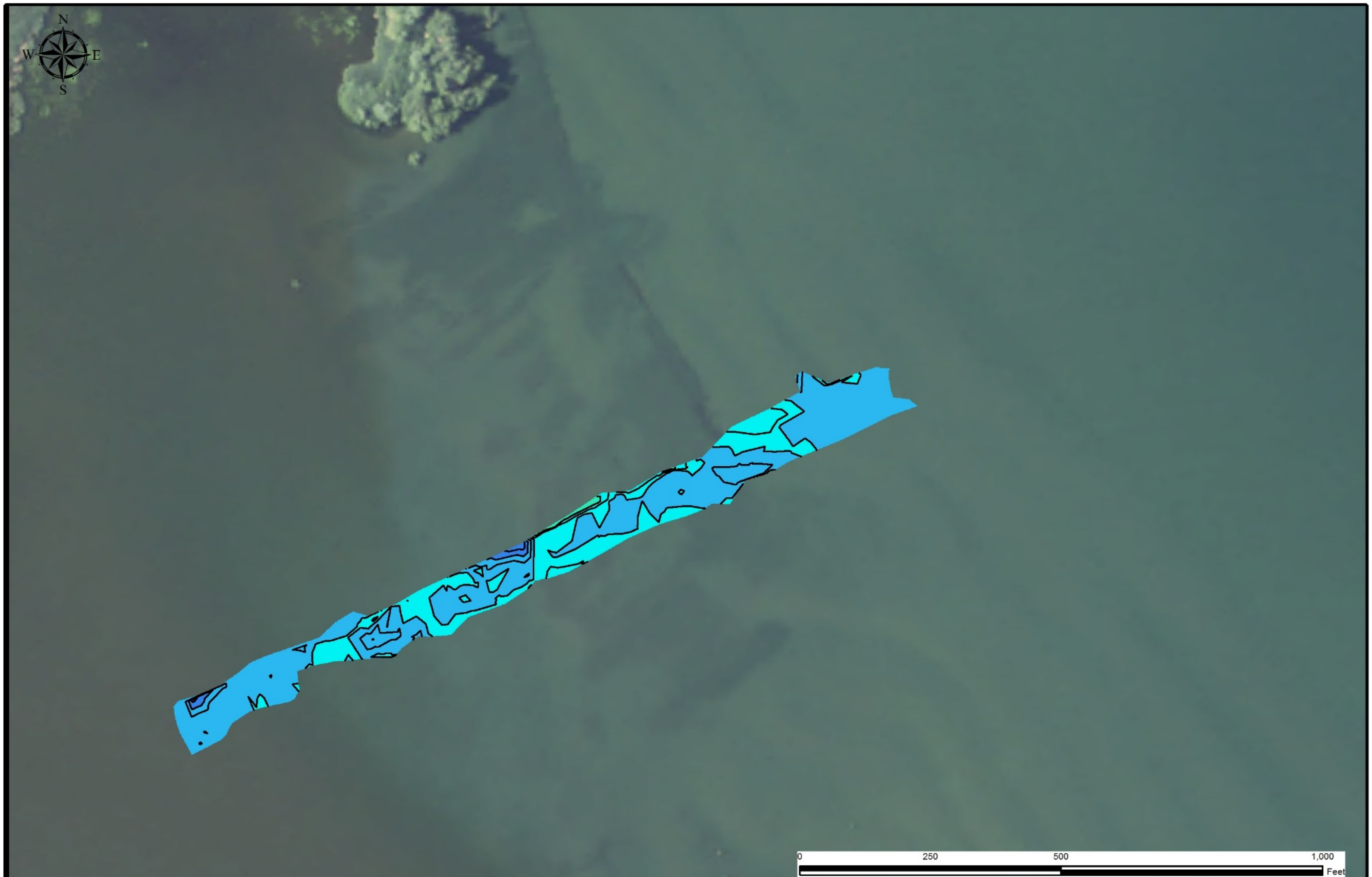
Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 8:07:31 AM

Braddock Bay DEM 9 August 2016

Braddock Bay Ecological Restoration

FIGURE 1

G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd




Elevation

| | | | |
|---|---|---|---|
| | > 8 (FEET) | | -4 - -2 |
| | 4 - 8 | | -8 - -4 |
| | 2- -4 | | -16 - -8 |
| | 0 - 2 | | < -16 |
| | -2 - 0 | | |


US Army Corps of Engineers
Buffalo District

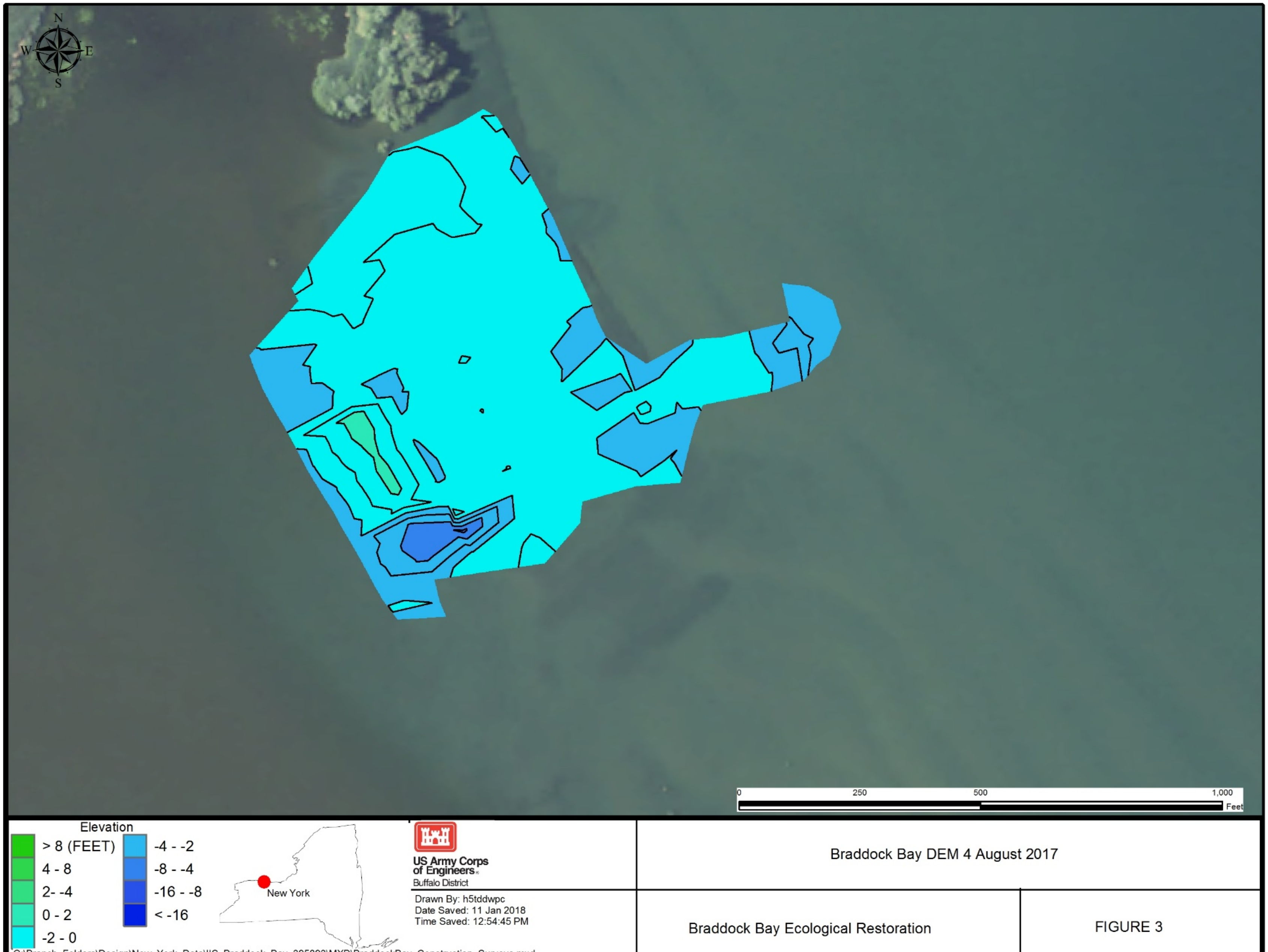
Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 8:07:31 AM

Braddock Bay DEM 13 April 2017

Braddock Bay Ecological Restoration

FIGURE 2

G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd




US Army Corps of Engineers
Buffalo District

Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay DEM 4 August 2017

Braddock Bay Ecological Restoration

FIGURE 3

G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd


US Army Corps of Engineers
Buffalo District

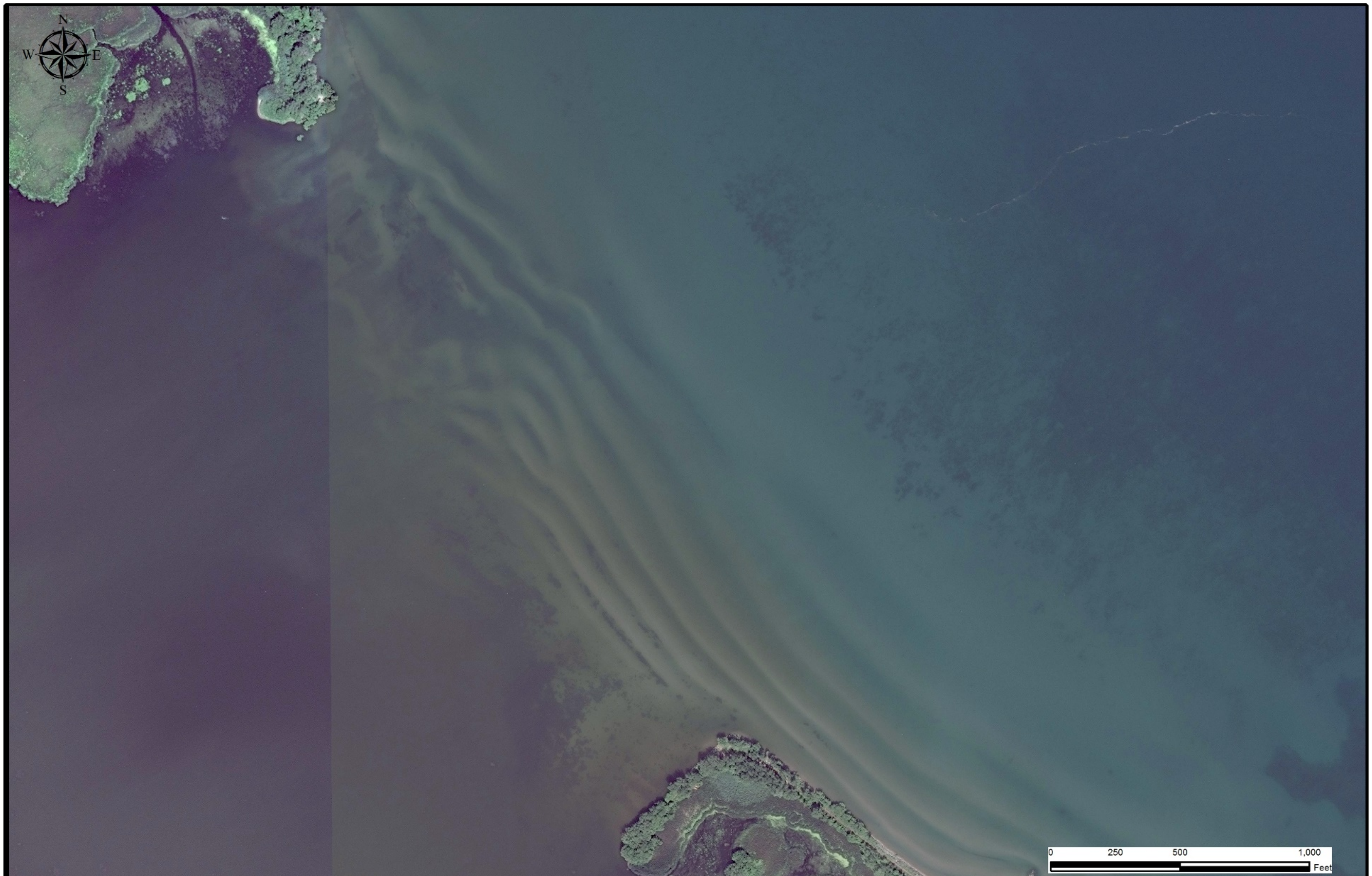
Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd

Braddock Bay Elevation Change - August 2016 to August 2017

Braddock Bay Ecological Restoration

FIGURE 4





US Army Corps of Engineers
Buffalo District

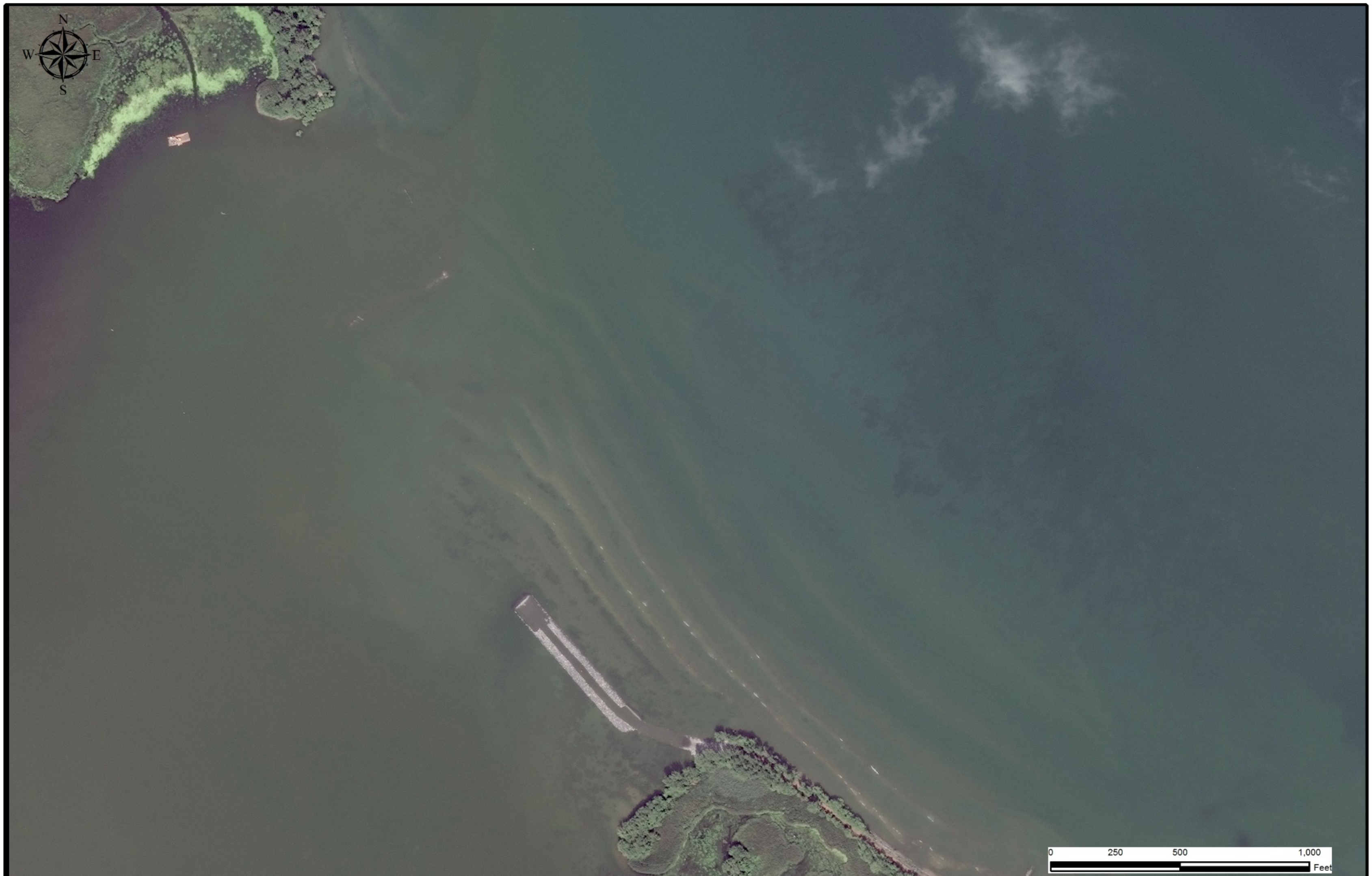
Braddock Bay 4 August 2016

Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay Ecological Restoration

FIGURE 5

Elevation Change
G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd





US Army Corps of Engineers
Buffalo District

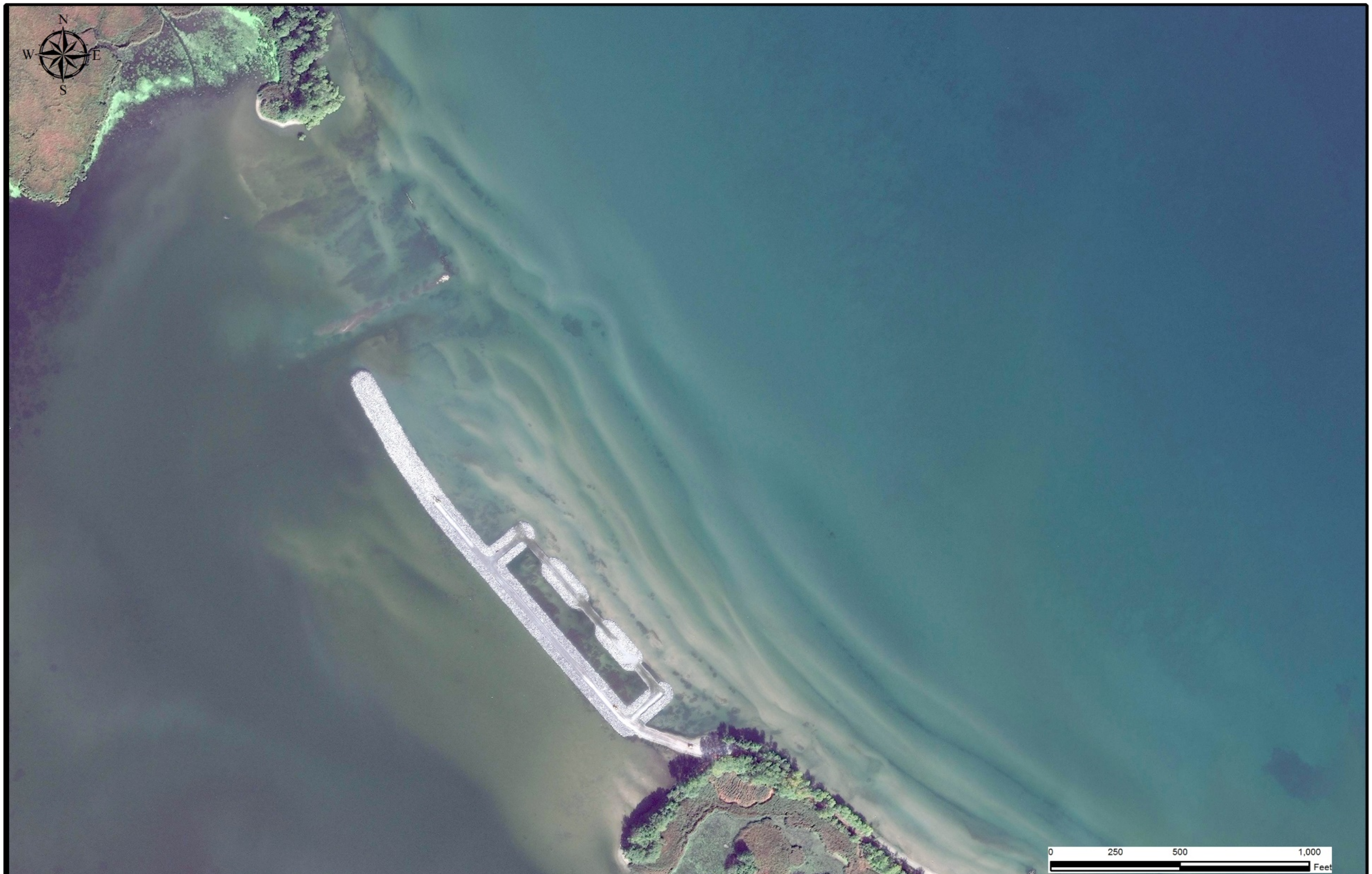
Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay 3 September 2016

Braddock Bay Ecological Restoration

FIGURE 6

Elevation Change
G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd





US Army Corps of Engineers
Buffalo District

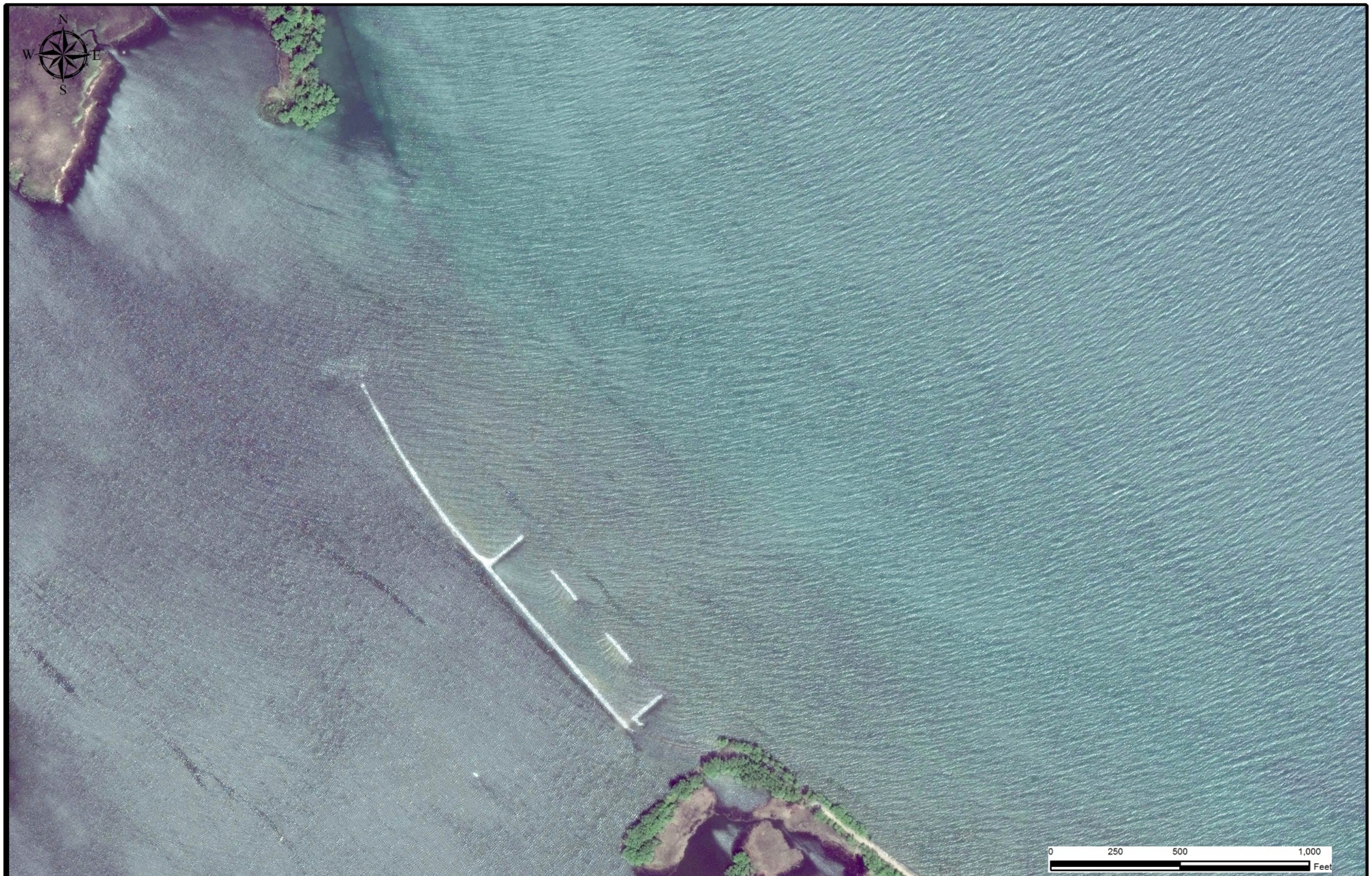
Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay 12 October 2016

Braddock Bay Ecological Restoration

FIGURE 7

Elevation Change
G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd





US Army Corps of Engineers
Buffalo District

Braddock Bay 3 June 2017

Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay Ecological Restoration

FIGURE 8

Elevation Change
G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd



US Army Corps of Engineers
Buffalo District

Braddock Bay 17 September 2017

Drawn By: h5tddwpc
Date Saved: 11 Jan 2018
Time Saved: 12:54:45 PM

Braddock Bay Ecological Restoration

FIGURE 9

Elevation Change
G:\Branch_Folders\Design\New_York_Data\IIS_Braddock_Bay_395893\MXD\BraddockBay_Construction_Surveys.mxd

# APPENDIX E: 2017 PHOTO LOG

# Appendix E: Braddock Bay Restoration 2017 Photo Log

11 November 2016 – Construction of the barrier beach and headland breakwaters

1 January 2017 – Barrier beach spine looking northwest

1 January 2017 – Placed sand fill behind headland breakwaters.

24 April 2017 –Barrier beach sand during start of high water event of 2017.

6 June 2017 –Vegetation establishing on habitat mounds during 2017 high water event.

6 June 2017 –Muskrat hut adjacent to restored areas within Braddock Bay wetland

2 August 2017 –Barrier Beach sand along spine.

2 August 2017 –Arrow head (*Sagittaria latifolia*) establishing along restored channels.

1 September 2017 –Bullrush and other emergent vegetation establishing along edges of restored potholes.

1 September 2017 –Restored pothole.