



Royal  
Botanical  
Gardens

# Wetlands Conservation Plan 2022-2026

*Includes RBG contribution to the HHRAP as it pertains to the restoration of the wetlands*



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**Document Description:**

This document summarizes operating strategies, projects, and needed resources for RBG marsh restoration and management between 2022 and 2026. Recommendations and an action plan are included, which will be pursued by RBG pending relevant approvals, compatibility with broader RBG strategies, funding, and support from outside organizations and the public.

## Executive Summary

**Wetland Restoration Goal:** While maintaining system connectivity restore the underlying conditions for biodiversity recovery and sustainability, quantified as a mesoeutrophic environment in the deltas and mesotrophic environments in the sheltered bays.

The 2016-2021 Wetland Restoration plan activities advanced the recovery of Cootes Paradise and Grindstone Marsh. However extreme circumstances and sewage spills significantly set back the restoration process and water clarity was generally much poorer during the entire period. Multiple and increasing frequency of spills occurred at Cootes Paradise with the 2018 Chedoke spill eliminating most aquatic life in the main area of the marsh, and the 2020 unresolved West Pond to Spencer Delta spill eliminating most aquatic life that had regenerated in the northwest region. As of the end of 2021 about 140 hectares of marsh vegetation is missing. A partnership with DFO Science helped confirm the highly impaired dissolved oxygen levels in the water as a result of the eutrophication. The Fishway catch fell to its lowest fish totals since it was first installed. However, the sheltered interior pond called Presidents Pond was transformed from a longstanding carp impacted plantless pond surrounded by invasive grass, to a diverse clear water pond and healthy environment including wild rice. The surrounding meadow marsh of this region and other areas also began transformation with a large-scale effort to eliminate the dominating European Manna Grass underway. In support of this a broader selection of wetland plants were created in the propagation system. All known locations of Phragmites were treated (~150 sites) with most sites eliminated. New locations continuing to establish because of watershed sources.

In 2021 forward movement with aquatic restoration occurred with the aid of the lowest summer water levels in 60 years. This facilitated both the removal of accumulated carp from the record flood years of 2017 and 2019 and substantially regenerated all damaged and lost emergent marsh during the extreme circumstances flood and spill conditions of previous years. The result is a net increase in 6 hectares of reeds over the 5 years. Eroding shorelines were further impacted by the poor-quality water during the record high water years of 2017 & 2019 with several sections of old oak forest falling into the water. However, several locations of shoreline were remediated, highlighted by the rebuild by a 300m section of shore in outer Grindstone Marsh in partnership with CN Rail. The record high water years also lead to the rebuild and upgrade of a number of the carp barriers and exclusion berms of Grindstone Marsh as all were overtopped during the record high water levels with carp damaging the associated regenerating habitat. The carp have since been extracted with habitat recovery occurring in 2021 except at outer Grindstone Marsh where no carp exclusion occurs.

This restoration plan summarizes items including the role of RBG in the HHRAP, the strategy looking forward independent of the HHRAP, resources required, partnerships, research opportunities, specific projects and locations. The plan is in parallel with the completion of the Hamilton Harbour Remedial Action Plan (HHRAP – completion date unknown), bringing the wetlands to a more sustainable state by 2026. An important role for RBG in this process is providing water quality-based communications on the environmental condition of the wetlands, the most important factor for wetland sustainability to support partner initiatives to improve inflowing waters.

### *Wetland Restoration Themes 2022-2026*

1. Exclusion and removal of Common Carp from the marsh areas to facilitate aquatic plant growth.
2. Emergent marsh planting to ameliorate Lake Ontario water level regulation limiting recovery.
3. Repair of historically damage eroding shorelines in Cootes Paradise Marsh, focusing on Hickory Island, Kingfisher Pt, Princess Pt, Sassafra Pt and Bulls Pt through bioengineering
4. Meadow Marsh restoration through invasive plant management with potential alignment with pollinators regional strategies.
5. Communication and monitoring of environmental conditions in the marshes.
6. Review and future strategy for the ongoing management of Grindstone Marsh, particularly the outer marsh.

In summary, the current Wetland Restoration Plan continues to address large-scale degradation stressors, Species at Risk protection and recovery, and invasive species management. These themes align with provincial and federal biodiversity strategies. RBG's planned wetland management actions between 2022 and 2026 are threaded through 16 separate project initiatives; their associated summaries are found in the Project Descriptions section. In addition to these themes, specific partner projects in the western section of the Desjardins Canal upstream of West Pond (owned by the City of Hamilton), and the wastewater treatment at the head of the canal, and stormwater management driving escarpment creek erosion issues will be key steps on the road to achieving wetland sustainability.

Actions are subject to variable water leveling and fund support. To complete the plan, staff compliment is forecasted to be the same as current. However, to execute the Chedoke area recovery plan large scale work including Environmental Assessments will be required, with the City of Hamilton currently intending to assist with the cost and the process as part of spill compensation. The most significant expense after staffing will be plants for restoration work, estimated at \$500,000 total (150,000 plants). In support of this, innovation work with floating wetlands made with biodegradable support structures will be trialed. There is also potential for RBG volunteers to assist with the plan propagation. This volunteer contribution can be helpful in leveraging partner funding, with this already noted to both the volunteers and RBG propagation. Basic infrastructure of boats and vehicles has been renewed, with the boathouse to be renewed and further renovations to the carp barriers anticipated given their ages

Financial contributions to RBG between 2016 and 2021 to support HHRAP work within the marshes was provided by the lead agencies Environment and Climate Change Canada and Ministry of Environment Conservation Parks providing base support for advancing projects. RBG donors and members provided a similar contribution. Partnerships with both these agencies are expected to continue going forward to the completion of the HHRAP. Partnerships with the Ontario Ministry of Natural Resources and Forestry had once been expected to be expected to grow under the Species at Risk and invasive species management themes however this has not transpired with mandates now shifted. However significant support from the City of Hamilton will follow as remediation projects for the Chedoke Spill progress. RBGs Project Paradise Fund still holds \$200,000 but will be depleted within the next couple years. Notable RBG funding raising opportunities will occur in the coming years including, the Cootes Paradise Fishway 25<sup>th</sup> anniversary celebration (2021), and supporting the propagation of plants. Opportunities will also present themselves as restoration success with individual wetland species such as turtles, eagles and wild rice occurs.

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# RBG 2022-2026 Strategic Plan

## ACHIEVING EXCELLENCE IN:

1. PREPARING FOR THE FUTURE
2. LEADERSHIP IN BIODIVERSITY AND ECOLOGICAL STEWARDSHIP
3. EXCELLENCE IN EXPERIENCES AND VISITOR ENGAGEMENT
4. STRONG CULTURE STRONG TEAM
5. FINANCIAL RESILIENCE & GROWTH

In the natural areas, we will continue to align with the U.N. Biodiversity Strategy and Niagara Escarpment World Biosphere and will be looking to partner with the federal government as they undertake new actions goals to 2030. We will also undertake projects to inventory and protect endangered species, as well as continue to develop and implement plans to manage the many current Invasive Species. Our wetlands restoration initiatives will continue to be our flagship environmental management project, working with local and government partners to monitor and recover the health of two of the largest remaining Lake Ontario coastal wetlands, Cootes Paradise and Grindstone Marsh. These marshes represent a third of RBG natural areas. Complementing the environmental projects, trail system infrastructure renewal will continue, ensuring trails remain open, safe, inspiring, and facilitate environmental protection and educational programming but at the same time reducing their disruption of the environmentally area.

### United Nations Biodiversity Conservation Goals to 2050

- To halt the extinction and decline of biodiversity.
- To enhance and retain nature's services to humans by conserving.
- To ensure fair and equitable benefits to all from use of genetic resources.
- To close the gap between available financial and other means of implementation and those necessary to achieve the 2050 Vision.

Climate Change is a principal challenge and wetlands are carbon sinks. Wetlands such as the coastal marshes are estimated to sequester about 100grams/m<sup>2</sup>/year (Bernal and Mitch 2012). The sheer scale of the wetland vegetation currently missing provides the most significant opportunity within the RBG lands to increase carbon capture. Essentially 200 hectares of plants are currently missing. At the same time river mouth marsh at RBG face significant further ecological health risk from Climate Change as they are more likely to be damaged by extreme events, particularly accelerated landscape erosion given the upstream land uses.

### ***Natural Lands Biodiversity Goal***

To manage Royal Botanical Gardens' conservation lands as integrated sanctuaries in the context of their international and local significance, both ecologically and culturally by enhancing, restoring, and maintaining habitats and linkages in balance with the public's need for spiritual renewal and exploration.

### ***Wetland Restoration Goal***

While maintaining system connectivity, restore the underlying conditions for biodiversity recovery and sustainability, quantified as a meso-eutrophic environment in the deltas & mesotrophic in the sheltered bays.

### **Longer Term Objectives**

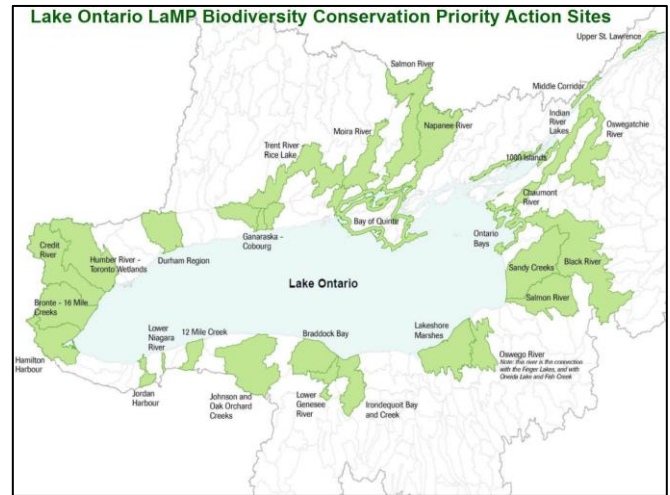
1. with partners, recover inflowing water quality to meet provincial/federal water quality objectives
2. restore natural water cycle patterns of Spencer Creek and Lake Ontario
3. remove non-native species dominating the system

### ***Key Partner Water Quality Related Plans***

- Great Lakes Water Quality Agreement
- Canada-Ontario Agreement for the Great Lakes
- Lake Ontario Nearshore Framework (in development)

- Lake Ontario Action and Management Plan
- City of Hamilton Wastewater Master Plan & Stormwater Master Plan
- City of Hamilton Chedoke Creek Water Quality Improvement Framework
- Cootes Paradise Chedoke Creek Spill Remediation Plan
- City of Hamilton Biodiversity Action Plan

As noted in the previous 2016-2021 wetland restoration plan, a significant driver of the success of the dominant harbour fish, Common Carp (*Cyprinus carpio*), and the overall unbalanced fish populations is the ability to survive anoxia in Hamilton Harbour. This anoxia is a direct result of the Woodward Ave. Wastewater Treatment Wastewater Plant, and so despite the fact its water does not flow directly into RBG wetlands, upgrade of this plant is critical for the long-term sustainability of the marshes.



### Looking Forward

During the period of this plan, a transition from RBG activities driven by the Great Lakes Recovery initiative (HHRAP) to the Great Lakes Biodiversity Strategy will occur as the HHRAP and the wetlands are to be delisted by 2021. At RBG, this transition began during the previous five years with initiatives specific to both Species at Risk and Invasive Species (other than carp) being undertaken. This was highlighted by the completion of an RBG Turtle Site Specific Plan and a *Phragmites* Management Plan. Given the biota of the wetlands, there are in excess of 20 partner level strategies RBG could align with (Appendix A). Moving forward, both Species at Risk and invasive species will become dominant drivers of future activities, with pollinators currently emerging as a potential new dimension. In addition, local cooperation will shift from the HHRAP to the Lake Ontario Management Plan, Cootes to Escarpment Ecopark System, and Niagara Escarpment World Biosphere Initiatives.

### Related Partner Plans

- Great Lakes Water Quality Agreement (State of the Lake Ecosystem Conference - SOLEC)
- Canada-Ontario Agreement on the Great Lakes
- Federal and Provincial Biodiversity Strategies with focus on Species at Risk, invasive species & pollinators
- Provincial Great Lakes Protection Act and Lake Ontario Action and Management Plan
- Federal North American Migratory Waterfowl & Shorebird Management Plans
- Great Lakes Wetlands Conservation Action Plan
- Nature Conservancy Great Lakes Conservation Blueprint
- Lake Ontario Water Level Regulation Plan 2017
- Ontario Invasive Species Strategy / Act

The International Joint Commission (IJC) recommends 16 ecosystem indicators composed of 41 measures as the best indicators in assessing progress under the GLWQA. The State of the Lakes Ecosystem Conference (SOLEC) also has a suite of indicators to measure the health of the Great Lakes. The SOLEC and IJC indicators are compared in chart form in Table 17 in Appendix A. From these, RBG will focus on improvements to the extent, composition, and quality of Coastal Wetlands. RBG on its own, or in partnership with appropriate agencies, will also continue to monitor various Great Lakes indicator species including the plant communities, migratory waterfowl, and fisheries, as well as support the Hamilton Harbour Remedial Action Plan (HHRAP) delisting criteria.

A currently unexplored dimension of the property management goals is with the North American Waterfowl and Shorebird Management Plans. Understanding these plans and determining what specific alignments can be

made will be part of planning. International interest in Great Lakes wetlands will continue to grow, and in the case of Lake Ontario, will be of particular interest as a new water level regulation plan has been implemented (Plan 2017). The International Lake Ontario-St. Lawrence River Study performed by the IJC provides a collection of Environmental Performance Indicators, shown in Table 18 in the Appendix A. Plan 2017 is expected to benefit key indicators of the Wetland Meadow Marsh Community (by 1.44 times over the current regulation plan) and the muskrat populations (by 2.59). These indicators line up with RBG's ongoing work to improve the quality of meadow marsh community in RBG wetlands and the quality of marsh habitat that will support native wildlife populations, including muskrats.

An extensive list of background reports has been generated over the years to inventory biota and explore the various issues affecting the marsh. This list of the most relevant reports is located in the reference reports section but is by no means an exhaustive list of reports pertaining to Cootes Paradise and Grindstone Marshes.

### ***The Primary Restoration Issue***

The primary issue to resolve is the historical loss of the entire wetland plant community and biota in areas flooded for periods longer than 1 month (Cootes Paradise Marsh = 208 ha). This is a result of extremely high Eurasian Common Carp (*Cyprinus carpio*) densities (800 kg/ha), these fish success largely a product of water pollution. The high density of carp caused a collapse of ecosystem function through destruction of the marsh channels, allowing formerly contained inflowing contaminants to disperse throughout the marsh. The feeding action of carp resulted in this fish being the primary source of suspended sediment and associated phosphorus in the water column. Through experience with carp exclusion, RBG finds measurable impacts occur at densities over 20 kg/ha. The success of the carp is a product of multiple factors noted under the section "Invasive Species" later in the document. These factors remain unresolved with an original HHRAP objective of 2015. Currently no date can be articulated to complete the needed water quality recovery projects while at the same time the carp population continues to damage parts of Grindstone Marsh and continues to result in the extirpation of native species. Due to these issues combined with higher lake levels resulting in further carp management challenges RBG staff support the original HHRAP intention to remove most the carp from the harbour system. Establishment of a single Carp barrier at Valley Inn bridge across Grindstone Marsh combined with a large-scale berm in outer Grindstone Marsh is an alternate solution.

### ***Secondary Issues***

Degraded inflowing water supplies, water level regulation, and system dominance by various non-native species comprise fundamental challenges for RBG coastal marshes. Inflowing water quality issues are highlighted by bacteria, phosphorus, sediment, nitrogen compounds, and potentially pesticides. This has resulted in 3 areas of sediment contamination including the interior of Westdale Inlet, the Desjardins Canal upstream of West Pond, and Chedoke Bay. Outer Grindstone Marsh shows metal contaminants impairment, but it is unknown if this is limiting biodiversity and needs further study. In 1994, non-native species represented >90% of the biological system with the chief invaders comprised of Common Carp, Eurasian Manna Grass (*Glyceria maxima*), Common Reed (*Phragmites australis*), and Mute Swan (*Cygnus olor*). In addition, water level regulation of Lake Ontario has maintained summer water levels high enough to prevent natural emergent marsh reestablishment from seedlings (nursery conditions) since the inception of the restoration. As a result, 11.5 km of shoreline within the marshes remains without emergent plants and virtually all new vegetation sites are a result of active planting by RBG staff and volunteers.

### ***Issues Summary***

- Physical destruction of plant communities and impairment of water quality by carp.
- Turbidity preventing light penetration to the bottom for plant growth derived from carp, urban and rural runoff, and eutrophication.
- Hypereutrophic inflowing phosphorus water sources, well exceeding guidelines for aquatic life.
- Below escarpment creek bank erosion and collapse in the small tributaries due to urban runoff.
- Localized sediment contamination from sewage and urban watersheds.
- Modified water cycles - both Lake Ontario and inflowing rivers
- Historical ditching of lower Spencer Creek and Chedoke Creek

- Dominance of several Eurasian non-native species
- Extirpation of native species
- Localized accumulation of inflowing litter and debris smothering and trapping biota

### ***The Key Performance Indicators for RBG Wetlands***

Measurement of the following list of topics will be used to track the state of the wetlands and the rate of progress of recovery. More details on the monitoring programs are provided in the monitoring section.

- Area of submergent marsh
- Area of emergent marsh
- Area of meadow marsh
- % Wetland native plants
- Area of Wild Rice
- Water clarity or water quality index
- Biomass of common carp
- Winter muskrat lodges present
- Yellow Perch population

### ***Wetland Restoration Themes 2022-2026***

This restoration plan summarizes items including the role of RBG in the HHRAP, the strategy looking forward independent of the HHRAP, resources required, partnerships, research opportunities, specific projects and locations. The plan is in parallel with the completion of the Hamilton Harbour Remedial Action Plan (HHRAP – completion date unknown), bringing the wetlands to a more sustainable state by 2026. An important role for RBG in this process is providing water quality-based communications on the environmental condition of the wetlands, the most important factor for wetland sustainability to support partner initiatives to improve inflowing waters.

1. Exclusion and removal of Common Carp from the marsh areas to facilitate aquatic plant growth.
2. Emergent marsh planting to ameliorate Lake Ontario water level regulation.
3. Repair of historically damage eroding shorelines in Cootes Paradise Marsh, focusing on Hickory Island, Kingfisher Pt, Princess Pt, Sassafras Pt and Bulls Pt through bioengineering
4. Meadow Marsh restoration through invasive plant management with potential alignment with pollinators regional strategies.
5. Communication and monitoring of environmental conditions in the marshes.
6. Review and future strategy for the ongoing management of Grindstone Marsh, particularly the outer marsh.

## Integration with the HHRAP

The HHRAP is triggered by the Great Lakes Water Quality Agreement, with both pre-dating federal and provincial Biodiversity Strategies. The HHRAP does not pertain to the entire area of RBG wetlands, focusing only on the highly impaired area as identified in 1992 HHRAP Stage 1 Report. These areas included the seasonally flooded habitats of meadow marsh and emergent marsh, and the permanently flooded submergent marsh. The initial habitat targets for Cootes Paradise and Grindstone Marshes were never accurately calculated, but the spirit was to restore the missing wetland and aquatic vegetation back to historical conditions (with no reference to species makeup for progress measures). As such, target numbers originally identified to be restored have since been refined by RBG with detailed Geographic Information System mapping (ARCGIS).

The current HHRAP targets for the marshes are;

- Cootes Paradise Marsh - 230 hectares of vegetation
- Grindstone Marsh – 40 hectares of vegetation
- Water Clarity > 1 meter 85% of the time.

The Grindstone Marsh habitat target has proven to be challenging as total area of habitat lost in Grindstone Marsh continued to increase following the onset of the initial HHRAP and assessment. This was further confounded by the lack of initial habitat measurements of the area, resulting in a HHRAP target for recovery of vegetated area that underrepresented the missing vegetation. As of 1999 the missing vegetation had reached 46 ha and the total area of missing vegetation was estimated to be 208ha.

Significant progress has been made during the HHRAP, with the area of missing vegetation down to about 137 hectares. With this the fully vegetated meadow marsh restoration is now focused on transforming the plants species to a native plant community for wildlife habitat. There are no indicator wildlife species, but the total area of this habitat contributes towards the overall habitat delisting target. Within RBG the meadow marsh plant community has targets measured as percent native species, and suitable common plant species. The ongoing challenge for the meadow marsh areas is that for decades the plant community has been almost entirely composed of a Eurasian plant species making the habitat quite ineffective in supporting native insects and wildlife. Measurable positive changes to this plant community have occurred in the past five years with support from both Environment and Climate Change Canada and the Trillium Foundation. Meadow marsh management now falls under federal and provincial biodiversity strategies linked with both Invasive Species and Species at Risk.

### **HHRAP Targets**

Within the HHRAP there are 11 Beneficial Use Impairments (BUIs), for which 5 are directly measured within RBG properties and several that rely on the health of the properties. One of the 12, BUI v, is currently listed as requiring further assessment to properly summarize its condition.

- v - Bird or Animal Deformities or Reproduction Problems (measured by ECCC)
- vi - Degradation of Benthos (marsh criteria currently not established, no lead assigned)
- viii - Eutrophication or Undesirable Algae
- xi - Degradation of Aesthetics (no criteria currently established)
- xiv - Loss of Fish and Wildlife Habitat

HHRAP BUIs with a direct link to RBG marshes.

- iii - Degradation of Fish Population (index measure by DFO in the harbour)
- iii - Degradation of Wildlife Populations (partial index by ECCC – colonial waterbird populations)
- x - Recreational Use - Beach closing and water contact sports (indexed by beach open measurement)

The objectives of the HHRAP measured in the RBG marsh habitat and the BUIs can be summarized as:

1. Achievement of water quality targets through restoration of inflowing water and exclusion of Common Carp (*Cyprinus carpio*).

2. Restoration of plant coverage through elimination of Common Carp and mitigation of Canada goose overpopulation.
3. Remediate onsite physical/chemical damages of historical impairment, including collapsing shorelines and localized sediment impairments at the western Desjardins Canal, Chedoke Bay, and Westdale Inlet.
4. Reestablishing lost species and acceleration plant community recovery through reintroductions

To measure the progress towards recovery of the HHRAP each of the BUIs has targets (delisting targets). The delisting targets, as available, are listed in Table 1. Several of the delisting targets are relative to comparison sites, while the measure of aesthetics has yet to be resolved. Both benthos and wildlife deformities have baseline data available; however, the actual HHRAP target is not chosen. In addition, RBG strives to achieve environmental conditions consistent with provincial and federal guidelines and in support of biodiversity. Two challenges have risen as RBG targets and alignment with federal and provincial guidelines/objectives do not always align with the initial HHRAP targets laid out in 1992. The challenges are twofold;

1. The HHRAP water quality targets for the marshes are not reflective of current federal and provincial guidelines/objectives for aquatic life, while the harbour targets are.
2. Several factors (i.e. pesticides, pharmaceuticals, and nitrates) have no HHRAP measures and yet are negatively affecting the marsh ecosystem.

The above two factors have confounded the City of Hamilton’s ability to determine capital infrastructure needs to mitigate wastewater and urban runoff pollution. Resolving the HHRAP water quality targets are currently the subject of the Cootes Paradise-Grindstone Marsh Water Quality Subcommittee.

Table 1. HHRAP delisting targets for RBG wetlands

Measure	BUI	Final Objective	Cootes Paradise 2021 Average	Grindstone Marsh 2021Average	Pre-Restoration (1990 combined/ averaged)
**Vegetated Area	iii	270 hectares	73 ha	19 ha	~60 hectares
* Water Clarity	viii	>100 cm	39 cm	42 cm	<30cm
* Total Phosphorus	viii	<50 ug/l	126 ug/l	168 ug/l	270 ug/l
* Total Suspended Sediment	viii	<25 mg/l	28 mg/l	43 mg/l	65 mg/l
* Unionized ammonia	viii	<0.02 ug/l	0.024 ug/l	0.15 ug/l	<0.02 ug/l
* Dissolved Oxygen	viii	>5mg/l	>5 mg/l	>5 mg/l	>5 mg/l
Aesthetics	xi	Unimpaired	Impaired	Impaired	Impaired
Benthos	vi	Relative to unimpaired site	Impaired	Impaired	Impaired
Wildlife deformities	v	Relative to unimpaired site	Unimpaired	Unimpaired	Impaired

\*measured at monitoring stations CP2 and GC1.

\*\*Improved wetland mapping revised the initial HHRAP target with 230ha in Cootes Paradise marsh and 40ha in Grindstone Marsh.

+ 12 out of 24 samples had a Secchi reading that was greater than depth. In this case, depth was used to calculate the average.

## Background Summary & Status

Royal Botanical Gardens has been providing protection, stewardship, and restoration of its wetland habitats since the 1940's. For the two coastal marshes impacted by inflowing polluted water, infilling, and Eurasian invasive species this has included many restoration projects from wetland planting programs to hydrological manipulations, to carp exclusion, and to species re-introduction. Concerns regarding inflowing water quality has also always been at the forefront. RBG has regularly requested that local municipalities that discharge wastewater into the properties aspired to maintain highest standards of effluent. Under the Great Lakes Water Quality Agreement of 1970s, the two remaining wetlands retained within RBG property holdings gained additional interest with the formation of the HHRAP and the unveiling of Project Paradise in 1993. Project Paradise was structured to set a restoration course and generate funds for RBG to contribute to projects. Project Paradise will discontinue as part of this plan and the restoration project will be rebranded as an RBG wetland biodiversity conservation project and part of the Niagara Escarpment World Biosphere. Focus will be placed on recovery of rare species, meadow marsh invasive plant species, migratory birds, and fish.

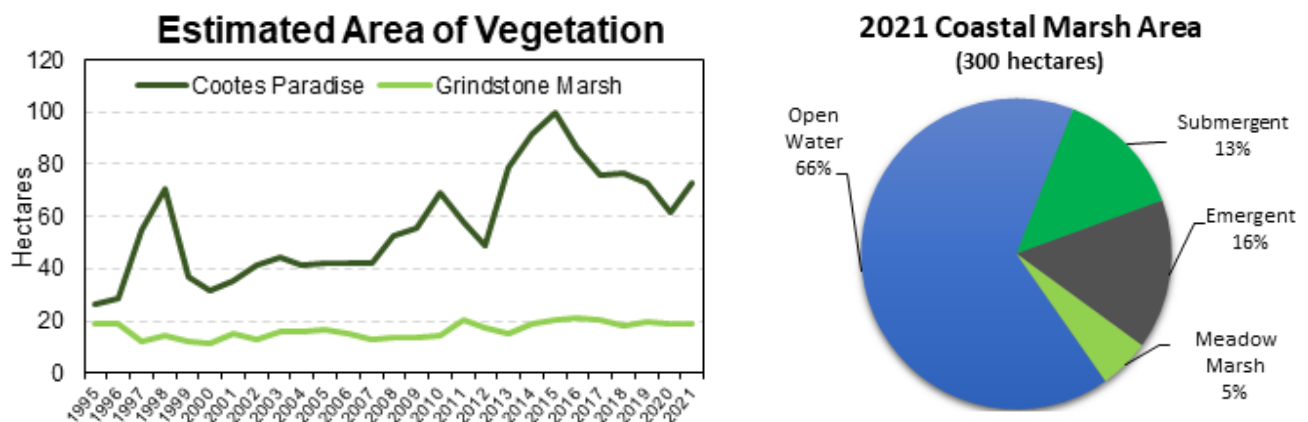
The goal of the Hamilton Harbour Remedial Action Plan (HHRAP) is the restoration of a degraded Great Lakes area (Area of Concern) as identified by the International Joint Commission (IJC) under the Great Lakes Water Quality Agreement (updated 2012). At RBG, the area covered includes the two rivermouth coastal marsh complexes of Cootes Paradise Marsh and Grindstone Marsh (bounded by the 76 msl contour). Overall, these wetlands extend up multiple watersheds, totaling approximately 400 hectares in size, and include over 30 km of shoreline and 25 subwatersheds. RBG owns all of Grindstone Marsh and nearly all of Cootes Paradise Marsh. West of Cootes Drive is owned by Hamilton Conservation Authority and portions of the old Desjardins Canal are owned by the City of Hamilton. Locally these areas represent 99% of the remaining undisturbed harbour shoreline and greater than 95% of the remaining wetland habitats. These are also the largest wetlands in the western half of Lake Ontario and the only coastal marshes protected within the Niagara Escarpment World Biosphere Reserve. The marshes are directly connected to the Lake Ontario water level. Lake Ontario water cycle variations can result in all or none of the marsh area flooded, and the typical annual cycle moves across 1/3 of the marsh area (~70 cm annual fluctuation). Dominant watersheds are Spencer Creek (270 km<sup>2</sup>) and Grindstone Creek (89 km<sup>2</sup>). Although impaired, these watersheds are two of the healthier watersheds remaining on Lake Ontario, with over 95% of the Spencer Creek watershed contained within the Greenbelt.



Figure 1. Map of RBG properties with Cootes Paradise Marsh as the central water feature

## Current Wetland Status

During 2016 to 2021, significant damage and habitat loss occurred (~30 hectares lost), with 2021 a return to improving conditions and recovery of habitat (plants). Images and statistics are provided in the section starting on page 52 of this document. Overall, water quality and clarity in Cootes Paradise Marsh declined from an annual average of 60cm clarity (2015) to 39cm (2021). Newly regenerated dense populations of white waterlily essentially disappeared from Westdale Inlet and West Pond tied to various spills. Emergent plants also dramatically decreased but rebounded in 2021 as a rare low water year occurred, the lowest since the 1960s, resulting in a rapid regeneration of the lost emergent marsh, and a net increase of 5.5 hectares from 2015 conditions, and complimented by planting. This net increase included about 7 hectares of new emergent seedlings established with the assistance of 1.5km of temporary goose exclusion fencing during 2021, reversing multiple years of losses. The total area of missing marsh vegetation at the onset of the HHRAP was 208 ha. and is now down to 137 ha of missing vegetation. Open water area is expected to be less than 5% of total area. In both 2017 and 2019 record high levels impacted carp exclusion ability and since 2017 4,288 large carp have been removed from the marsh.



Site specific areas of recovery have also occurred within the marsh. Cootes Paradise's Presidents Pond area habitat dramatically improved with the elimination of a mixture of dominating invasive plants and carp and now grows the largest wild rice population at RBG. Wild Rice and submergent plants responded in 2021 to the improving conditions with wild rice growing in a dozen areas and submergent plants reestablishing a presence. Water lilies are expected to return with time, and substantial effort was made to reintroduce Yellow Waterlily (*Nuphar variegatum*) with small populations now found in all inlets. A focus on the health of the meadow marsh habitats and elimination of invasive plant species became a focus, with much of the Phragmites eliminated and the large swaths of European Manna Grass now in management (~20 hectares). At the same time the ash trees growing in these areas all died off due to Emerald Ash Borer. Remnant carp are a result of their reluctance to leave the shallow cold marsh for the winter holding in water <15 cm deep, however, there has been very little carp reproductive success in the marsh during recent years and so substantial population decline has occurred (Figure 3). Overall, the marsh continues to be eutrophic and in late summer declines to hypereutrophic conditions resulting in extensive algae blooms and considerable collapse of the submergent plant community. The impact on dissolved oxygen is severe with a study in partnership with DFO Science illuminating this. Fish and wildlife populations, which are mostly based in Hamilton Harbour have followed the recent declines in marsh habitat. As an example, less fish passed through the Fishway in 2021 than 2015, with only native Bowfin populations improving and the non-native Goldfish and Rudd also increasing.

In Grindstone Marsh conditions have also declined with total vegetation in 2015 of 20 hectares, while in 2021 it was 19 hectares. As with Cootes Paradise 2021 represented a year of substantial recovery to restore the condition back to achieve 19 hectares. At the outset of the HHRAP an estimated 40 ha of marsh vegetation was missing and worsened to an estimated 46 ha by 1999. The original 40 ha is only estimated from aerial photos and the experience of one of the authors (Theysmeyer pers. obs.) as it was not quantified in the field in the early 1990s. In outer Grindstone Marsh (not carp protected), the vegetated area remains at near zero. At the



same time emergent plants now occur along a stretch of the western shore of this marsh area (by Carrolls Bay), a result of a 300m long shoreline restoration project in 2016 supported by CN Rail. Long Pond and Pond #1, show measurably improved plant community, and after the removal of carp from record lake levels Ponds #2-4 have returned to essentially restored condition and grow wild rice. In total 2770 large carp have been removed from these marsh areas since 2017. However Long Pond water quality has declined. As with Cootes Paradise a focus on the health of the meadow marsh habitats and the elimination of invasive plant species became a focus. Much of the Phragmites has been eliminated and the large swaths of European Manna Grass are now in management. Issues with flooding (poor quality water) of restoration areas and carp exclusion are slowing recovering, with multiple projects implemented to improve the situation. An increase in the beaver population tunneling through the exclusion berms has resulted in a challenge in maintaining carp exclusion. The rising beaver population also experienced a substantial die off in 2019-20. Long Pond, the second largest area after Outer Grindstone Marsh, remains a challenge to access to complete work and eutrophication has increased in recent years for reasons yet to be determined. Outer Grindstone marsh area continues to be overrun with carp, however DFO Great Lakes Science Lab harbour wide population monitoring indicates the overall population is down by about 80% as compared to 25 years previous. Inflowing Grindstone Creek water quality is also somewhat improved, a result of agricultural practices changes in the watershed, however urban runoff into the small tributaries south of Waterdown is causing severe bank collapse and erosion into the marsh.

RBG projects in the previous 5 years also included a variety of public access and aesthetic improvements; public education programs; public education signage; extensive wetland replanting; large scale carp barrier upgrades to work in higher water levels; carp removal operations; and goose management. In Cootes Paradise, a total of about 85,000 cattails and 1,500 water lilies were planted as well as an annual program to re-establish wild rice, and the addition of extensive meadow marsh plants (25,000 plus plants as well as shrubs and seed). Newly planted reeds are currently protected with 1.5 km of temporary fencing. In Grindstone Marsh, three of the four carp exclusion berms have been rebuilt, and four of the five carp exclusion structures have been upgraded from temporary experimental structures to more permanent metal barriers. In addition, the wetlands were mapped in detail providing RBG with high quality base maps, bathymetry maps, and historical aquatic plant community data. Databases continue to be updated for the various monitoring programs; the Fishway database the most extensive, containing over 100,000 records.

RBG worked with multiple partners to complete projects on-site highlighted by the shoreline rebuild at Outer Grindstone Marsh with CN Rail and supported new major capital projects to improve water flowing into the property. In partnership with the Bay Area Restoration Council, annual volunteer planting contributes 2,000+ new plants to the marshes every year, plants which hopefully continue to multiply and expand. The operation of the Main/King and Royal CSO tanks improved dramatically in 2019 following multiyear large-scale spills, now reducing the number of overflows. Overflows from this tank continue to be overwhelming, and substantially exceed policy objectives for spills annually with 450 million litres overflowing in 2021 (City of Hamilton 2021). An addition four uncontrolled CSOs came to light in the past five years helping to further explain the ongoing water quality issues. The King Street WWTP (located in Dundas) has final upgrade objectives resolved and is currently in need of \$50million for its reconstruction, a current Water Quality Agreement priority. Until this occurs it continues to create hypereutrophic conditions in West Pond and downstream into Cootes Paradise Marsh.



Figure 2. Cootes Paradise's Rat Island in the Spencer Creek delta, 2021 (upper photo), and 2015 (middle photo) and 2011 (lower photo). Emergent Marsh regeneration at this site been the secondary focus complimenting carp exclusion and was fully recovered with the aid of low water in 2021.

## Invasive Species

Eurasian invasive species are a significant challenge in the RBG natural areas. During the period of 2016-2021, the invasive species dimension of the provincial biodiversity strategy emerged as a significant provincial priority, culminating in the passage of the Ontario Invasive Species Act in 2015 and including species such as Common Reed (*Phragmites australis*). Federally aquatic invasive species also emerged as a priority with the management work expanded to include Asian Carp (excluding Common Carp). Prior to 2010, Common Carp was the species of focus through the HHRAP. However, between 2010 and 2015, initiatives for several other species have occurred, particularly in relation to Species at Risk protection. The implications of the new legislation for RBG are yet to be determined, but it can be anticipated as a future source of funding support both on the management and monitoring front. In recognition of this RBG is drafting an invasive species management strategy to summarize the top priorities going forward. As of 2015, Common Carp and *Phragmites* have RBG management plans, with Eurasian Manna Grass (*Glyceria maxima*) soon to follow. Both *Phragmites* and European Manna Grass principally occupy the meadow marsh habitat, a habitat that is also a Lake Ontario Health wetland health indicator. The list of non-native invasive species of concern identified in the RBG wetlands is found in Table 3 below. Of the listed species, Mute Swans, Goldfish, Rudd, and Flowering Rush are identified as emerging issues adding to the already challenging list of species. As part of the invasive species strategy, a target threshold level triggering management action for non-native species abundance will need to be established along with options for funds to support management activities.

In theory, Eurasian species such as the Common Carp would not be expected to out-compete native species, unless the habitat was altered to disfavour the native species, or a suitable natural predator did not exist in North America. This is demonstrated elsewhere on the Great Lakes where unpolluted wetlands are not dominated by carp. Altered/impaired water quality allowed Common Carp to reach 90% of the fish biomass, equivalent to an estimated 800 kg/ha in Cootes Paradise. This resulted in the loss of most native species across all biological community levels, including plants, invertebrates, fish, birds, mammals, and multiple Species at Risk. RBG has found that associated issues begin at densities of over 20 kg/ha. Carp arrived in the late 1800s and were locally established as a dominant species by the 1940s. Most of RBG wetland loss occurred between 1937 and 1950. Key drivers of carp population include eutrophication, anoxia and ammonia issues in adjacent Hamilton Harbour, watershed sediment input, and alteration of the natural marsh water cycle.

Table 2. Identified factors contributing to the historical success of Common Carp (*Cyprinus carpio*).

Life History	Issue	Strategy
Reproduction	Favoured by the regulation of Lake Ontario – typical regulated peak seasonal shoreline flooding aligns with reproductive habitats (June spawning – flooded vegetation)	<ol style="list-style-type: none"> <li>1. Long term - Return variability to seasonal water level peak and return peak period to May.</li> <li>2. Short term - Exclude carp from reproductive habitats</li> </ol>
Summer Habitat	Favoured by turbid open water river mouth marshes and backwaters.	<ol style="list-style-type: none"> <li>1. Reduce turbidity of inflowing water, nutrients, and fine particulate.</li> <li>2. Short term – exclude carp from river mouth habitats with barriers and by returning of Old Desjardins Canal remnant to wetland depth</li> </ol>
Wintering habitat	Favoured through tolerance to elevated ammonia and depressed dissolved oxygen levels in Hamilton harbour.	<ol style="list-style-type: none"> <li>1. Address ammonia and dissolved oxygen issues in both the harbour and west Desjardins Canal.</li> </ol>
Feedback loop 1 – <i>Vacant niche</i>	Open niche created by loss of wetland vegetation in the wetland areas.	<ol style="list-style-type: none"> <li>1. Exclude carp from wetlands</li> <li>2. Restore inflowing water quality</li> <li>3. Reestablish natural water cycle patterns</li> </ol>
Feedback loop 2 – <i>Lack of Predators</i>	Lack of predators to maintain a balanced system.	<ol style="list-style-type: none"> <li>1. Restore wetland fish habitat, with marsh species expect to eat young carp.</li> <li>2. Bald Eagle, Mink, Northern Pike &amp; Muskellunge for moderate sized carp.</li> </ol>

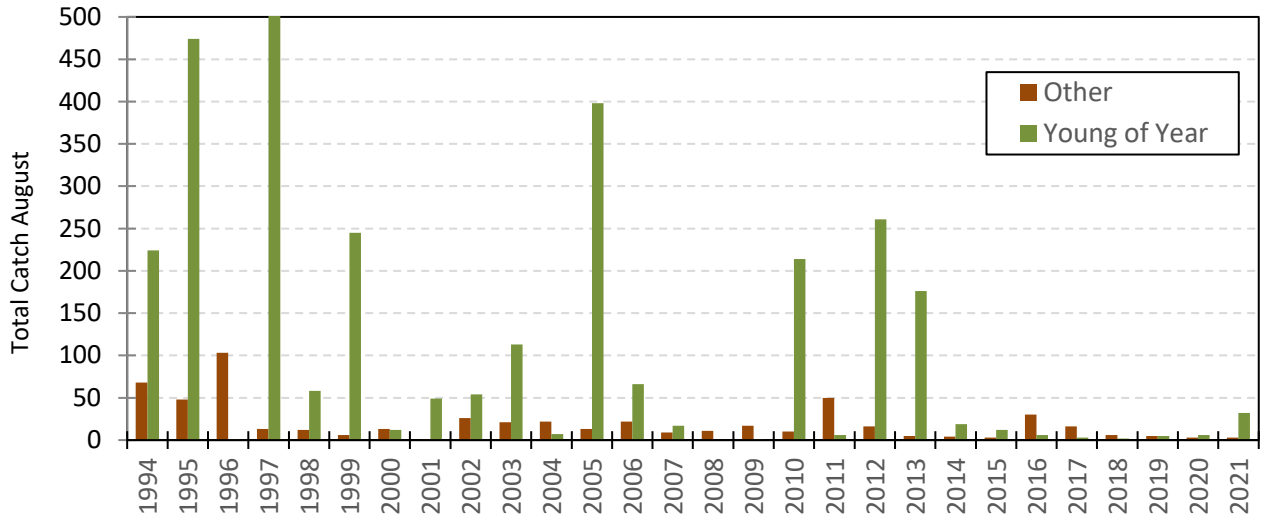


Figure 3. Trends in Common Carp abundance at Cootes Paradise from August electrofishing monitoring (22 transects). 1997 total young of the year carp catch was 2,009 fish.

Table 3. Summary of abundant invasive species found within RBG wetlands.

Species	Status
Eurasian Manna Grass ( <i>Glyceria maxima</i> )	Covers 40% of the meadow marsh habitats as monocultures
Giant Reed Grass ( <i>Phragmites australis</i> )	Localized monocultures cover less than 1 hectares
Red Canary Grass ( <i>Phalaris arundinacea</i> )	Localized, suppressed by Eurasian Manna Grass
Purple loosestrife ( <i>Lythrum salicaria</i> )	Sporadic and controlled by previously introduced beetles (1994)
Flowering Rush ( <i>Butomus umbellatus</i> )	Localized, but emerging as a potential problem
European Crack Willow ( <i>Salix fragilis</i> )	Dominant wetland tree species
Yellow Iris ( <i>Iris pseudoacorus</i> )	Localized, but emerging as a potential problem
Himalayan Balsam ( <i>Impatiens glandulifera</i> )	Localized annual flower occurring in Grindstone Marsh
Common Carp ( <i>Cyprinus carpio</i> )	Became dominant in the 1950s, 800kg/ha as of 1994
White perch ( <i>Morone americana</i> )	Currently declining, in the 1990's a very abundant fish species
Round Goby ( <i>Neogobius melanostomus</i> )	Locally abundant in Grindstone Creek and Carroll's Bay marsh.
Goldfish ( <i>Carassius auratus</i> )	Increasing, recently reached status as a common species
Rudd ( <i>Scardinius erythrophthalmus</i> )	Increasing, recently reached status as a common species
Red-ear slider ( <i>Trachemys scripta elegans</i> )	Abundant near public access areas
European Mute Swan ( <i>Cygnus olor</i> )	A dominant breeding waterbird

## Species at Risk

RBG's Species at Risk (SAR) program objectives include providing regular status updates (every 3-5 years) for all SAR species that occur on RBG lands. This process is evolving with the ever-increasing list of species under threat. As of the end of 2015, 28 listed SAR have been observed in association with the wetlands in the preceding decade (see Table 4). With the transition away from the Hamilton Harbour Remedial Action Plan, efforts supporting SAR biodiversity strategies in the wetlands will emerge as significant. This process was initiated for struggling species such as turtles started with the creation of the Site-Specific Plan for turtles (Harrison and Theijsmeyer 2014) and with background inventory work completed for freshwater mussels (Theijsmeyer and Richer 2017, Morris et al. 2017). In the past, funding was secured for Prothonotary Warbler and Least Bittern habitat projects, as well as most recently for aerial insectivore bird surveys. In addition, the populations of two SAR at Royal Botanical Gardens (Red Mulberry and Few-flowered Club-rush) represent the critical remaining populations in Canada, and as such are the focus of research and management initiatives. The status updates identify issues to focus future management actions, which subsequently feed into the creation of Site-Specific Plans. To provide additional protection for concentrations of SAR, RBG has branded specific off-trail areas as Special Protection Areas. This further minimizes off-trail activities and emphasizes the unique nature of the property. The areas currently include two locations in Cootes Paradise Sanctuary and one location in Hendrie Valley Sanctuary, with two of these sites consisting primarily of wetland habitat.

Key Species at Risk that we anticipate will assist with obtaining funding support include:

- Northern Map Turtle and Blanding's Turtle (general wetland habitat)
- Lilliput Mussel, potential for Eastern Pondmussel and Mapleleaf Mussel (aquatic habitat)
- Least Bittern (emergent marsh habitat)
- Prothonotary Warbler (swamp forest habitat)
- Eastern Ribbonsnake (wetland and swamp forest habitat)

We anticipate Southern Wild Rice (*Zizania aquatica*), a dominant plant in the restored RBG wetlands, will be added to the Species at Risk list within the coming years, following COSWEIC/COSARO assessment. Royal Botanical Gardens appears to be the province's primary information organization on this species, with only Lakehead University also taking an interest in the past. Southern Wild Rice spontaneously reappeared in Grindstone Marsh in 1998 and has since generated reintroduction research and projects.

Reintroducing SAR species extirpated from RBG has the potential to strategically align with similar efforts for currently extirpated, but listed, species. If other agencies undertake related initiatives, and wetland and overall aquatic conditions recover to a stable healthy environment, current opportunities can include:

- Grass Pickerel (potential for natural recolonization) (Special Concern federally and provincially)
- Redside Dace (Special Concern federally, Endangered provincially)
- Bridle Shiner (Special Concern federally and provincially)
- Lake Sturgeon (current subject of OMNRF reintroduction work in Lake Ontario) (Great Lakes population assessed by COSEWIC as Threatened federally, Threatened provincially)
- Jefferson Salamander (can potentially naturally recolonize from nearby/upstream populations)
- Hills Pondweed (potential for natural recolonization) (Special Concern federally and provincially)

Aerial insectivore birds are also of significant concern for biodiversity protection; population trends showing rapid decline have resulted in several recently being added to the Species at Risk list. Due to the migratory bird staging significance for these species at RBG, they are relevant as breeding residents, foraging area residents, and as staging migrants (which currently occur in the thousands). These birds are also connected to the marsh's invertebrate populations, which in turn also support other insectivorous SAR birds, namely the Acadian Flycatcher, Olive-sided Flycatcher, and Canada Warbler. Aerial insectivore birds relevant to the marsh include:

- Chimney Swift (Threatened federally and provincially)
- Bank Swallow (assessed as Threatened by COSEWIC, Threatened provincially)
- Barn Swallow (assessed as Threatened by COSEWIC, Threatened provincially)
- Common Nighthawk (Threatened federally, Special Concern provincially)
- Eastern Whip-poor-will (Threatened federally and provincially)

Species at Risk surveys conducted in 2015 to update the status of RBG's known Bank Swallow colonies found that they are now no longer nesting on RBG land. Black Terns, though not classed as an aerial insectivore, can rely heavily on insects and will nest only in hemi marsh conditions (~50% open water and 50% emergent vegetation). During the past 3 years (2012-2015), Black Terns have been observed foraging at Cootes Paradise Marsh.

Table 4. Wetland-related Species at Risk at RBG, and their current wetland use status.

Common Name	Scientific Name	SARO	SARA/ (COSEWIC)	Wetland use at RBG	Last seen at RBG
Bald Eagle	<i>Haliaeetus leucocephalus washingtoniensis</i>	SC	(NAR)	migratory, breeding	2021
Prothonotary Warbler	<i>Protonotaria citrea</i>	END	END	migratory, breeding	2017
Least Bittern	<i>Ixobrychus exilis</i>	THR	THR	migratory, breeding	2021
American Eel	<i>Anguilla rostrata</i>	END	THR	permanent	2020
Atlantic Salmon (Lake Ontario population)	<i>Salmo salar</i>	END	Reintroduction program	migratory, breeding	2020
Eastern Pondmussel	<i>Ligumia nasuta</i>	END	END	permanent	2010
Lilliput	<i>Toxolasma parvus</i>	THR	END	permanent	2021
Mapleleaf Mussel	<i>Quadrula quadrula</i>	SC	SC	permanent	2021
Eastern Musk Turtle	<i>Sternotherus odoratus</i>	SC	THR	permanent	2009
Blanding's Turtle	<i>Emydoidea blandingii</i>	THR	THR	permanent	2021
Northern Map Turtle	<i>Graptemys geographica</i>	SC	SC	permanent	2021
Snapping Turtle	<i>Chelydra serpentina</i>	SC	SC	permanent	2021
Acadian Flycatcher	<i>Empidonax vireescens</i>	END	END	migratory, breeding	2017
Bank Swallow	<i>Riparia riparia</i>	THR	THR	migratory, breeding	2021
Barn Swallow	<i>Hirundo rustica</i>	THR	THR	migratory, breeding	2021
Chimney Swift	<i>Chaetura pelagica</i>	THR	THR	migratory, breeding	2021
Common Nighthawk	<i>Chordeiles minor</i>	SC	THR	migratory, breeding	2021
Spotted Gar	<i>Lepisosteus oculatus</i>	THR	THR	permanent	2006
Red Knot	<i>Calidris canutus rufa</i>	END	END	migratory	2012
Yellow Rail	<i>Coturnicops noveboracensis</i>	SC	SC	migratory	2012
American White Pelican	<i>Pelecanus erythrorhynchos</i>	THR	(NAR)	migratory	2021
Canada Warbler	<i>Cardellina canadensis</i>	SC	THR	migratory	2021
Golden Eagle	<i>Aquila chrysaetos</i>	END	(NAR)	migratory	2021
Horned Grebe	<i>Podiceps auritus</i>	SC	SC	migratory	2021
Rusty Blackbird	<i>Euphagus carolinus</i>	SC	SC	migratory	2021
Olive-sided Flycatcher	<i>Contopus cooperi</i>	SC	THR	migratory	1975; 2021
Eastern Ribbonsnake	<i>Thamnophis sauritus</i>	SC	SC	permanent	1985; 2014 (unconfirmed)

Common Name	Scientific Name	SARO	SARA/ (COSEWIC)	Wetland use at RBG	Last seen at RBG
Black Tern	<i>Chlidonias niger</i>	SC	(NAR)	migratory (bred historically)	late 1960s, 2018
Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC	SC	permanent	historical
Redside Dace	<i>Clinostomus elongatus</i>	END	END	permanent	historical
Blue Racer	<i>Coluber constrictor foxii</i>	END	END	permanent	historical
Gray Ratsnake	<i>Pantherophis spiloides</i>	END	END	permanent	historical
Timber Rattlesnake	<i>Crotalus horridus</i>	EXP	EXP	permanent	historical
Eastern Whip-poor-will	<i>Antrostomus vociferous</i>	THR	THR	migratory	1965
King Rail	<i>Rallus elegans</i>	END	END	migratory, breeding	1981
Jefferson Salamander	<i>Ambystoma jeffersonianum</i>	END	THR	permanent	1984
Eastern Spiny Softshell Turtle	<i>Apalone spinifera spinifera</i>	END	THR	permanent	1984
Cerulean Warbler	<i>Setophaga cerulea</i>	THR	END	migratory, breeding	1996
Northern Brook Lamprey	<i>Ichthyomyzon fossor</i>	SC	SC	permanent	1997
Short-eared Owl	<i>Asio flammeus</i>	SC	SC	migratory, breeding	1999
Silver Shiner	<i>Notropis photogenis</i>	THR	THR	permanent	1999
Louisiana Waterthrush	<i>Parkesia motacilla</i>	THR	THR	migratory, breeding	2003
Wood Turtle	<i>Gleptemys insculpta</i>	END	THR	permanent	1994 (suspected pet release)

SARO – Species at Risk in Ontario List (<https://www.ontario.ca/environment-and-energy/species-risk-ontario-list>)

SARA – Species at Risk Act (2003) ([http://www.registrelep-sararegistry.gc.ca/sar/index/default\\_e.cfm](http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm))

(COSEWIC) – Committee on the Status of Endangered Wildlife in Canada; rank is in brackets when SARA/COSEWIC differ, or if species does not yet have federal status on SARA schedules but has been assessed as at-risk by the Committee

SC – Special Concern; THR – Threatened; END – Endangered; EXP – Extirpated; EXT – Extinct; NAR – Not at Risk

Historical – not observed on RBG land in over 10 years.

## Restoration Strategies and Actions

The strategies and actions integrate invasive species management and Species at Risk protection within them. In alignment with the HHRAP, the projects target recovery of wetland area first, and wetland plant community quality second. The primary objective for the wetlands is restoring wetland plant coverage to Cootes Paradise and Grindstone Marshes, with this total area (270 hectares) a HHRAP delisting criteria. The interior bay water quality goal in particular, a mesotrophic environment, supports and RBG plant diversity objectives. These wetlands contribute to numerous other beneficial use impairments (BUI's) and HHRAP delisting targets.

Six principal themes dominate RBG's on site wetland management actions intended between 2022 and 2026. These themes are threaded through 15 separate project initiatives with their associated summaries found in the "Projects Description" section of this document. The success of implementation will vary based on funding availability and water levels. Aside from the below, the King St Waster Water Plan and the Desjardins Canal upstream of West Pond to the WWTP (City of Hamilton land) negatively affecting the pond, lower Spencer Creek, and the western half the marsh will require a project to reduce contaminants. In addition to these projects RBG will provide communications to support partner efforts to improve inflowing waters with Chedoke Creek Watershed and Hickory Brook featuring prominently.

1. Exclusion and removal of Common Carp from the marsh areas to facilitate aquatic plant growth.
2. Emergent marsh planting to ameliorate Lake Ontario water level regulation.
3. Repair of historically damage eroding shorelines in Cootes Paradise Marsh, focusing on Hickory Island, Kingfisher Pt, Princess Pt, Sassafra Pt and Bulls Pt through bioengineering
4. Meadow Marsh restoration through invasive plant management with potential alignment with pollinators regional strategies.
5. Communication and monitoring of environmental conditions in the marshes.
6. Review and future strategy for the ongoing management of Grindstone Marsh, particularly the outer marsh.

Table 5. Wetland project titles and timelines, subject to change based on water levels and funding.

Project	2022	2023	2024	2025	2026
The Cootes Paradise Fishway	x	x	x	x	x
The Spencer Creek Delta Project	x	x	x		
Cootes Paradise Shoreline Repair (Gabion Stone sites and eroding islands and points)	x	x	x	x	x
Cootes Paradise Inner Bay Wildlife Project	x	x	x	x	x
Wild Rice and Deep-Water Plants	x	x	x	x	
Meadow Marsh Invasive Plant Removal	x	x	x	x	x
Stream Habitat improvement (McMaster partner)	x	x	x		
RBG Center Urban Runoff Management	x	x			
Chedoke Bay Project		x	x		
Sunfish Pond & Long Pond Carp Exclusion	x	x	x	x	x
Grindstone Marsh Delta (the Elbow)	x	x	x	x	x
Hendrie Valley Oxbow Ponds and Invasive Plants	x	x	x	x	x
Outer Grindstone Marsh (by Carroll's Bay)		?	?	?	?
Grindstone Marsh Carp Exclusion System Review	x	x	x		
Floating Wetlands – Temporary	x	x	x	x	x

### Actions Summary

1. Maintain Common Carp densities to <20 kg/ha through the use of 6 fish barriers, while maintaining system connectivity with fishways.
2. Carp removal from Long Pond and other locations as needed.
3. Accelerate restoration of marsh river channels as biofilters and corridors, with targeted restoration emergent marsh planting projects along Spencer Cr, Grindstone Cr, and Chedoke Cr.
4. Recontour the Chedoke Creek delta to reestablish a natural levee, also acting as a water quality protection barrier to the adjacent Cootes Paradise sheltered bay.



5. Work collaboratively with partners to create an interim mitigation system for ongoing Chedoke Creek sewage spills. (Bubblers and floating wetlands).
6. Stabilization of island shorelines through bioengineering plantings.
7. Removal of old shoreline erosion armour stone and restoration with bioengineering plantings.
8. Introductions of several late summer submergent plant species as well as water lily species.
9. Ongoing reintroduction and propagation of Southern Wild Rice.
10. Recovering inflowing water quality through
  - i. support/input to municipal Wastewater, and Stormwater plans.
  - ii. Support/input to Conservation Authority Watershed planning
  - iii. Coordination with McMaster for Urban runoff changes to campus for West campus.
  - iv. Community involvement activities to educate about the relevance of these plans.
  - v. Communication of environmental status at key interpretation points with a focus at Princess Pt and the Fishway.
11. Mitigation of RBG Centre stormwater runoff.
12. Creation of the Cootes Paradise Marsh Inner Bay migratory waterfowl protection area.
13. Management of dominating invasive species of; *Phragmites*, Eurasian Manna Grass, and Mute Swans
14. Mitigation of the effects of the overabundant Canada Goose population for plant regeneration including temporary fences at planting sites and population control through selective egg oiling.
15. Integration Species at Risk habitat projects with focus on Blanding's Turtle habitat use areas.
16. Training young professionals in the field of environmental stewardship.
17. Monitoring to provide the evidential basis for remedial action efforts of both RBG and partner agencies undertaking activities on the waters that flow into our wetlands.
18. Monitoring – to provide updates on the status of the delisting criteria.
19. Recovery of natural water cycles through direct input to the St. Lawrence Board of Control.
20. Providing support to partner agency research and monitoring programs.
21. Community engagement and education focused at the Fishway, Nature Centre programs, public speaking engagements, and volunteer opportunities.
22. Volunteer opportunities to allow citizens to experience the wetlands, as well as better understand the issues affecting the wetlands.
23. Educational opportunities through wetland school programs, interpretive signage, RBG website, open houses, and communication of monitoring results.
24. Participation of selected HHRAP technical committees and regional surface water project committees
25. Continue to implement and support trash cleanup programs on the shorelines of RBG watersheds, with groups such as the Stream Cleanup, Bay Area Restoration Council, and McMaster student clubs.

### **Staffing**

- To execute the plan RBG will continue to require the existing staff complement as well as volunteers
- Head of Natural Lands
- Aquatic Ecologist
- Monitoring Ecologist
- Species at Risk Biologist
- Propagation Support
- Biotechnician
- Aquatic Intern (x2)
- Short term contract assistance as individual projects demand.

### **Volunteer Assistance**

- Seed collection and plant propagation
- Wetland planting and invasive plant species removal
- Spring marsh bird and amphibian monitoring
- Fall migratory bird monitoring

### ***Capital Projects and Items***

Anticipated capital projects to support and advance the wetland restoration include;

1. Wetland Plants (~\$500,000)
2. New Boathouse (\$150,000)
3. Blackbird Marsh berm and structure relocation (\$20,000)
4. Chedoke Bay Delta Reestablishment (\$1,750,000)
5. Lower Chedoke Creek interim wastewater treatment (\$2,500,000)
6. Access path improvement to Long Pond (\$5,000)
7. Cootes Paradise Fishway basket repairs (\$15,000)
8. Cootes Paradise Fishway off grid power system (\$80,000)
9. Cootes Paradise Marsh gabion basket/rock removal (TBD)
10. Grindstone Marsh Pond 1, 3 & 4 collapsing creek bank restoration, and Grindstone Creek shore repair by Plains Rd bridge (\$35,000)
11. RBG Main Centre storm mitigation (\$150,000)
12. Replacement fleet vehicle to electric F150 Lightning (\$70,000)
13. Replacement electrofisher unit (\$15,000)
14. Relocated and updated storage compound associated with RBG Masterplan property use updates. (\$TBD)

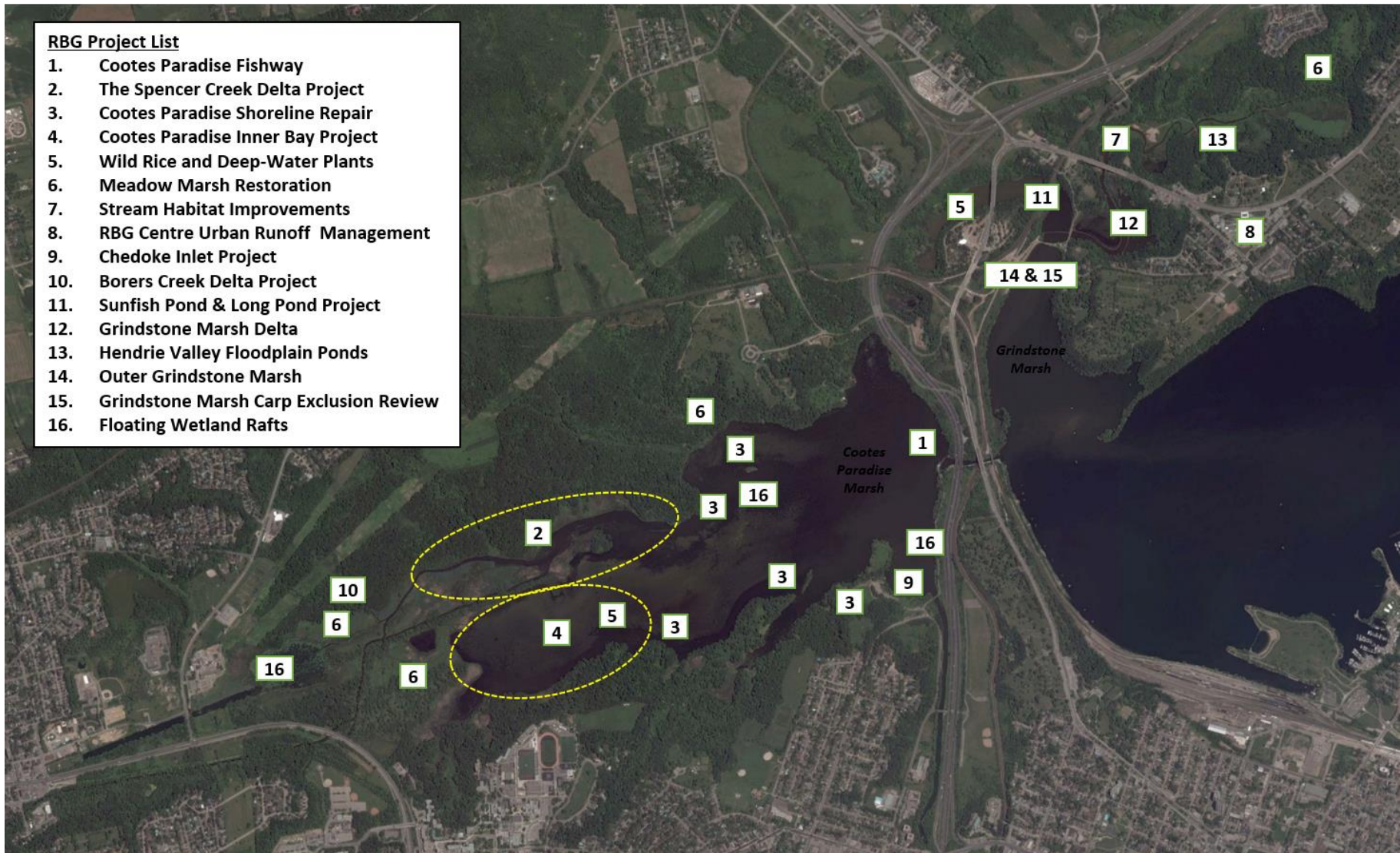


Figure 4. Projects Overview Map for 2022-2026 wetland project description locations.

# Restoration of Plant Community & Climate Change

## **Wetland Types**

Restoring water quality to the wetland goal of meso-eutrophic in the creek deltas and mesotrophic in the sheltered bays is the most crucial step in reestablishing a sustainable plant community. After water quality, plant community make up is then structured by water cycles. The wetlands of RBG can be split into two broad water cycle categories, those influenced by the back flooding from Lake Ontario, the coastal marsh portions, and those with water levels that are a function of direct precipitation and inflowing waters, the floodplain portion. Currently Lake Ontario water level regulation places this divide at about the 75.5msl contour. At the intersection of these two cycles there is a transition area between these two wetland water cycles which covers an extensive area due to the annual and inter annual variations in the Lake Ontario water cycle.

Climate Change is a principal challenge and wetlands are carbon sinks. Wetlands such as the coastal marshes are estimated to sequester about 100grams/m<sup>2</sup>/year (Bernal and Mitch 2012). The sheer scale of the wetland vegetation currently missing provides the most significant opportunity within the RBG lands to increase carbon capture. Essentially 140 hectares of plants are currently missing. At the same time river mouth marsh at RBG face significant further ecological health risk from Climate Change as they are more likely to be damaged by extreme events, particularly accelerated landscape erosion given the upstream land uses.

The areas associated with the inflowing waters in Cootes Paradise Marsh are increasing with the reestablishment of emergent plants. This currently includes all areas to the west of Rat Island following Spencer Creek, as well as portions of Long Valley, Hickory Valley, and Westdale Inlets. In the Grindstone Marsh system, the inflowing waters control all areas upstream of the Plains Rd Bridge over Grindstone Creek, as well as Long Pond. Within these areas, the wetlands can be further subdivided into mineral and organic marshes, and further subdivided again using the Ecological Lands Classification System (ELC).

Originally almost all the wetland areas were under the influence of river levels rather than back flooding by the lake, with the exception of outer Grindstone Marsh area. With the loss of the marsh channels to retain the water, and the dredging of the Desjardins Canal through Burlington Heights, the outflow channel became disproportionately large relative to the inflow, allowing the retained wetland waters to drain out. At the same time due to isostatic rebound, over the long term, the lake is continuing to back flood into the wetlands creating “drowned river mouth marshes”. This rebound rate is 1- 3 mm per year.

Within the coastal marsh (primary HHRAP focus of restoration), the boundary between the perennial emergent marsh and submergent wetland vegetation is a function of the water cycle. The boundary occurs at the point where in 4 out of 5 years permanent flooding occurs in the summer season. This can be further refined within the longer-term water cycle patterns, defining the maximum extent of the emergent zone as bounded by the shoreline interface of the lowest summer water cycle water level. The resulting exposed summer mudflat causes massive emergent marsh regeneration by seedlings on the mudflat. A transition zone remains where low winter water levels expose areas of marsh where summer water levels will prevent emergent marsh establishment. This high disturbance area (which experiences cycles of draining, drying, freezing, and flooding) is dominated by an annual species of wild rice (*Zizania sp.*), a result of substantial average annual water level fluctuation (70 cm) and further enhance by the Lake Ontario Regulation Plan. Through extensive wetland mapping between 2010 and 2015, all the plant community zones within the wetlands are now mapped (**Error! Reference source not found.**) and a bathymetry map is contained in the Appendix.

## **Key plants**

- Swamp - TBD
- Meadow marsh - Lakebank Sedge (*Carex lacustris*)
- Emergent Zone - Cattail (*Typha sp.*)
- Transition Zone - Wild Rice (*Zizania aquatic*)
- Submergent Zone - White Water Lily (*Nymphaea odorota tuberosa*)

- Littoral Zone/Deep submergent Zone – Wild Celery (*Vallisneria americana*)

#### Restoration Activities by Habitat Type

##### **Swamp** – Keystone Plants; Silver Maple (*Acer saccharinum*), herbaceous plant - TBD

- Assess ELC data and map to determine if data gaps exist and resolve
- Determine future management options
- Follow the Eurasian Manna Grass (*Glyceria maxima*) Management Strategy such that this plant is no longer the dominant herbaceous species
- Develop a management plan for the dominant woody invasive non-native species, Crack willow (*Salix fragilis*)

##### **Meadow Marsh** - Keystone plant: Lakebank Sedge (*Carex lacustris*)

- Assess ELC data and GIS map to determine if data gaps exist and if so update the information
- Develop a monitoring protocol using 1x1 m plots randomly selected throughout the habitat
- Follow the *Phragmites* Management Plan with the objective to maintain *Phragmites* at less than 1% of the meadow marsh/shallow marsh (ELC community series) area by the end of 5 years
- Continue the Eurasian Manna Grass (*Glyceria maxima*) Management Strategy with the following objectives:
  1. Protect the (<1% of total) intact native meadow marsh and lake bank sedge habitat in Borer's Creek floodplain, Marshwalk (Coastal wetland), and South Pasture Swamp (oxbow wetland).
  2. Eliminate along the steep shorelines in the shallow marsh habitats throughout.
  3. Eliminate from the Spencer floodplain east meadow marsh area.
  4. Eliminate from the Grindstone Creek floodplain area.
  5. Maintain Manna Grass at less than 1% of the meadow marsh/shallow marsh (ELC community series) at Boathouse area, Kingfisher Bay, Princess Point, Pine Point Inlet, Osprey Marsh, North Grindstone Creek (Plains Rd bridge to Snowberry Island)

##### **Emergent Marsh** – Keystone plant: Cattail (*Typha sp.*) coastal, Burreed (*Sparganium eurycarpum*) ponds

- Water Quality – support watershed water quality improvements by partners to restore trophic status
- Common carp control through operation of carp barriers and fishways to protect reeds from being crushed during spawning activities
- Canada goose and mute swan control through egg oiling and habitat modification, and the reestablishment of natural predators
- Fencing of marsh plantings and emergent seedlings in low water years
- Removal of gabion baskets and armour stone along formerly wind-blown shores
- Implementing the *Phragmites* Management Plan with the objective to maintain *Phragmites* at less than 1% of the meadow marsh/shallow marsh (ELC community series) area by the end of 5 years
- Be vigilant to identify new invasive species and keep a close eye on existing non-native species that may require management actions
- Support improvements to the King Street Wastewater Treatment Plant that will minimize algae growth which smothers aquatic vegetation
- Marsh plantings to help establish healthy populations of Hardstem & Softem Bulrush (*Schoenoplectus sp.*), Prairie Cordgrass (*Spartina pectinata*), River Bulrush (*Scirpus fluviatilis*), and cattail

##### **Transition Marsh** - Keystone plant: Wild Rice (*Zizania sp.*)

- Common carp control through operation of carp barriers and Fishway to protect seedlings from uprooting, and to maintain good water clarity
- Marsh river channel restoration using cattail planting and natural sedimentation processes to facilitate restoration of marsh river channels to protect habitat from damaging inflowing waters
- Canada goose and mute swan control through egg oiling and habitat modification, and the reestablishment of natural predators

- Create a seed bank in various locations through seeding and seedling planting of southern wild rice in inlet areas as conditions become appropriate. Inlets in Cootes Paradise Marsh include Mac Landing, Double Marsh, Westdale Inlet, Princess Point Bays, Hickory Bay; Pond 1, Pond 2, South Pasture Swamp, and Blackbird and Osprey Marshes in the Grindstone System.
- Rebuild two tanks in the aquatic nursery to maintain captive population of wild rice
- Water Quality - support improvements to the King Street Wastewater Treatment Plant and urban runoff to minimize filamentous algal growth and sediment inputs currently smothering aquatic vegetation.

**Submergent Marsh** - Keystone plant: White Water Lily (*Nymphaea odorata*)

- Common carp control through operation of carp barriers and Fishway to protect seedlings from uprooting and to maintain good water clarity
- Carp removal to maintain a population <20 kg/ha
- Marsh river channel restoration using cattail planting (bioengineering) and natural sedimentation processes to protect interior bay habitat from damaging inflowing waters
- Restoration planting of late season submergent plants including Tape Grass (*Vallisneria americana*) and floating-leaved pondweeds (*Potamogeton nodosus/natas*), with new propagation tanks to support project.
- White water lilies added to inlet areas as conditions become appropriate, such as the inner bay of Cootes Paradise Marsh, Princess Point Bay, and Hickory Bay
- Water Quality - support water quality improvements by partners throughout the rural watershed
- Water Quality - support improvements to the King Street Wastewater Treatment Plant and urban runoff to minimize filamentous algal growth and sediment inputs currently smothering aquatic vegetation.
- Support mitigation of the impaired Desjardins Canal sediments to eliminate smothering filamentous algae.

**Planting Plan**

Plantings will focus largely on the emergent and meadow marsh plants, with smaller scale projects pertaining to the submergent marsh (**Error! Reference source not found.**). This focus is a result of Lake Ontario water level regulation. Currently, approximately 11 km of shoreline in Cootes Paradise and Grindstone Marshes remain without emergent vegetation. This also contributes to shoreline erosion and damage was particularly felt during the 2017 and 2019 record breaking water levels in Lake Ontario. New areas of shoreline erosion have started, and already existing areas have worsened. Restoration projects have started on repairing these areas and will continue through the next 5 years. Several locations in Cootes Paradise Marsh were protected with armour stone in the 1970, and efforts to replace the areas with plant material has been ongoing since 2015. The high-water levels in 2017 and 2019 delayed the progress of this project and created higher priority sites to remediate, extending this project beyond 2021. Excluding 1999 and 2021, virtually all emergent plant re-establishment has been through plantings, with these plants expanding naturally once secure. The ongoing missing plants are a consequence of both lake level regulation and the smothering rafts of algae and debris (eutrophication). Summer lake levels have exceeded 75.2 msl most years during the HHRAP, with only 1999 and 2021 providing low enough lake levels during the spring to germinate emergent seedlings along some of the marsh shorelines and Spencer creek delta. For emergent seedling germination and subsequent shoreline stabilization to occur, a maximum summer water level of less than 74.75 msl is required. Through planting efforts, we hope to establish 4 km of emergent shore habitat by 2026 and remove all shoreline armouring.

Seed and planting densities

- Emergent Marsh: 4 plants/m<sup>2</sup>
- Shoreline: 8 plants/m<sup>2</sup>
- Meadow Marsh Flowering Plants: 6 plants/m<sup>2</sup>
- Meadow Marsh Grasses & Sedges: 4 plants/m<sup>2</sup>
- Seeding 8kg/ha.

Major planting projects will include;

- Shoreline remediation (i.e., removal of armour stone and replanting with emergent marsh)
- Cootes Paradise Spencer Creek delta emergent marsh
- Cootes Paradise Chedoke Creek delta emergent marsh

- Stabilization of Cootes Paradise Island shorelines.
- Cootes Paradise Inner Bay Project.
- Shorelines of Grindstone Marsh carp protected areas.
- Replacement of *Phragmites* and Eurasian Manna Grass stands with native meadow marsh plants with a particular focus at Spencer Creek floodplain (Cootes Paradise Marsh) and the upper reaches of Grindstone Marsh.

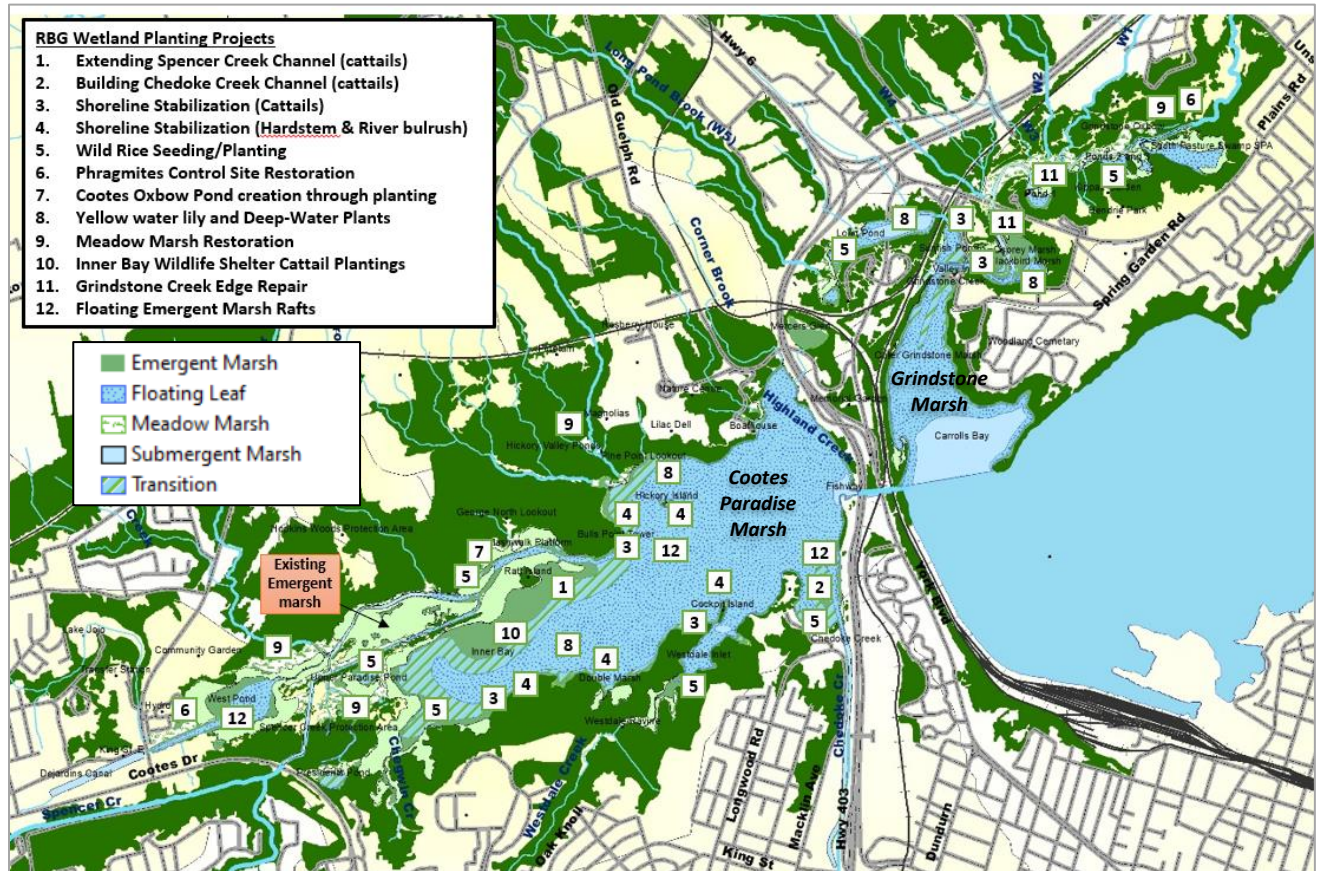


Figure 5. Future planting areas, existing emergent and meadow marsh (light green), and predicted plant community zones based on current Lake Ontario water cycles of operating Plan 2014.

Sourcing of plants to support the work is a significant project as an estimated 30,000 plants and 10 kg of mixed wetland seed are needed each year. As an ongoing project, RBG maintains propagation tanks for wild rice and wetland holding tanks with capacity for 5,000 plants (as plugs). Future work for RBG propagation are currently under review, with propagation of the needed wetland plants under consideration for space. The extent of meadow marsh species required is unknown as the current invasive plant management plans in these areas anticipate significant natural regeneration from the seed bank, and seeding will be the preferred approach. Yellow and white waterlily planting objectives will be achieved through direct transplants from in-situ populations and therefore do not require additional sourcing. Emergent marsh plantings will be protected from geese and mute swans with temporary fencing until established, with 1.5 km in use at 12 sites as of the end of 2021. The planting seasons for the various plant groups are influenced by water cycles and fish and wildlife reproduction activity, with planting times as follows;

- emergent marsh plants - late April & July and Early August
- meadow marsh seeding/planting – May & July to September
- water lilies and deep water submergent plants – August

Table 6. Wetland Project Estimated Plant Needs 2022-2026

Project	Total	2022	2023	2024	2025	2026
The Spencer Creek Delta Project	15,000	5,000	5,000	5,000	TBD	TBD
Cootes Paradise Shoreline Repair	31,000	5,000	8,000	8,000	5,000	5,000
Cootes Paradise Inner Bay Project	34,000	6,500	7,500	7,500	7,500	5,000
Wild Rice and Deep-Water Plants	2,000	-	500	500	500	500
Meadow Marsh Restoration	23,000	3,000	5,000	5,000	5,000	5,000
Meadow Marsh Seeding	75kg	45kg	20kg	10kg	TBD	TBD
Stream Habitat improvement	4,500	1,500	1,500	1,500	TBD	TBD
Sunfish & Long Pond Project	2,000	1,000	1,000	TBD	TBD	TBD
Chedoke Bay Project	5,200	-	-	25,000	20,000	TBD
Grindstone Marsh Delta	7,300	1,500	2,000	TBD	TBD	
RBG Centre Rain Garden	13,000	3000	10,000			
Floating Wetlands	13,000	1,000	4,000	4,000	4,000	TBD

### ***Shoreline Repair Stabilization***

As part of the ongoing restoration of historically damaged habitat, a review and mapping of the state of the RBG shorelines was completed in 2015 (Figure 6). Wave erosion, a result of the historical loss of vegetation has severely undercut several areas of natural sand shorelines within RBG. These areas of erosion were worsened by the record-breaking water levels of 2017 and 2019. Further, the terrestrial slope vegetation found upslope on the shores represents much of the undisturbed plant communities left along the shores of Lake Ontario. Cootes Paradise Marsh has a total of 27 km of shoreline, 6.8 km of which remains without regenerated emergent marsh vegetation. Lack of vegetation recovery is a result of historical shoreline wave protection (such as gabion baskets), unmitigated erosion sites, and water level regulation. Grindstone Marsh has an additional 4.3 km of shoreline in similar condition, with most of this found in Long Pond and Carroll's Bay areas where wind fetch has a much lower effect and with no armouring having occurred. The shoreline stabilization goal is, in combination with the regenerating submergent plant wave breaking effect, to restore undercut eroding shorelines planting a 4 m wide band of emergent marsh and shrub thicket to jump start plant re-establishment.

The shoreline repair falls into two broad categories: those historically armoured with gabion stone and baskets (250 m), and those that are natural beach shorelines that have yet to re-generate vegetation. A subset of the latter includes the natural beach shorelines of the three islands in Cootes Paradise Marsh, which totals 520 m. Together these total 770 m are the priority areas for restoration between 2016 and 2021. Armour stone was installed in the 1970s to protect fragile upland plant communities from collapsing into the marsh. In addition to the existing gabion baskets, 205 m of shoreline have loose gabion stone spread along the shoreline. The heavy rock is proving to be a barrier for planting and plant growth. The remaining shorelines in the western half of the marsh are largely low gradient shore and have revegetated, while the eastern shoreline is almost entirely composed of fill, a result Hwy 403. Additional beach locations of focus are the north and south shorelines in the eastern half of Cootes Paradise Marsh with a total of 470 m of shoreline requiring attention.

Erosion in Cootes Paradise Marsh is a consequence of the historical loss of aquatic vegetation, generating long wind fetch and waves. The shorelines themselves represent sensitive habitats, often steep sandy shorelines, with the uplands part of the Cootes Paradise Area of Natural and Scientific Interest (ANSI). Since recovery of the marsh vegetation is occurring through a variety of HHRAP actions, shoreline repair can be initiated. Natural regeneration is not expected in the short term due to Lake Ontario water level regulation water levels that precluded natural emergent vegetation reestablishment. The current regulation plan prevents lower water levels that would otherwise create nursery conditions and subsequent natural regeneration of appropriate vegetation. For much of the remaining unvegetated areas this would require a maximum spring water level of 74.7msl.



Table 7: Prioritization of shoreline repair issues at Cootes Paradise Marsh and Grindstone Marsh.

Area	Issue	Length (m)	Details	Priority
Cootes Paradise Inner Bay	Non-emergent Shoreline	380	Kingfisher Point	HIGH
	Erosion		Point Specific	MEDIUM
South Shore	Non-emergent Shoreline	975		HIGH
	Erosion	100		MEDIUM
	Gabion Baskets	255		HIGH
	Loose Gabion Stone	205		MEDIUM
	Unsanctioned Trails		4	MEDIUM
Westdale Inlet	Non-emergent Shoreline	625		MEDIUM
	Erosion	230		MEDIUM
	Old Infrastructure		one concrete filled garbage can	HIGH
	Unsanctioned Trails		4	HIGH
Princess Point	Non-emergent Shoreline	685		MEDIUM
	Erosion	50		MEDIUM
	Unsanctioned Trails		8	MEDIUM
East Shore	Non-emergent Shoreline	1,325		MEDIUM
	Erosion	115		MEDIUM
	Old Infrastructure		one concrete pipe; two rusty culverts	MEDIUM
North Shore	Non-emergent Shoreline	930		MEDIUM
	Erosion	65	Captain Cootes trail eroding	HIGH
	Old Infrastructure		Concrete slabs; logs and chains	MEDIUM
	Gabion Baskets		At Boathouse	MEDIUM
	Unsanctioned Trails		3	MEDIUM
Bull's Point	Non-emergent Shoreline	340		MEDIUM
	Erosion	35		HIGH
	Old Infrastructure		Aquadam	HIGH
Islands	Non-emergent Shoreline	520	Collapse and loss of archeology	HIGH
Grindstone Marsh Carroll's Bay*	Non-emergent Shoreline	2,200	Localized significant toe erosion	MEDIUM
Long Pond*	Non-emergent Shoreline	950	Significant toe erosion in need of assessment	HIGH
Sunfish Pond	Non-emergent Shoreline	400		MEDIUM
Osprey Marsh	Non-emergent Shoreline	300		MEDIUM
Lower Grindstone Creek	Non-emergent Shoreline	450	Mostly highly shaded by north facing forest	MEDIUM
Pond 1	Non-emergent Shoreline	250	Shaded by north facing forest	MEDIUM

\*unassessed erosion sites

**Priority Legend**

HIGH
MEDIUM
LOW

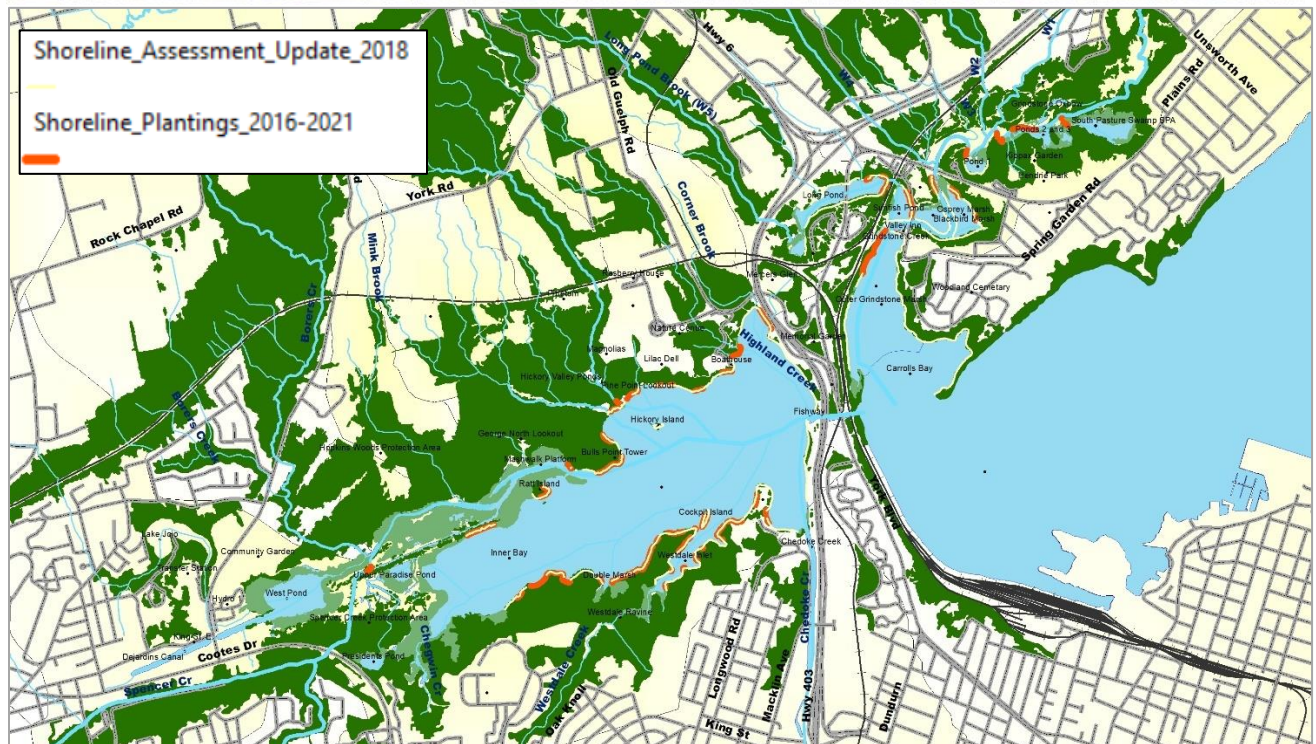
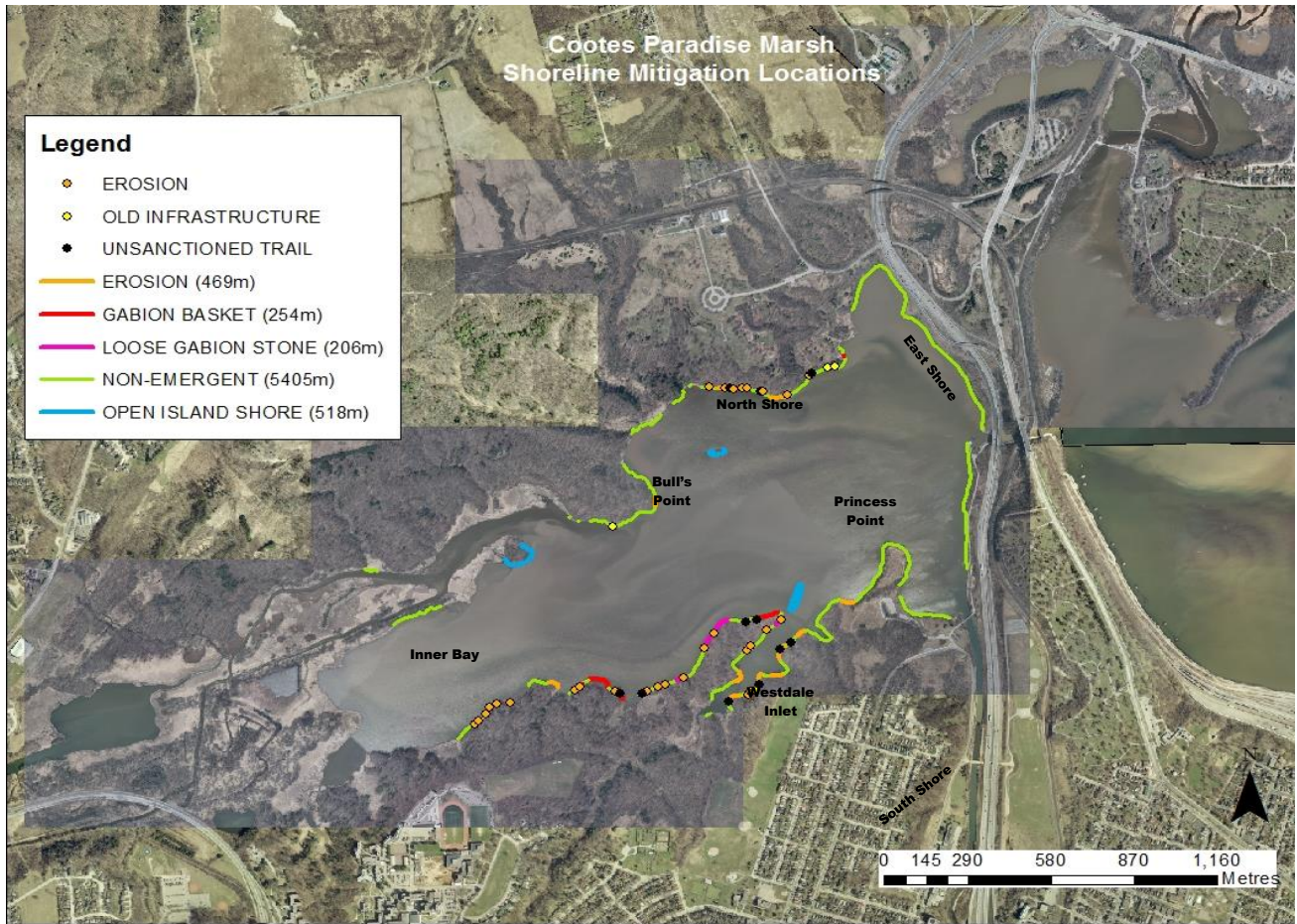


Figure 6. Shoreline condition of Cootes Paradise Marsh. Shoreline restoration planting priorities will focus on gabion basket and stone removal, and island shoreline stabilization between 2022 and 2026.

## Water Quality and HHRAP Partners

The work completed by RBG in the marshes is focused on recovering and measuring wetland/marsh plant communities. These plant communities are the bases of the food web, supporting many dimensions of the Hamilton Harbour ecosystem, most significantly fish reproductions. Within the marshes the areas of issues are portrayed in the Figure 7 aerial photo. In this photo, the June 2015 plant coverage is visible, both in areas of recovery and in missing areas associated with specific watersheds of the marshes (Table 8). Virtually all issues limiting plant recovery at this point are related to impaired quality of inflowing water. Overall, 80% of Hamilton Harbour watershed surface waters enter the system through these two marshes. Based on our HHRAP committee experience, RBG considers most source locations are known by the partners. In the specific case of urban runoff from the old urban areas of Dundas, Waterdown, and Ancaster, the specific stormwater outfall points in need of remediation have yet to be summarized.

Recovering inflowing water quality limiting the recovery of biota in marsh is the most crucial step in sustainability and delisting the Hamilton Harbour AOC. The summary chart and map (Table 8, Figure 7) highlights current impaired marsh subareas, the watershed-based issues, and important actions required to recover the inflowing water quality. The issues fall into three major themes.

1. Sewage and sewage related treatment
2. Urban runoff quality and quantity
3. Localized rural issues particularly in Grindstone Marsh

These issues are expected to figure prominently in the 2022-2026 HHRAP Bay Area Implementation Team workplan to reach delisting, with background available in the HHRAP Stage 1, Stage 2 and Stage 2 update.

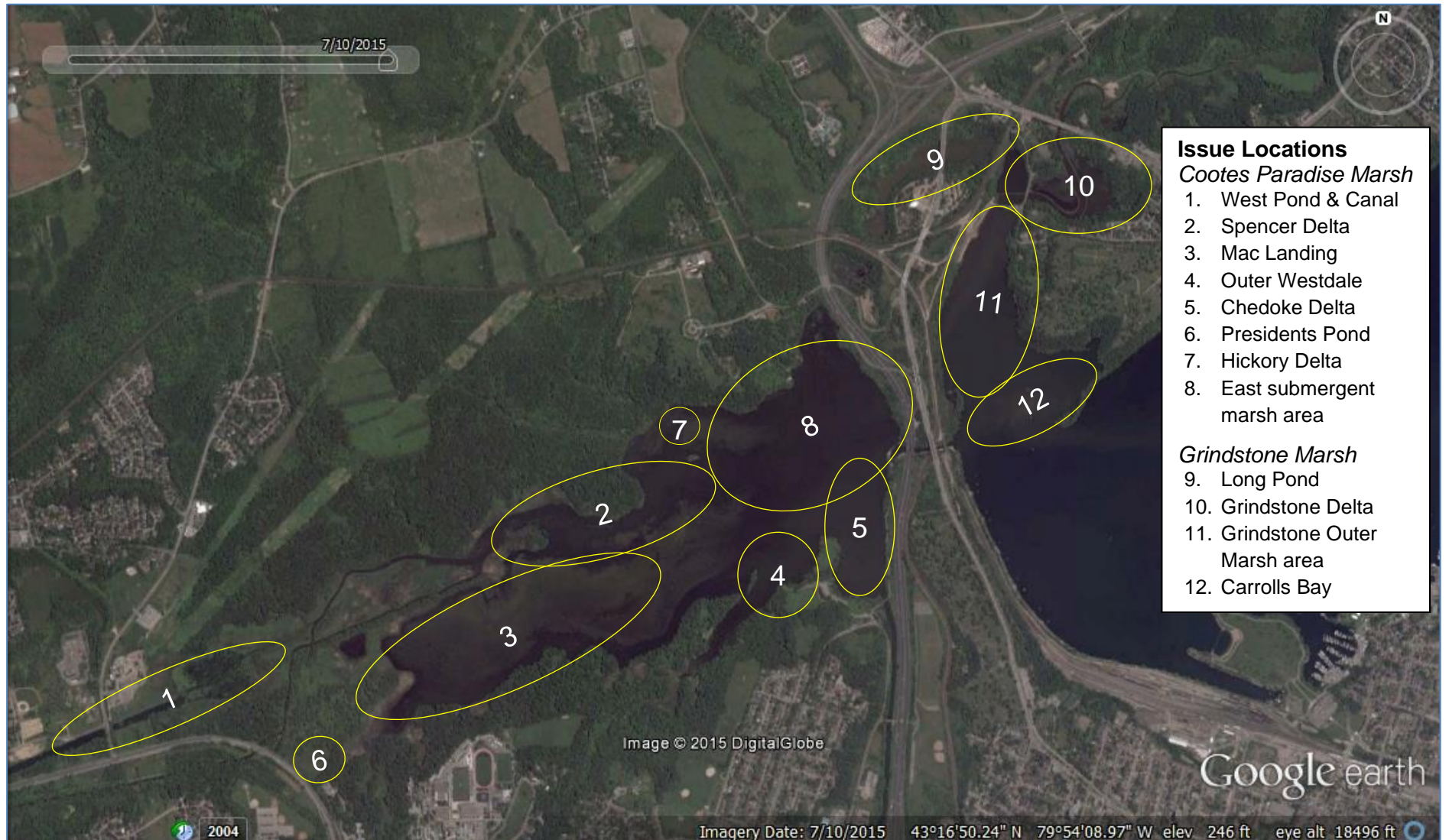
RBG also emphasizes that water quality in the harbour is also of significant importance to the sustainability of the marsh. It is expected that if the harbour continues to be seasonally anoxic in large areas, the fish community will continue to be dominated by low oxygen tolerant species, such as the non-native Common Carp and Goldfish, and native catfish. This results in an ongoing obligation for fish community management that at a minimum consists of management of Common Carp using carp barriers and fishways.

To provide clear information to the community on water quality conditions and watershed issues Royal Botanical Gardens will establish an information resource webpage feature information about water quality status and resources for stormwater management and sewage control status. Further in support of work for Chedoke Creek a watershed information resource map will be established at the Princess Point canoe/Kayak launch at Cootes Paradise adjacent to the creek and waterfront trail.

Table 8. Summary chart of water issues, associated areas affected, shown in Figure 7, and action themes to delist the wetland portion of the HHRAP.

Location (figure 7)	Approx. Area	Issues limiting success	Recommended Remedial Actions
<b><i>Cootes Paradise Marsh</i></b>	<b>240 ha</b>	= total HHRAP area within RBG Boundaries	
1. West Pond & Desjardin Canal	9 ha.	<ul style="list-style-type: none"> <li>• Hypereutrophication from Dundas WWTP</li> <li>• Eutrophication from Canal sediment</li> </ul>	<ul style="list-style-type: none"> <li>• Effluent Improvement to eutrophic</li> <li>• Mitigation of sediment</li> </ul>
2. Spencer Delta	20 ha.	<ul style="list-style-type: none"> <li>• Eutrophication from Dundas WWTP</li> <li>• Urban Runoff (Dundas, Ancaster, Waterdown)</li> <li>• Rural runoff Borers Creek Watershed</li> <li>• Possible herbicides?</li> </ul>	<ul style="list-style-type: none"> <li>• Effluent Improvement to meso-eutrophic</li> <li>• Stormwater management</li> <li>• Buffer rural waterways</li> <li>• Herbicide study</li> </ul>
3. Mac Landing and Inner Bay	40 ha.	<ul style="list-style-type: none"> <li>• Urban Runoff (McMaster &amp; Main St)</li> </ul>	<ul style="list-style-type: none"> <li>• Effluent relocation and improvement</li> </ul>
4. Outer Westdale	3 ha.	<ul style="list-style-type: none"> <li>• Westdale Sterling CSO</li> </ul>	<ul style="list-style-type: none"> <li>• CSO improvement</li> </ul>
5. Chedoke Delta	18 ha.	<ul style="list-style-type: none"> <li>• CSOs &amp; Cross Connections</li> <li>• Urban runoff</li> <li>• Landfill leachate?</li> </ul>	<ul style="list-style-type: none"> <li>• CSO improvement &amp; connection removal</li> <li>• Stormwater management</li> <li>• Complete leachate project</li> </ul>
6. Presidents Pond	1 ha.	<ul style="list-style-type: none"> <li>• Potential DDT remnants 1950s</li> </ul>	<ul style="list-style-type: none"> <li>• Investigate issue</li> </ul>
7. Hickory Delta	2 ha.	<ul style="list-style-type: none"> <li>• Cross Connections?</li> <li>• Rural Runoff</li> </ul>	<ul style="list-style-type: none"> <li>• Connection removal</li> <li>• Buffer rural waterways</li> </ul>
8. East submergent marsh area	60 ha.	<ul style="list-style-type: none"> <li>• Combined effects of above stressors</li> </ul>	<ul style="list-style-type: none"> <li>• Implement above items</li> </ul>
<b><i>Grindstone Marsh</i></b>	<b>77 ha.</b>	= total HHRAP area within RBG boundaries	
9. Long Pond	6 ha.	<ul style="list-style-type: none"> <li>• Carp</li> <li>• Urban runoff? Clappison's Corner area?</li> </ul>	<ul style="list-style-type: none"> <li>• Remove carp</li> <li>• Investigate and mitigate runoff</li> </ul>
10. Grindstone Delta	8 ha.	<ul style="list-style-type: none"> <li>• Carp</li> <li>• Urban &amp; rural runoff, Possible herbicides?</li> </ul>	<ul style="list-style-type: none"> <li>• Remove carp</li> <li>• Stormwater management</li> <li>• Buffer waterways</li> </ul>
11. Grindstone Outer Marsh	22 ha.	<ul style="list-style-type: none"> <li>• Carp</li> <li>• Urban &amp; rural runoff, Possible herbicides?</li> </ul>	<ul style="list-style-type: none"> <li>• Remove carp</li> <li>• Stormwater management</li> </ul>
12. Carroll's Bay	17 ha.	<ul style="list-style-type: none"> <li>• Carp</li> <li>• Urban &amp; rural runoff, Possible herbicides?</li> </ul>	<ul style="list-style-type: none"> <li>• Remove carp</li> <li>• Stormwater management</li> </ul>
<b>Total habitat to recover</b>	<b>160 ha.</b>	Totally missing vegetation as of end of 2021	

Figure 7. Site specific areas for inflowing water issue (lacking plants) within Cootes Paradise and Grindstone Marshes downstream of various watersheds.



## Monitoring

RBG manages its natural lands with a goal of supporting international ecosystems for migratory birds and fish, protecting rare species, and aligning with Great Lakes monitoring protocols. In connection with this, the monitoring program at RBG targets the subcomponents as summarized in Table 9 & Table 10. Table 9 summarizes the monitoring of RBG’s wetlands as they relate to RBG’s restoration goals. Table 10 summarizes the monitoring as it relates to the goals of delisting the HHRAP (delisting is anticipated in 2021). The monitoring activities are divided this way because delisting of the harbour incorporated delisting various beneficial use impairments (BUIs) that relate directly to Cootes Paradise and Grindstone Marshes. However, restoration and management of RBG’s wetlands are not solely focused on goals of the HHRAP, and restoration and management of these wetlands will continue after the Harbour is delisted as an AOC. As such, RBG has its own monitoring goals and activities for the wetlands.

The Key Performance Indicators RBG will use are:

- Area of submergent marsh
- Area of emergent marsh
- Area of meadow marsh
- % Wetland native plants
- Water Clarity or water quality index
- Common Carp abundance
- Winter muskrat lodges present
- Yellow Perch population

Table 9 Anticipated Monitoring Activities of RBG Wetlands related to RBG’s wetland restoration goals.

Monitoring Category	Component	2022	2023	2024	2025	2026
1. Plant Community	Submergent	X	X	X	X	X
	Transitional (wild rice)	X	X	X	X	X
	Emergent		X			X
	Meadow Marsh		X		X	
2. Endangered Species	Mussels, turtles, birds (Varying species by year)	X	X	X	X	X
3. Birds and Amphibians		X	X	X	X	X
4. Migratory Waterfowl		X	X	X	X	X
5. Fisheries Index	Electrofishing	X	X	X	X	X
6. Benthic Invertebrates	OBBN			X	X	
	Emergent traps			X		
7. Aquatic Mammals	Muskrat/beaver surveys	X	X	X	X	X

1. Wetland Plant Community monitoring as it pertains to the HHRAP, plus meadow marsh status as it pertains to Great Lakes wetland monitoring
2. Endangered Species monitoring (mussels, turtles, and birds)
3. Marsh monitoring for wetland birds and frogs/toads (Marsh Monitoring Program)
4. Migratory waterfowl – annually in the fall with assistance of volunteers (Long Watch). Index locations in Cootes Paradise East marsh and Hickory Bay, and Grindstone locations will be in Ponds 2-4.
5. Fisheries Index (39 long term August electrofishing transects)
6. Benthic Invertebrates – (potential student research project with focus on impacts to aerial insectivores and incorporating the use of emergent benthic invertebrate traps)
7. Aquatic Mammals (Winter muskrat den and beaver lodge surveys)

## Hamilton Harbour Remedial Action Plan Linkages

Within the HHRAP there are 12 Beneficial Uses Impaired (BUIs), for which 5 are directly measured within RBG properties and several additions that rely on the health of the properties. One of the 12 (BUI v) is currently listed as requiring further assessment to properly summarize its condition.

v - Bird or Animal Deformities or Reproduction Problems (measured by Environment Canada – under review)

vi - Degradation of Benthos (marsh criteria currently not established, no lead assigned)

viii - Eutrophication or Undesirable Algae

xi - Degradation of Aesthetics (no criteria currently established)

xiv - Loss of Fish and Wildlife Habitat

HHRAP BUIs with a direct link to RBG marshes.

iii - Degradation of Fish Population (measured by DFO in the harbour)

iii - Degradation of Wildlife Populations (measured by EC – colonial waterbird populations)

x- Beach closing and water contact sports

Table 10. Anticipated monitoring activities related to HHRAP

Connection	Monitoring Category	2022	2023	2024	2025	2026
Delisting Efficacy measure	Water Quality	X	X	X	X	X
Delisting	Plant Community – Submergent area	X	X	X	X	X
Delisting	Plant Community – Emergent area		X			X
Delisting	Aesthetics Monitoring	X			X	
Delisting	Benthos Population			X		
Efficacy measure	Sediment Recharacterization at sewage inlet points			X		
Efficacy measure	Bathymetry Map/ Sedimentation Rates					X
Efficacy measure	Fishway + Salmon Redds	X	X	X	X	X
Efficacy measure	Fisheries – carp/ overall YOY	X	X	X	X	X
Community Involvement	Marsh Monitoring Program	X	X	X	X	X
Plant protection*	Goose / Swan Nests & summer residents	X	X	X	X	X

\*The extent of nest monitoring will be reduced according to the recommendations of RBG's Goose Management 2015 Summary Report.

### 1. Water

- annual / biweekly, standard, restoration sites, delisting stations
- Single season projects
  - Chedoke Bay post actions (Pre (2016), year TBD for berm creation)
  - Hickory Bay (single year TBD)
  - CP1 (ongoing in support of Chedoke Cr remediation)
  - Pond 4 (single year TBD)

### 2. Plant community

- Submergent (annually 32 sites)
- Emergent coverage (2017, 2020)
- Emergent plant community (2016, 2019)
- Meadow marsh plant community (2017, 2020)

3. Aesthetics (Smart phone survey to be developed, Cootes Paradise Fishway interpretation cart, boat launch)
4. Benthos – OBBN monitoring in Cootes Paradise and Grindstone Marshes in 2024-25
5. Sediment Chemistry – contaminated areas (Chedoke, Westdale Inlet, Desjardins Canal and West Pond) updated in 2024-25
6. Sediment Deposition Rates – field work completed in Grindstone Marsh in 2026 and Cootes Paradise Marsh in 2025; the updated bathymetry map to be completed in 2026
7. Fishway (annually)
8. Fish – Salmon (annually, Spencer and Grindstone Creeks)
9. Fish -Young of the year monitoring (annually – August 32 sites)
10. Marsh Monitoring Program
11. Nesting geese/swans and summer residents
12. Photo records of key restoration sites updated – Westdale, Spencer Delta, West Pond, Mac Landing, Carroll’s Bay, Pond 1, Grindstone Elbow, and Chedoke Bay.

## Ongoing Planning

RBG will continue to participate in several HHRAP committees pertaining to water quality and land use in order to prioritize the significance of watershed issues, as well as report on progress towards the delisting of Cootes Paradise Marsh and Grindstone Marsh. These include: the Cootes Paradise Water Quality technical team, the Hamilton Harbour technical team, the BAIT committee, and appropriate Fish and Wildlife related committees. We will also participate in the Hamilton Conservation Authority Subwatershed Stakeholder Advisory Committee, the Hamilton and Halton Watershed Stewardship programs, the Cootes to Escarpment advisory group and the recently formed Lake Ontario Coastal Wetlands Working Group.

Table 11. HHRAP Related Committees

<i>Lead</i>	<i>Alternate</i>	<b>Committee</b>	<b>Lead Group</b>
Head of Natural Lands	Head of Education	BAIT - Bay Area Implementation Team	ECCC & OMECP
Head of Natural Lands	Head of Natural Lands	HHRAP Fish and Wildlife Committee	DFO & ECCC
Aquatic Ecologist	Head of Natural Lands	HHRAP Technical Team	ECCC
Aquatic Ecologist	Monitoring Ecologist	HHRAP Cootes Paradise Water Quality	OMECP
Head of Natural Lands	Aquatic Ecologist	Watershed Advisory Group	BARC

In support of projects to occur in this planning period, as well into the future, several summary reports will be generated. The anticipated list is found in Table 12.

Table 12. List of planned RBG reports and the anticipated year of completion.

<b>Report Topic</b>	<b>Year of Completion</b>
RBG Marshes Status for habitat and Fish and Wildlife Populations	2022
RBG Centre Storm water Management Plan	2022
Meadow Marsh Status following Plant Community Restoration Activity	2023
Water Quality Status and Progress towards Recovery	2023
Long Pond and Tributaries Assessment Report	2023
Treed Swamp Inventory and Strategy	2024
Sediment Condition for contaminated sites	2025
Benthic Invertebrates of Cootes Paradise and Grindstone Marsh	2025
Sediment Accumulation in Cootes and Grindstone	2026
Status of RBG Marshes Vegetation as it Pertains the HHRAP Targets	2026



## Potential Research Projects

Review of ongoing challenges has identified a list of potential research topics as well as research topics in progress (Table 13). Undertaking research at Royal Botanical Gardens requires a research permit administered through RBG’s Science Department. Royal Botanical Gardens welcomes partnerships projects to inform management activities. Studies to resolve the status of HHRAP delisting criteria with partner agencies are a part of the research project list.

Table 13. Summary of Research topics of interest for the RBG wetlands, the anticipated lead and partner agencies, and an anticipated year of completion. (DFO = Fisheries & Oceans Aquatic Sciences Laboratory)

Theme of Study	Project	RBGs Status	Partner Group
Water Quality	<ul style="list-style-type: none"> <li>Pesticides and Pharmaceuticals in Grindstone Creek Marsh system</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Inventory Pesticide runoff into wetlands and the effects</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Watershed herbicide effect on wetlands plants</li> </ul>	RBG lead?	
	<ul style="list-style-type: none"> <li>Neonicotinoids testing in invertebrates</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Dissolved Oxygen loggers in the marshes</li> </ul>	Partner	DFO lead
	<ul style="list-style-type: none"> <li>Updated Marsh Bathymetry Maps</li> </ul>	RBG lead	
	<ul style="list-style-type: none"> <li>Historical Sediment accumulation in Cootes Paradise and Grindstone Marsh</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Pre-European bathymetry map – by sediment cores (potential student research project)</li> </ul>	Partner	
Plants	<ul style="list-style-type: none"> <li>Allopathic effect of Eurasian Manna Grass and <i>Phragmites</i> on native plant species</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Seed bank studies in meadow marshes (complete with sediment core study)</li> </ul>	RBG lead	
	<ul style="list-style-type: none"> <li>Carbon Storage relationships</li> </ul>	Partners	
Fish and Wildlife	<ul style="list-style-type: none"> <li>Inventory and tracking of Map Turtles to determine population trends and habitat use aligning with the fish telemetry study.</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Fish telemetry with DFO and OMNRF</li> </ul>	Partner	DFO lead
	<ul style="list-style-type: none"> <li>Mussels Carroll’s Bay – are they there and are they impacted by harbour sediment metal contaminants?</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Sediment ammonia and overwintering turtles and frogs in West Pond</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Groundwater quality entering at herptile overwintering sites</li> </ul>	Partner	
	<ul style="list-style-type: none"> <li>Radio tracking of female Blanding’s turtles to nest sites to protect the eggs</li> </ul>	RBG lead	
	<ul style="list-style-type: none"> <li>Micro plastics in Cootes Paradise and Grindstone Marsh</li> </ul>	partner	
	<ul style="list-style-type: none"> <li>Marsh Amphibian reproductive success limitations</li> </ul>	partner	
	<ul style="list-style-type: none"> <li>Blanding’s Turtle hatchling survival success</li> </ul>		
	<ul style="list-style-type: none"> <li>Groundwater Springs map – Grindstone Marsh (Cootes Paradise lowlands completed)</li> </ul>	RBG lead	

## **Outreach and Education**

### ***Community Involvement***

Public involvement is essential and the Gardens partners with groups such as the [Bay Area Restoration Council](#) (BARC) and RBG Volunteers and Biodiversity Guardians. These partnerships are to engage the community to participate and learn how they can be involved in the stakeholder plans that affect inflowing water and are fundamental to the recovery and sustainability of the wetlands. Remediation of Chedoke Creek will play a prominent role in partnership with the City of Hamilton. Princess Point water access location will provide an onsite linkage between the watershed projects and the environmental condition of the adjacent bay, with wild rice sustainability growing in the bay the ultimate measure of success. In addition, monitoring results of the ongoing wetland recovery are presented each February at an open house at RBG Centre. Other opportunities to involve the public include marsh replanting events, monitoring of amphibians, shoreline, and stream cleanups, TurtleWatch, and the Cootes Paradise Fishway. In addition, 2022 will be noteworthy within the recovery project as the 25<sup>th</sup> anniversary of the Cootes Paradise Fishway a year of World Fish Migration Day celebration. This will involve an event at the Fishway.

### ***Education***

RBG will continue to work closely with BARC to provide outreach and volunteer opportunities with the local community. The Classroom Mini-Marsh program allows young students to actively participate in the restoration of Cootes Paradise Marsh. Marsh plants are grown at school and later returned to RBG to be planted in Cootes Paradise Marsh. RBG also coordinates multiple volunteer marsh plantings with BARC to accelerate plant regeneration in the marsh.

At the Nature Interpretive Centre (NIC) and RBG Centre, RBG will deliver educational programs themed on the restoration of the wetlands at both the primary and secondary school levels. Programs offered each year include Biodiversity/Project Paradise, Fishway Demonstration, and Interactions in the Environment/Conservation and Stewardship, with several thousand school children expected to attend each year.

Additional ways in which RBG plans to disseminate project information include; redevelopment of the main display at RBG's Nature Interpretive Centre on the history of the wetland and its restoration, updating the downloadable data package for school project use, a mobile phone trail experience linking with our current GEOTRAILs package, and updating several interpretive signs along RBG trails at the marsh. An updated in-class learning unit will be developed with the support of multiple school boards. In addition, RBG will continue to support post-secondary projects and field trips and will further develop these tours with specific themes pertaining to both Invasive Species and Species at Risk. Available RBG Factsheets that will be updated include Cootes Paradise Fishway, Amphibians, Waterbirds, Mussels, Breeding Birds, and Reptiles. Annual Marsh Status Update. In addition, existing status monitoring data will become more easily accessible for community information as well as research projects as digital information platforms evolve. This already includes the use of Great Lakes Datastream web portal (water quality).

### **Points of Engagement**

1. Fishway interpretation and signage
2. RBG educational school programs
3. RBG Centre and Nature Interpretive Centre and RBG Centre displays
4. Revitalized RBG Boathouse Area
5. Princess Point Canoe Launch at the mouth Chedoke Creek Watershed
6. Hendrie Parks Woodland Garden Stormwater Wetland
7. Trail interpretive signage
8. Webpage for project information, water quality data, and summary reports
9. Great Lakes Datastream online portal
10. Restoration planting enclosure fence signs
11. Annual open house
12. Annual HHRAP Science workshop

## Project Descriptions

Below includes 17 projects. The implementation of the projects is subject to funding and water level limitations with the water level having the potential to vary 1.5m between years limiting access. Goose herbivory and population control will occur in support of the various projects associated with planting. The overabundant goose population is a product of open turf areas found beyond the marshes. The projects are centered around the following themes and priorities

1. Exclusion and removal of Common Carp from the marsh areas to facilitate aquatic plant growth.
2. Emergent marsh planting to ameliorate Lake Ontario water level regulation.
3. Repair of historically damage eroding shorelines in Cootes Paradise Marsh, focusing on Hickory Island, Kingfisher Pt, Princess Pt, Sassafras Pt and Bulls Pt through bioengineering
4. Meadow Marsh restoration through invasive plant management with potential alignment with pollinators regional strategies.
5. Communication and monitoring of environmental conditions in the marshes.
6. Review and future strategy for the ongoing management of Grindstone Marsh, particularly the outer marsh.

### **1. The Cootes Paradise Fishway**

The goal of the project is to exclude non-native Common Carp (*Cyprinus carpio*), while maintaining free passage for other fish species. The Fishway was built in 1996, beginning operation in 1997. It utilizes 5cm wide grates to allow free passage of water and smaller fish, while screening out larger adult carp. Six fishway cages are seasonally operating to move native fish species in and out of the marsh in association with spawning migrations. Aside from the carp exclusion function, the operation provides valuable monitoring information of water quality and fish populations, a primary visitor contact point, rich public educational experiences, and the elimination of harbour powerboats from the sensitive and shallow habitats of Cootes Paradise Marsh. Over time the excluded carp population is expected to dramatically decline as Cootes Paradise Marsh also represents the primary spawning location for carp at the western end of Lake Ontario. Ongoing maintenance items are expected to increase, as the structure is now over 25 years old.

Common Carp historically reached 90% of the marsh fish biomass, equivalent to an estimated 800 kg/ha, resulting in loss of most native species across all biological community levels, including plants, invertebrates, fish, birds, mammals, and multiple species at risk. Ongoing carp exclusion experience at RBG indicates that associated issues begin at densities of over 20 kg/ha. Common carp arrived in North America the late 1800's and were established as a dominant species at RBG by the 1940's. Most of the wetland loss occurred between 1937 and 1950. The first carp management project at RBG was initiated in 1951. Key drivers of carp population include eutrophication of the marsh, anoxia, and ammonia issues of the hypolimnetic zone of the harbour, excessive inputs of watershed sediment, and alteration of the natural marsh water cycle.

In 2022, World Fish Migration Day and the Fishways 25<sup>th</sup> anniversary will be celebrated with visitors and great opportunities for outreach and education. World Fish Migration Day is celebrated at the Fishway, every alternate year.

### **2. The Spencer Creek Delta Project**

The primary goal of the project is to continue the re-establishment of emergent marsh along the lower Spencer Creek channel to Bulls Point to create a cattail biofilter for inflowing contaminants, garbage, and sediment. This then provides protection for the sensitive marsh habitat to the southeast (the Inner Bay) as well as focal point for litter cleanup activity. Secondly the project helps re-establish a migratory corridor for various fish and wildlife species, creates marsh habitat, and aids visitor travel in canoes and kayaks. This project involves the re-establishment of the missing emergent marsh portion through Cootes Paradise Marsh through emergent marsh replanting now focused to the Ratt Island/Bulls Pt area. Upwards of 50,000 cattails to be planted is anticipated. Extensive temporary fencing will be used to prevent goose browse during the vegetation

establishment period as well as to influence sediment deposition locations. Selective goose population control will also be implemented in this region to prevent further issues with the existing overpopulation.

Overall, Cootes Paradise Marsh is the main river mouth of Hamilton Harbour with its main tributary Spencer Creek. The watershed of Spencer Creek is connected to over half of the lands draining to the harbour and includes the communities in West Flamborough, Dundas, Ancaster, and part of Waterdown. Historical channel loss was a result of a variety of activities. In the 1800's, the lower reaches were ditched, first behind a now abandoned rail line (1852), and then into the Desjardins Canal (1870's). Subsequently the last 4-5 km of channel just upstream of Hamilton Harbour was completely lost with the loss of the wetland plants in Cootes Paradise Marsh. With the exclusion of carp in 1997, these plants are returning, helping to provide a framework for channel formation. In addition, in 2001 the creek channel was shifted out of the Desjardins Canal, through removal of debris at an old channel crossing point along the canal edge. This allowed the creek to begin channel reformation through natural sediment depositional processes and plant growth.

This project moves at the rate of natural processes but continues to be enhanced through strategic wetland plantings at the mouth of the ever-lengthening channel. As of 2021, about 1.6 km of new channel has reformed and 75,000 plants had been planted (2010-2021). In 2021 following several years of planting losses, low water levels facilitate regeneration of much of the delta. The principal plant used to build the Channel edge/biofilter is cattail (*Typha sp.*). Smaller scale patches of invasive plants including small *Phragmites* patches and Eurasian Manna Grass are also targeted for further management in the upper delta, with management in progress and these species substantially removed as of the end of 2021. Wild rice and yellow water lily will be planted in the inlets along the channel. Species at Risk associated with this habitat area currently include Least Bittern, various turtle and mussels, Spotted Gar, American Eel, and Bald Eagles.

### **3. Cootes Paradise Shoreline Repair**

The goal of the project is to restore undercut eroding shorelines by naturally stabilizing (bioengineering) the shore with a 4m wide band of plants using emergent marsh and shrub thicket plants. Cootes Paradise Marsh has a total of 27 km of shoreline, 6 km of which remains without vegetation, while Grindstone marsh has about 3.5 km without vegetation. Of this, in Cootes Paradise about 700 m will also require physical repairs prior to planting. The shoreline for physical repair falls into two broad categories, including shorelines historically armoured with gabion basket/armour stone (250 m) and collapsing forested bank/sand beach shorelines. The priority areas for restoration between 2022 and 2026 are the open shore locations of the inner Bay of Cootes Paradise Marsh, the adjacent armour stone shorelines, and eroding bank/beach at Bulls Point, Princess Point and Kingfisher Point, and the islands (320 m). Removed armour stone will be recycled into the most severely undercut locations as support fill were possible. In Grindstone Marsh shorelines of focus will be the unvegetated sections of Sunfish Pond and Osprey Marsh. In many cases temporary fencing will be needed to prevent goose browse of public trampling of the plants during the establishment period. The remaining eastern shoreline is almost entirely composed of fill, a result of Hwy 403 construction and links separately with projects associated with the Chedoke Creek Inlet.

The erosion is a consequence of the historical loss of aquatic vegetation, generating long wind fetch and waves and was worsened in several locations during 2017 and 2019. The armour stone was installed in the 1970s to protect fragile upland plant communities from collapsing into the marsh. Most of the shorelines represent sensitive habitats, often steep sandy shorelines of Old Growth Forest, with the lands part of the Cootes Paradise Area of Natural and Scientific Interest (ANSI). As recovery of the marsh vegetation is occurring through a variety of actions and waves are dampened and reduced, shoreline repair can be initiated. Natural regeneration is not expected due to Lake Ontario Regulation, which currently generally prevents low water nursery conditions for natural reestablishment of appropriated vegetation.

#### **4. Cootes Paradise Inner Bay Wildlife Project**

The goal of the project is to facilitate the protection of migratory waterfowl and Species at Risk through establishment of sheltered marsh area. The project location is west Cootes Paradise Marsh, south of the Old Desjardins Canal, with an area covering 20 hectares. The project works in tandem with the Spencer Creek Delta project creating protect areas with emergent plantings and separating the area from watershed water quality impairments and reduce human disturbance. Establishment of buoys to indicate public access restrictions will also be part of the project. Planting emergent plants is necessary to overcome the limiting natural seedling regeneration effect of Lake Ontario water regulation as well as temporary fencing to protect plantings from goose browse during the establishment. The large planting areas at the bays eastern end incorporates natural bathymetric contours providing a pinch point to define the bay. Emergent plantings will also be completed along the shoreline lengths still lacking in emergent marsh vegetation (380 m) and wild rice, and yellow and white waterlily will be reintroduced. Smaller scale patches of invasive Eurasian Manna Grass are also targets of removal in the bay, to be removed prior to replanting with native species. The project will include signage at the eastern end entrance of the bay to help manage human activity. Species at Risk associated with the area include all aerial insectivore birds, Bald Eagles, Least Bittern, American White Pelican, and various turtle and mussel species.

#### **5. Meadow Marsh Invasive Plant Management**

Meadow marsh is a priority habitat for recovery in Lake Ontario coastal marshes and is used as an environmental indicator for Lake Ontario water level regulation. Both Grindstone and Cootes Paradise Marsh have large areas of meadow marsh and containing multiple oxbow ponds but are dominated by highly invasive grass species. The RBG goal for this habitat is to restore a native plant community long dominated by native plants. The combined total area of this habitat at RBG is mapped at 45 ha. Although much of the potential meadow marsh zone is vegetated, the plant community present is almost entirely non-native and thus not of useful character to most insect and wildlife species. Two extremely aggressive non-native plant species dominate RBG's meadow marsh areas, Common Reed (*Phragmites australis*) and Eurasian Manna Grass (*Glyceria maxima*). Secondly Reed Canary Grass (*Phalaris arundinacea*) has substantial populations including in lower Borers Creek are of Cootes Paradise, and in middle Grindstone Marsh.

RBG started managing *Phragmites* in 2013 and *Glyceria maxima* in 2016 and has had great success in both projects. Management of *Phragmites* is left to touchup treatments for the remnants of the past stands and monitoring for new stands. *Glyceria* occupies a much larger area than the *Phragmites* and is intermixed in large areas of cattail growth. This management required specific conditions of dry ground and dormant native species. Currently approximately three quarters of RBG *Glyceria* had been managed at least once and if conditions permit, all of RBG's *Glyceria* stands will have received at least one treatment by the end of this 5-year period.

Mapping of the meadow marsh zone has identified 31 subareas containing meadow marsh in Cootes Paradise Marsh and 14 in Grindstone Marsh (water boundaries and peninsulas were used to identify separate meadow marsh areas from one another -Appendix A). In Cootes Paradise Marsh, the 31 meadow marsh areas (which either currently contain meadow marsh vegetation or have potential to) make up a total area of 36 ha. In Grindstone Marsh, the 14 sites consist of about 6 ha of meadow marsh area. Future enhancement projects of the meadow marsh zone will include management of these two invasive species as well as native planting efforts. Overall efforts will be prioritized based on the quality of the existing habitat and thus the inclusion of native species (more pristine habitats will be prioritized over impaired areas); area made up of invasive species (both area of the invasive species and proximity to other invasive stands will be considered and small stands which are more isolated will be given greater priority); existing efforts to remove invasive species (areas for example that contain areas cleared of *Phragmites* will be given priority over areas without previous invasive species management); areas supporting species at risk will be given higher priority. A priority area of focus is around President's Pond in Cootes Paradise Marsh, and where Species at Risk including turtles and Prothonotary Warbler occur. Given the diversity of wildflower species that would occupy the meadow marsh and its large area, its restoration would significantly contribute to the provincial pollinator strategy.

## **6. Wild Rice and Deep-Water Plants**

The goal of this project is the re-establishment of wild rice, water lily species, floating leaf pondweed, and tape grass as dominant species in the deeper water areas of the marsh. These species exist at very low population levels currently due to poor late summer environmental conditions and small seed bank. Ongoing projects are underway to improve environmental growing conditions to the point where the species can again be abundant. Wild rice, an annual (starting from seed each spring), is considered one of the cornerstone plants of the Gardens' wetlands. To ensure this short-lived species is not extirpated again, a captive population is maintained within the Gardens' plant propagation area.

Historically, wild rice (*Zizania sp.*) dominated the local wetlands, with this species ideally suited to the highly variable water level regime of Lake Ontario. The variability places extensive disturbance on the wetland through regular flooding, drying, and freezing, favouring "annual plants" such as wild rice. This species was lost from the areas many decades previous, however only a few years into the current restoration process, a few individual plants spontaneously appeared in the recovering Hendrie Valley Ponds. These plants were Southern Wild Rice (*Zizania aquatic*), a species nearly extirpated from Canada. This inspired a project focused on re-establishing the species in 2001.

## **7. Stream Habitat Improvement**

The goal of the project is to stabilize areas of large-scale bank erosion to improve water quality and stream habitat within RBG properties. Multiple north shore tributaries of Cootes Paradise Marsh, including Mink Brook, Long Valley Brook, Borers Creek and Hickory Brook are the target as well as the Spring Creek associated with urban drains from McMaster. At Hickory Valley Brook there are currently two areas of erosion for repair along Hickory Valley trail. Lower Grindstone Creek also has several erosion points along the carp exclusion berms in Hendrie Valley as well as past damage at the location of the Plains Rd West bridge crossing. Borers Creek is subject to ongoing large scale debris jams resulting from ongoing dead falling ash trees as well as destabilized flows from Waterdown urban runoff. Urban runoff contamination and erosion from McMaster University runoff into the small spring feed creek in Mac Landing Inlet (part of the inner bay) will begin mitigation through changes via the Campus Masterplan as well as proposed associated LRT transit hub. At this hub Main St. West drainage was incorrectly connected to this campus storm drain further damaging the outlet area. In addition, extensive meadow marsh area and Eurasian Manna Grass management will be associated with the projects. Species at Risk associated with these areas are various turtle species as well as several terrestrial area herbaceous plants.

Property acquisition is also targeted for this project for below escarpment headwater areas of multiple Cootes Paradise small tributaries. In December 2015, Royal Botanical Gardens previously purchased a 42.5 acre farmed property in the Niagara Escarpment Plan area (targeted for acquisition under multiple natural heritage strategies). The property is one of a short list of highly erodible fields below the escarpment still farmed. The headwater tributaries of Mink and Long Valley Brooks continue to be farmed through (i.e., no stream buffers and row crops through the stream bed). One property owner is associated with these agricultural fields. Acquisitions and renaturalization is part of the RBG 25-year masterplan as well as the Cootes to Escarpment Ecopark System.

## **8. RBG Centre Urban Runoff Management**

The goal of this project is to provide water quality improvement to RBG Centre's stormwater runoff before the waters reach the natural environment in Grindstone Marsh. The short-term goal of the project is to reduce runoff volume from a 1 in 5-year rainstorm by 50% and have the water entering the ponds consistently meet water quality guidelines for aquatic life. RBG Centre and parking lot impervious surface runoff drain under Plains Road, discharging through a pipe located in the Woodland Garden of Hendrie Park Garden. This water then follows a spring fed ravine to the Hendrie Valley oxbow ponds. The large volumes of stormwater runoff are damaging to the sensitive oxbow pond habitat and are causing significant slope erosion in the Woodland

Garden and in the forested spring fed ravine. The larger flows have also resulted in the flooding of the marsh carp exclusion structure found at the connecting point between Pond 2 and Grindstone Creek.

Stormwater as a resource is an element of the RBGs new 25-year Master Plan, with this location a priority project initiated in 2021, following multiple large scale rain events reflective of Climate Change overwhelming the system. The already failing old drainpipe broke causing collapse of the ravine slope. Sediment washed downstream including into Pond 2 wetland. Emergency repairs were made to reestablish a stable bank and discharge system. Substantial makeover of the stormwater system is a priority element of the RBG 25-year Masterplan to be accomplished in both the near and long term. This large project will involve a contractor to evaluate the current system and plan for the best way to manage the runoff while protecting the ravine and wetland habitat, combined with the creation of a formal wetland feature adjacent to Hendrie Parks Woodland Garden for water quality improvement. This feature will have stormwater interpretation and educational opportunities as a large accessible feature boardwalk is also planned to connect Hendrie Park to the valley through this same area.

Similar issues are emerging throughout the surrounding ravine systems upstream of the marshes, exacerbated by Climate Change. Within the Hendrie Valley Ponds system, a nearby outflow associated with a Plains Road a stormwater outfall (City of Burlington), located at the upper end (southeast corner) of Pond 4 and will require monitoring and ultimately mitigation. Species at Risk associated with the project are turtles.

## **9. Chedoke Inlet Project**

The principal goal of the Chedoke Bay project is to prevent contaminated water from entering and dispersing through the wetland habitat and wetland public access location (Princess Point) and to shorelines left over from infilling of the marsh. Secondly it is to use the high-profile public access point as information and education location for visitors for urban stormwater and combined sewer overflows. Chedoke Creek and Inlet is in the southeast corner of Cootes Paradise Marsh at the mouth of Chedoke Creek. This creek is the poorest quality water flowing into the marshes and has a long history of supplying impaired water quality to the marsh and harbour. As a short-term step RBG has acted at the mouth of the creek by creating a berm built of Christmas trees to extend the creek levee out into the bay which will help to contain the contaminated water within the creek channel and reduce mixing with the wetland habitat. For the longer term the RBG Masterplan identifies recreation of the infilled delta feature and renaturalized shorelines. A key measure of success will be the ability to grow wild rice within a pen that eliminates goose in the bay. This project will be combined with a larger Lower Chedoke Creek Environmental Assessment lead by the City of Hamilton, one of several large-scale new initiatives to restore creek water quality.

Chedoke Creek continues to provide untreated sewage into Cootes Paradise Marsh, and the Main King CSO tank continues to be the second largest location by volume for sewer overflows for Hamilton Harbour overall. Coordinated monitoring continues to occur between Ministry of Environment Conservation and Parks, City of Hamilton and Hamilton Conservation Authority with information shared at the HHRAP Cootes Paradise and Grindstone Marsh Water Quality Technical Team. Starting in 2021 the City of Hamilton also started publicly posting overflows and water quality monitoring results for the CSO tanks and the creek.

Following the 2014-2018 Chedoke sewage spill the City of Hamilton has undertaken substantial background planning to both remediate the spill and plan the overall needed remediation of this creeks water quality. Areas of severe contamination have been identified for dredge and will be mostly completed in 2022. Moderate contaminations areas have been identified for mitigation work through sediment inactivation and floating treatment wetlands and will be trialed in 2022 for potential future mitigation work in the marsh. A second severely contaminated area in the inlet requires further planning for mitigation.

The original creek channel and inlet was historically filled, ditched, and relocated through the creation of the Kay Drage landfill, Hwy 403, and Macklin Ave. with the low water channel further lost through the loss of wetland vegetation via water pollution and high densities of Common Carp. The creek is currently attempting

to reform its low water channel and delta on the current sediment delta in the bay. The delta area contains no wetland vegetation due to the ongoing water pollution. The project will continue to re-contouring the delta to create a natural riverbank levee, followed by replanting with cattails. Species at Risk associated with the site currently include aerial insectivores and multiple turtle species.

### **10. Borers Creek Delta Invasive Plant control Project**

The goal of the project is to eliminate invasive plants that are now moderately established and encroaching into the remnant ecosystem (about 4ha). This is a sub project of the broader meadow marsh initiative due to its unique semi-isolated location. Borers Creek delta is a large, isolated site located in the northwest corner of Cootes Paradise Marsh. Borers Creek is the 3<sup>rd</sup> largest tributary of Cootes Paradise connecting into Spencer Creek in the west area of the marsh and helping form the creek levees that create nearby West Pond. The site contains remnant meadow marsh dominated by Lakebank Sedge as well as Silver Maple/Swamp White Oak Forest and includes several small oxbow pond features. European Manna Grass is the principal invasive species penetrating in from Cootes Paradise Marsh area, but significant amounts of Multiflora Rose, Common Buckthorn and Reed Canary Grass are also establishing. The creek drains from Waterdown and urban runoff has substantially destabilized the creek and is also causing substantial erosion as well as deposition of debris. Along with elimination of invasive plant species the area requires ongoing management of debris jams in the creek and stream bank remediation project where erosion is collapsing an old growth forest upland area containing rare plants.

### **11. Sunfish Pond & Long Pond Project**

The goal of this project is the recovery of clear clean marsh water habitat with the aid of carp exclusion. Sunfish Pond and Long Pond are part of the historical outflow channel of Cootes Paradise Marsh. Construction of rail lines in the 1850s reset the outflow to an alternated location, leaving this area a 7-hectare, distinct marsh area within the Grindstone Marsh complex. The system is impaired by remnant carp populations and watershed suspended sediment and potentially ongoing sewage input. Exclusion of the harbour's Common Carp is at Sunfish Pond using an interim strategy of a small carp barrier and 300m Christmas tree berm. The structure was replaced in 2019 to accommodate higher lake levels and a second barrier was added at the outflow of Long Pond. Long Pond is distinctly named as it is partially separated from Sunfish Pond by a rail line berm. Aside from being coastal marsh habitat, it is the primary location for the Endangered mussel species Lilliput at RBG. Actions to continue the recovery of water quality start with an updated inventory of conditions report and recommendations.

Work from 2022 to 2026 to facilitate nature regeneration of the plant community will including the ongoing maintenance of the berm, operation of the carp barriers and removing the remainder of the Long Pond carp population and continuing to monitor for subsequent carp invasions. Establishing emergent marsh through planting around the entire perimeter will also be a focus. Sunfish Pond barrier system will have to maintained to provide carp protection for Long Pond and in recent years has been regularly compromised by the recovering beavers tunneling through the berm. Following the removal of most of the carp a drop in suspended solids has been detected in water quality sampling. A mirrored drop in phosphorus levels has not. occurred indicating the need to further investigate water quality of the tributaries for sources of sewage Partnering with other agencies to improve inflowing water quality will also be a priority moving forward. Long Pond is also unique containing meadow marsh area not dominated by Eurasian plant species. Multiple mussel and turtle Species at Risk are associated with the site.

### **12. Grindstone Marsh Delta (the elbow)**

This project is located at the mouth of Grindstone Creek in Hendrie Valley Sanctuary and adjacent to the RBG's Laking Garden. The goal of this project is to provide an interim system to exclude carp and watershed pollution through reconstructed riverbanks and carp barriers, as well as reestablish shoreline emergent vegetation through planting. As with Cootes Paradise Marsh, the loss of wetland plants resulted in the loss of the last several kilometers of wetland river channel in the Grindstone Creek Delta. In January of 2000,



following the success of the previous years' smaller-scale pilot projects, and the lack of the planned carp barrier for the marsh area through the HHRAP, the Gardens implemented an innovative experimental wetland restoration project, re-establishing a portion of the channel as well as creating carp barriers to protect a portion of the wetland. Used Christmas trees collected by local municipalities formed the riverbanks, helping to recreate about 1 km of natural channel and redefine and protect the wetland areas. These marsh areas are called Osprey Marsh and Blackbird Marsh (about 5 hectares), an area historically called the "elbow". The project is intended as an interim measure until longer term water quality improvements and carp elimination can be accomplished.

Blackbird & Osprey Marshes contain four small carp barrier structures inserted into two 450m temporary berms/riverbanks, blocking carp access to the wetlands while maintaining the natural flow of water and movement of organisms. Over time, the Christmas trees naturally biodegrade, leaving a build-up of sediment and reeds as a riverbank. However, the height of the riverbanks must be maintained above the lakes maximum level to prevent carp access, and as a result the berms are annually augmented with additional trees. In addition, the growing population of beavers now tunnels through the berms compromising the carp exclusion function with repairing these tunnels and ongoing project. Further the 2017 and 2019 record breaking water levels have highlighted faults in the interim Christmas tree berms overtopping the ability to block carp. Berms are currently upwards of 2m tall in some locations. The experimental barrier structures were replaced with upgraded metal versions in 2013 & 2014 and made taller in 2021, and significant portions of the berms were relocated, expanding the marsh areas. Additional berm adjustments are possible. As with the other carp exclusion projects, the restriction of carp from their reproductive areas is resulting in the decline of the overall harbour carp population.

Osprey Marsh berm has not been able to be properly maintained to be effective in the highwater levels with half of the berm constructed of dredged marsh sediment and is relatively inaccessible except under very low lake levels. This section is continually degrading and is currently the lowest portion of the berm and requires a substantial rebuild, but in a very difficult to access location. Mitigation to this section is required before carp can be blocked from entering the marsh in high water levels. Other invasive species, including *Phragmites* and Eurasian Manna Grass, are also targets of management as is the re-establishment of emergent plants along the newly formed riverbanks and interior open shorelines. In addition, the most downstream 100 m of Blackbird Marsh berm will be relocated and rebuilt to match the actual edge of Grindstone Creek. Species at Risk associated with the area include multiple turtle and mussel species, with several other species candidates to return with the improving habitat.

### **13. Hendrie Valley Oxbow Ponds and Invasive Plants**

The goal of this project is to exclude carp from four of the five ponds through invasive species management with existing barriers and to repair Grindstone Creek bank at Pond 1 and Pond 3. As with the other harbour connected wetlands, this area requires ongoing management of berm height to ensure carp are excluded while maintaining native fish migrations, such as the Northern Pike. The five ponds form a 15-hectare oxbow pond system located along the upper portion of Grindstone Marsh, within the Gardens' Hendrie Valley Sanctuary. All the ponds were damaged by carp during high water levels in 2017 and 2019 and received berm upgrades to recover the sagging creek bank carp exclusion berms. Restoration of the pond most downstream to the lake and not spring feed – was initiated in 2001, with the berm rebuilt and replaced in 2013 and further upgraded in 2021. This pond has proven more challenging to maintain carp exclusion; however, with ongoing efforts it continues to recover its vegetation naturally. The fifth pond located on the north side of the creek channel has been beyond the capacity of staff to recover, however, is an intended project during the period of this plan.

Restoration of three of the four ponds was the first projects initiated (1994) within the Remedial Action Plan, as the wetlands were the primary remaining spawning location of Northern Pike. They are also the primary location of the remaining Species at Risk population of Blanding's Turtle. The inflowing extensive spring waters are of good quality, maintained by several large springs; however, the wetland plants and flooding patterns were significantly degraded and impacted by carp and watershed urbanization. Once the carp were

successfully excluded in 1999, the ponds rapidly recovered clear water and the associated plants community and became among the finest examples of oxbow wetland habitat at the western end of Lake Ontario. Ongoing watershed urbanization in Waterdown and Climate change are posing further challenges to maintain both clean water and carp exclusion.

#### **14. Outer Grindstone Marsh**

Outer Grindstone Marsh represents a unique situation within RBG wetlands and the HHRAP. It is associated with several delisting targets including water quality and plants but has no carp exclusion. This marsh area is currently nearly devoid of aquatic vegetation. This marsh remains independent of the interim carp control initiatives being applied to the remainder of RBG marshes due to the large open connection to the harbour. In relation to the plant delisting and recovery targets, it represents the bulk of the target total area of potential aquatic vegetation area for Grindstone Marsh (about 22 ha) as well as adjacent littoral zone aquatic vegetation of 17 ha behind Carrolls Point. The key stressors are inflowing watershed sediment and the carp of the harbour. Within the HHRAP the area currently serves as the measure of marsh sustainability (a marsh restoration experimental control), reflecting if underlying stressors mitigated.

Outer Grindstone Marsh, due to the loss of aquatic vegetation, has become synonymous with the term Carroll's Bay, a term historically applied to the deeper open water at the south end of the inlet. The inlet is in the Northwest corner of Hamilton Harbour at the mouth of Grindstone Creek with the bed of entire inlet to the high-water mark owned by RBG. Grindstone Creek watershed is 89km<sup>2</sup>, with the creek mouth marsh extending 2/3 of the way to the end the harbour inlet of Carroll's Bay.

Actions will include monitoring of water quality, birds, fish, benthos, and aquatic plants as per the monitoring schedule. Shoreline restoration work was completed between 2016-17 in partnership with CN Rail resulting in the repair of 300m of historically damaged shoreline (former water's edge road) and continues to remain stable. Floating buoy signage will continue to be seasonally installed at the outer edge of the marsh to inform harbour boaters of the shallow water and the sensitive species still present. There is potential for creation of a berm along the Grindstone Creek lower water channel, like the Elbow and Sunfish Pond, however a potential project will need to overcome the thick bog like strata underlying the marsh (>50ft) investigated through Borehole work in 2021. RBG Species at Risk related activities will involve aerial insectivore birds, turtles, and freshwater mussels.

#### **15. Grindstone Marsh Carp Exclusion Updated**

The feasibility of establishing a single carp barrier at the Valley Inn bridge crossing is recommended for review by HHRAP partners. Several significant issues have arisen driving a re-emphasis of this original HHRAP recommendation. These include higher lake levels limiting carp exclusion ability with the interim upstream berms, rising beaver populations which then tunnel through carp exclusion berms compromising integrity, and the current lack of a recovery timeline for water quality and thus the needed change in the fish community structure. All these factors are resulting in the ongoing extirpation of native species from the Grindstone Marsh system as well as year-to-year failures of the various carp exclusion projects. Longer term carp exclusion is anticipated to be needed for the likely to arrive additional Asian Carp species. A carp barrier located at the Valley Inn bridge was an element of the original HHRAP Fish and Wildlife recovery strategy (1992). Sediment strata investigations have also recently been undertaken (Boreholes), to potentially link in a berm system for Outer Grindstone Marsh.

#### **16. Floating Wetland Rafts - Temporary**

The goal of the project is to establish a technique for creating biodegradable floating wetlands for establishing emergent marsh in locations with ongoing water quality challenges. The floating wetlands can be used in sites such as West Pond and Chedoke Bay in Cootes Paradise where algae are dense, and otherwise smoother regenerating plants. The use of floating wetlands is prescribed for the Chedoke sewage spill remediation and is already in progress to remove accumulated excess nutrients. Floating wetlands for the Chedoke spill

remediation are based on removing/harvesting vegetation from the rafts, with the rafts ultimately requiring total removal as the frames are constructed from non-biodegradable materials. Floating wetlands made of entirely biodegradable material will be trialed with the intention of using them as both temporary water quality improvement features at sites of poor water quality as well as a new means to established emergent marsh plants in areas priority areas. This includes areas where the combination of poor water quality, and waves or water levels prevent the establishment of new emergent plants (i.e., Spencer Delta and Hickory Island Cootes Paradise and outer Grindstone Marsh). Rafts of up to 20ft across and that float for several years to allow emergent plants to mature before sinking are the objective.

### ***17. Community Involvement***

Public involvement is essential and the Gardens partners with groups such as the Bay Area Restoration Council, Stewards of Cootes Watershed, Hamilton Naturalist Club, Burlington Green, Field and Stream Rescue, Trout Unlimited local chapter, Dundas TurtleWatch and RBG Volunteers to engage the community to participate and learn how they can be involved in the stakeholder plans that affect inflowing water. In addition, monitoring results of the ongoing wetland recovery are presented each February at an open house at RBG Centre. Other opportunities to involve the public include marsh replanting events, monitoring of amphibians and marsh birds through the Marsh Monitoring Program, monitoring of migratory waterfowl, shoreline and stream cleanups, Turtlewatch, and the Cootes Paradise Fishway. The scale and diversity of activities justified the creation of a volunteer coordinator position at RBG, which started in 2019.

## Key Performance Measure Results 2016-2021

The following measures were used to measure progress and success

1. Area of submergent marsh, emergent marsh and meadow marsh
2. % Wetland native plants
3. Area of Wild Rice
4. Water clarity or water quality index
5. Biomass of common carp
6. Winter muskrat lodges present
7. Yellow Perch population

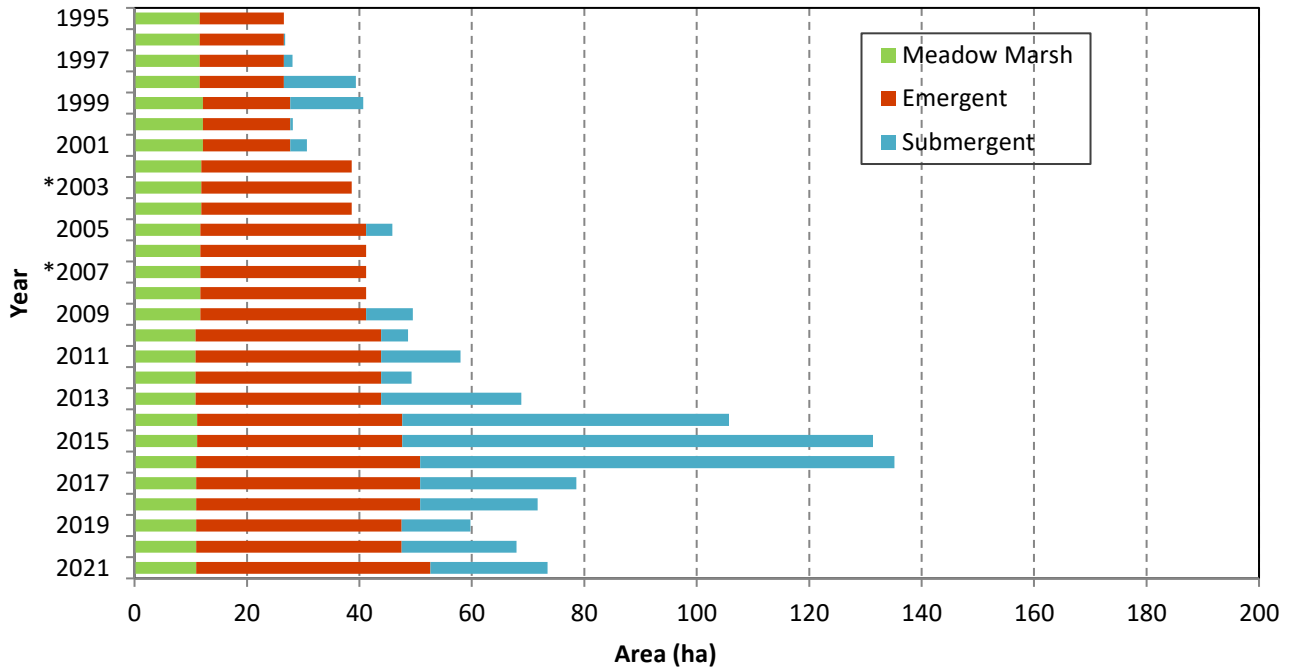
Table 14. The projects of 2016-2021 Wetland Restoration Plan and basic summary of status

Project	Comments/Status
The Cootes Paradise Fishway	Operated annually, overtopped with emergency repairs, all portions upgraded save for the boat gate (in progress). Structure is aging.
The Spencer Creek Delta Project	Substantial improvement, thousands of cattails planted, large areas of temporary fence in place to protect from Canada Geese. Heavily damaged by highwater and spills however 7 hectares added through low water and seedling germination in 2021.
Cootes Paradise Shoreline Repair	Further substantial damage by record high water levels. Several locations repaired including Princess Pt, Hickory Bay, Ratt Island, and near the RBG boathouse. Remediation at Kingfisher Point, Bulls Point and Sassafras Point reinitiated.
Cootes Paradise Inner Bay Wildlife Project	Generally lost and damaged due to highwater, however 2021 resulted in the entire north edge regenerated in cattails. Significantly impacted by stormwater from McMaster and Main St West Hamilton. A contaminated spring also located at Chegwin Marsh.
Meadow Marsh Invasive Plant Management	Large areas under management with herbicide with reseeding and replanting initiated. Phragmites only remains as scattered individual plants.
Wild Rice and Deep-Water Plants	Largely damaged and abandoned due to high water and sewage spills. Wild Rice remains in holding tanks in RBG propagation and is established in interior ponds of Grindstone Marsh and Cootes Paradise. Yellow water lily reestablishment re-initiated in 2021
Stream Habitat Improvement	Several sections under recovery along Grindstone Creek, Spencer Creek and Hickory Brook.
RBG Centre Urban Runoff Management	Project funds received in 2021 and initiated with the damaged outlet drain in the Woodland Garden area reconstructed
Chedoke Inlet Project	Interim Christmas Tree berm established in the delta as a containment feature for the polluted waters. Large scale spill damaging much of the Cootes Paradise Marsh environment. Remediation Plans in progress at multiple levels of planning.
Sunfish Pond & Long Pond Project	Upgraded for higher lake levels, substantial carp removed, ongoing issues with wildlife tunneling through the carp exclusion berm. Water quality in Long Pond worse and requires investigation.
Grindstone Marsh Delta (the elbow)	Partially upgraded for higher lake levels, substantial carp removed, ongoing issues with wildlife tunneling through the carp exclusion berm. Osprey Marsh berm continuing to decline and inaccessible under ongoing higher water levels.
Hendrie Valley Oxbow Ponds and Invasive Plants	Recovered habitat following flooding, carp exclusion repaired for higher lake levels, substantial carp removed, ongoing issues with wildlife tunneling through the carp exclusion berm. Wild Rice established and smaller scale invasive plant elimination initiated.
Outer Grindstone Marsh (Carrolls Bay Area)	Very little aquatic life (plantless) and with poor water quality, with ongoing lack of carp control. 300m of shoreline restored with an edge of emergent plants
Community engagement in Restoration	Plantings, temporary fence repairs, garbage cleanups and marsh monitoring all undertaken. Partnership with Bay Area Restoration Council ongoing.

**Measures of Progress**

**Area of Submergent, Emergent and Meadow Marsh**

**Cootes Paradise Marsh Vegetation Changes**



**Grindstone Marsh Vegetation Changes**

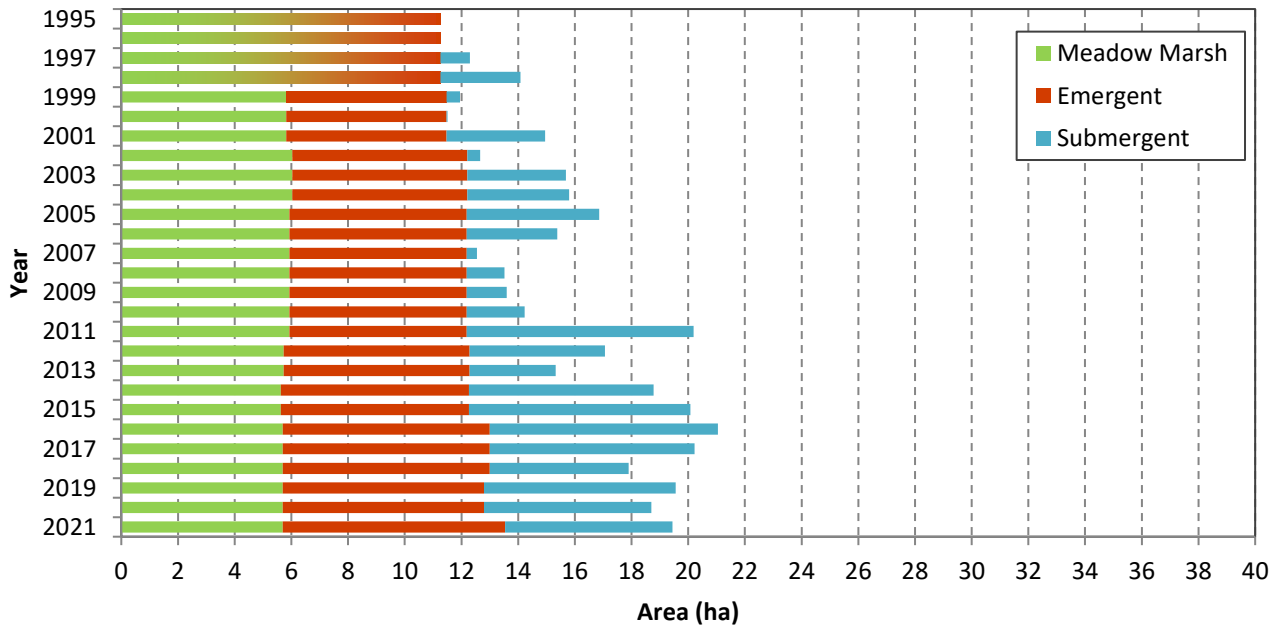


Figure 8. Trends in plant coverage for Cootes Paradise and Grindstone Marsh as measured at intervals. Aquatic Plants monitored annually August, Emergent and Meadow Marsh coverage updated about every 3 years.

## Native vs Introduced Species

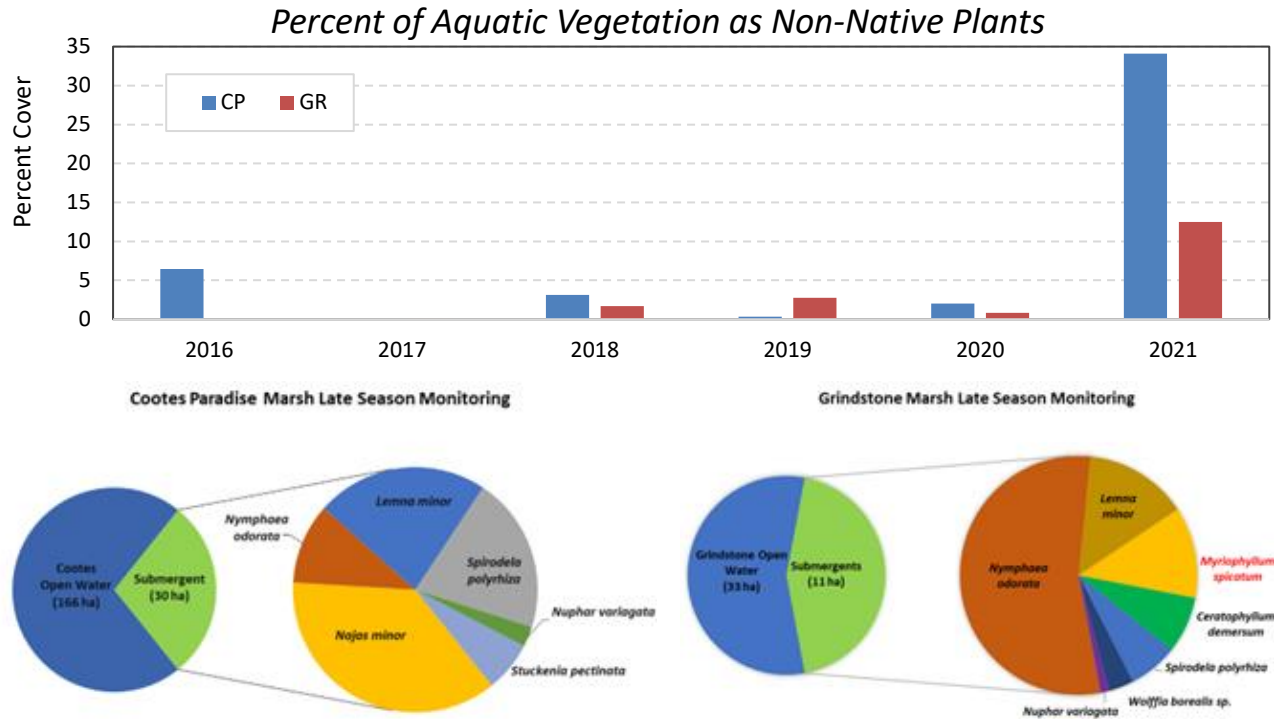
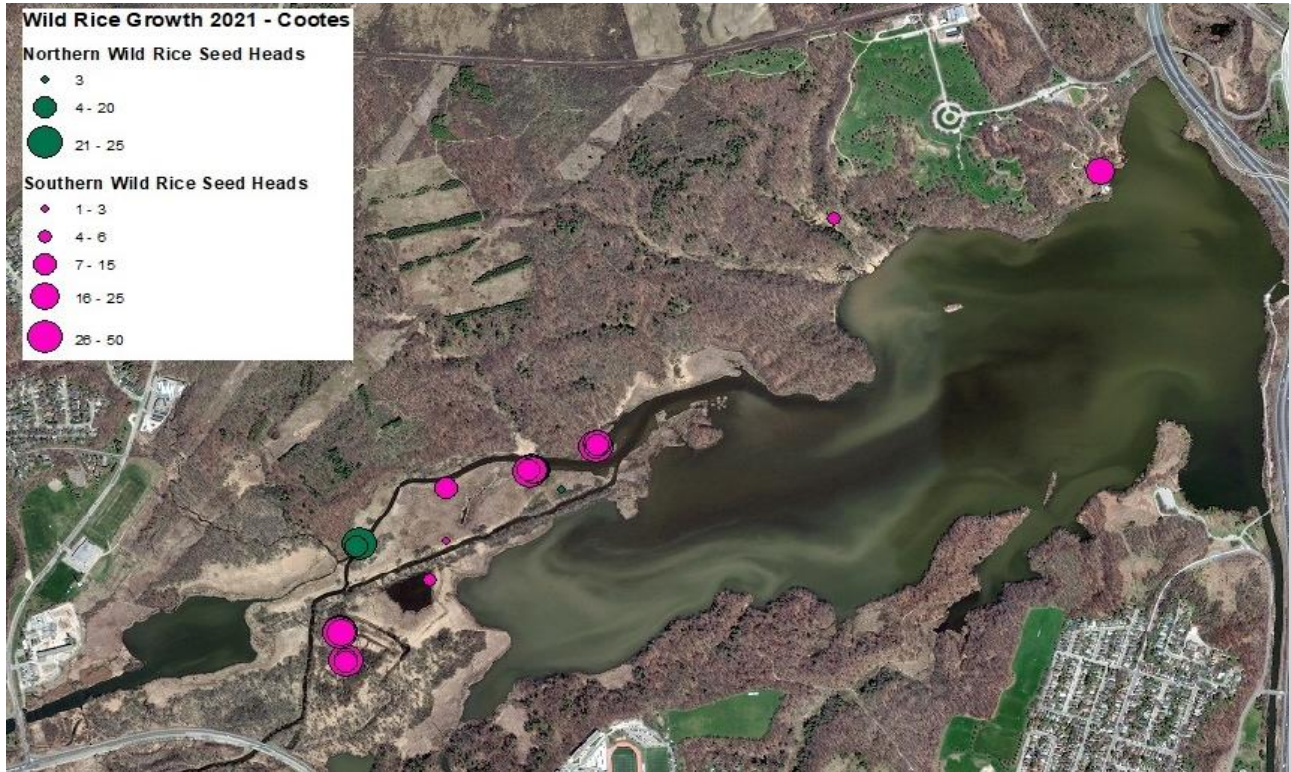


Table 15. Aquatic plant index monitoring species list pooled for 5-year intervals. Species in red are introduced

Cootes Paradise Index Monitoring - August		Grindstone Marsh Index Monitoring - August	
1996-2000	2016-2021	1996-2000	2016-2021
14 Species	18 Species	11 Species	23 Species
<i>Ceratophyllum demersum</i>	<i>Ceratophyllum demersum</i>	<i>Ceratophyllum demersum</i>	<i>Ceratophyllum demersum</i>
<i>Elodea canadensis</i>	<i>Lemna minor</i>	<i>Lemna minor</i>	<i>Elodea canadensis</i>
<i>Lemna minor</i>	<i>Lemna trisulca</i>	<i>Myriophyllum spicatum</i>	<i>Heteranthera dubia</i>
<i>Lythrum salicaria</i>	<i>Myriophyllum spicatum</i>	<i>Nymphaea odorata</i>	<i>Lemna minor</i>
<i>Myriophyllum spicatum</i>	<i>Najas minor</i>	<i>Polygonum sp.</i>	<i>Lemna trisulca</i>
<i>Nasturtium officinale</i>	<i>Nuphar variagata</i>	<i>Potamogeton amplifolius</i>	<i>Myriophyllum spicatum</i>
<i>Nymphaea odorata</i>	<i>Nymphaea odorata</i>	<i>Potamogeton foliosus</i>	<i>Najas flexilis</i>
<i>Polygonum sp.</i>	<i>Potamogeton crispus</i>	<i>Potamogeton natans</i>	<i>Najas minor</i>
<i>Potamogeton crispus</i>	<i>Potamogeton foliosus</i>	<i>Potamogeton nodosus</i>	<i>Nuphar lutea</i>
<i>Potamogeton foliosus</i>	<i>Potamogeton sp.</i>	<i>Potamogeton richardsonii</i>	<i>Nuphar variagata</i>
<i>Potamogeton sp.</i>	<i>Riccia fluitans</i>	<i>Stuckenia pectinata</i>	<i>Nymphaea odorata</i>
<i>Stuckenia pectinata</i>	<i>Ricciocarpos natans</i>		<i>Persicaria lapathifolia</i>
<i>Vallisneria americana</i>	<i>Spirodela polyrhiza</i>		<i>Potamogeton crispus</i>
<i>Zannichellia palustris</i>	<i>Stuckenia pectinata</i>		<i>Potamogeton foliosus</i>
	<i>Utricularia vulgaris</i>		<i>Potamogeton sp.</i>
	<i>Elodea canadensis</i>		<i>Riccia fluitans</i>
	<i>Vallisneria americana</i>		<i>Ricciocarpos natans</i>
	<i>Potamogeton perfoliatus</i>		<i>Rumex verticillatus</i>
			<i>Spirodela polyrhiza</i>
			<i>Stuckenia pectinata</i>
			<i>Utricularia vulgaris</i>
			<i>Vallisneria americana</i>
			<i>Wolffia borealis (sp)</i>

## Area of Wild Rice

Wild rice is only measured as small point populations and was nearly extirpated from the marshes during 2016 to 2021. Naturally regeneration populations exist in RBG propagation, Presidents Pond, Hendrie Pond 4 and scattered areas within the Spencer Creek delta of Cootes Paradise. Reseeding at selected locations occurs annually using seed from the RBG propagation area plants. Almost all plants are *Zizania aquatica*.



### Water Clarity and Water Quality Index

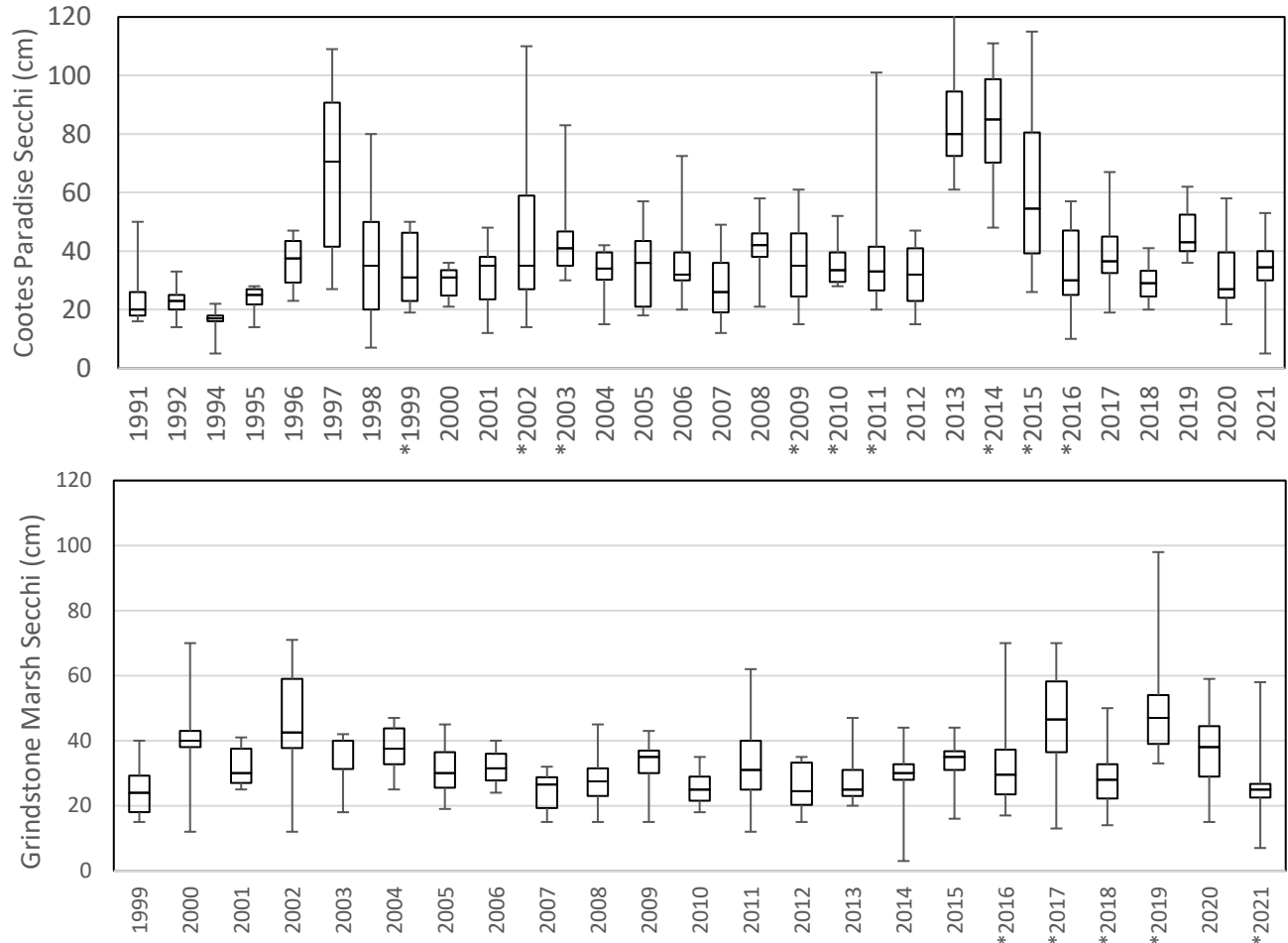


Figure 9. Water clarity (secchi depth spring and summer samples) for Cootes Paradise and Grindstone Marsh delisting stations (CP2, GC1) from 1991 to 2021. \*data include Secchi recorded depth when on the bottom.

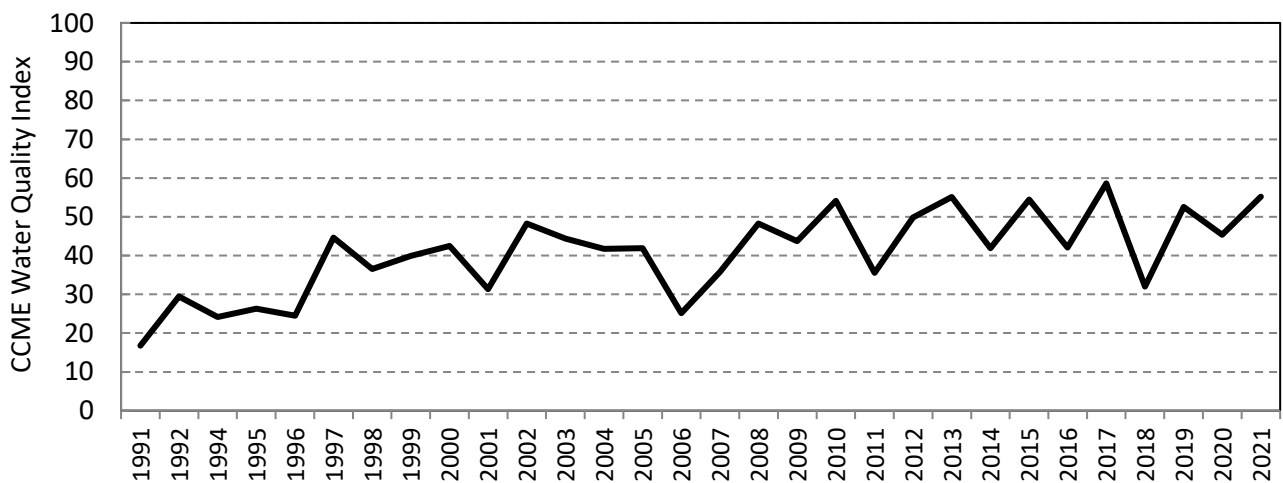


Figure 10. Water Quality Index Score for Cootes Paradise as measured at the centre station (spring & summer). CCME – Canadian Council of Ministers of Environment (<45 = impaired, 45-64 marginal, 65-79 fair, 80-95 Good, 95-100 Excellent)



**Muskrat Population**

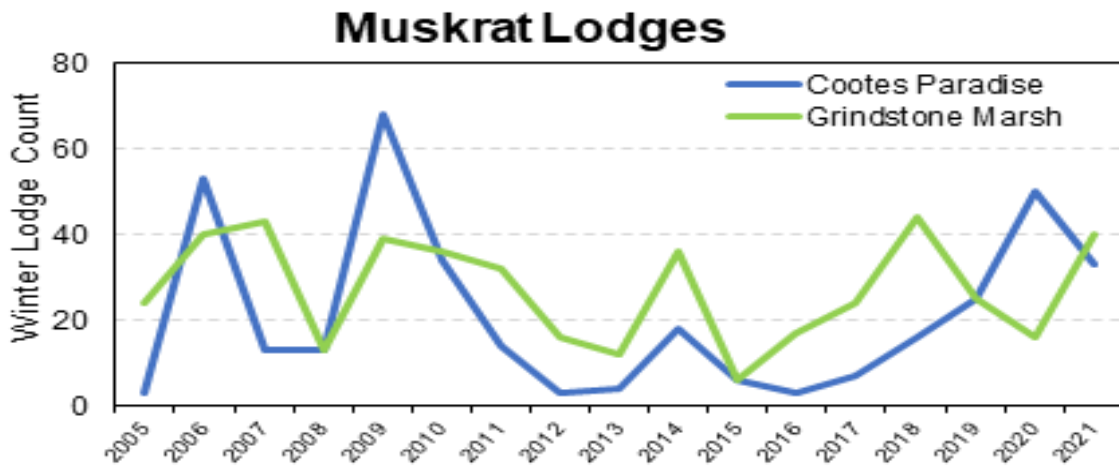


Figure 11. Trends in Muskrat Lodges as counted during the winter in Cootes Paradise and Grindstone Marsh

**Common Carp Abundance**

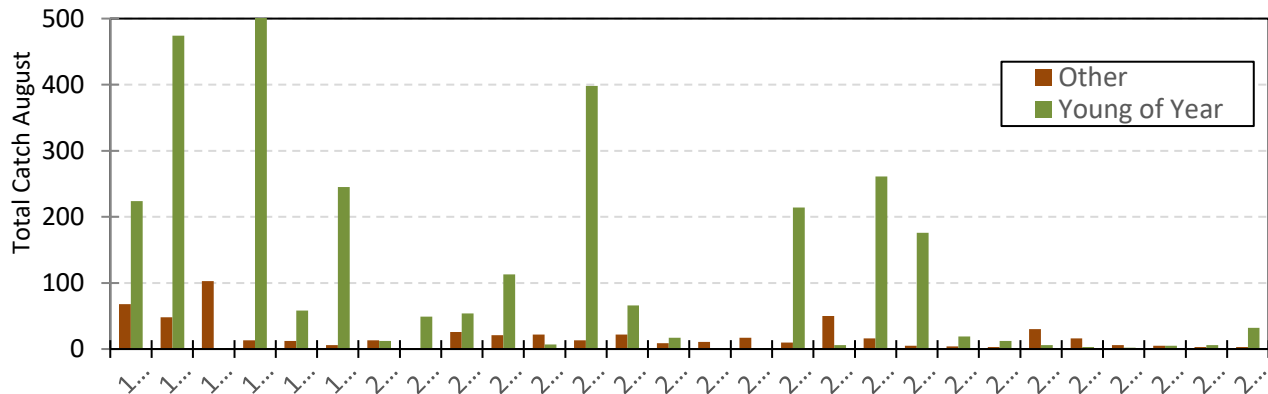


Figure 12. Trends in Common Carp abundance at Cootes Paradise from August electrofishing monitoring (22 transects). 1997 total young of the year carp catch was 2,009 fish.

**Yellow Perch**

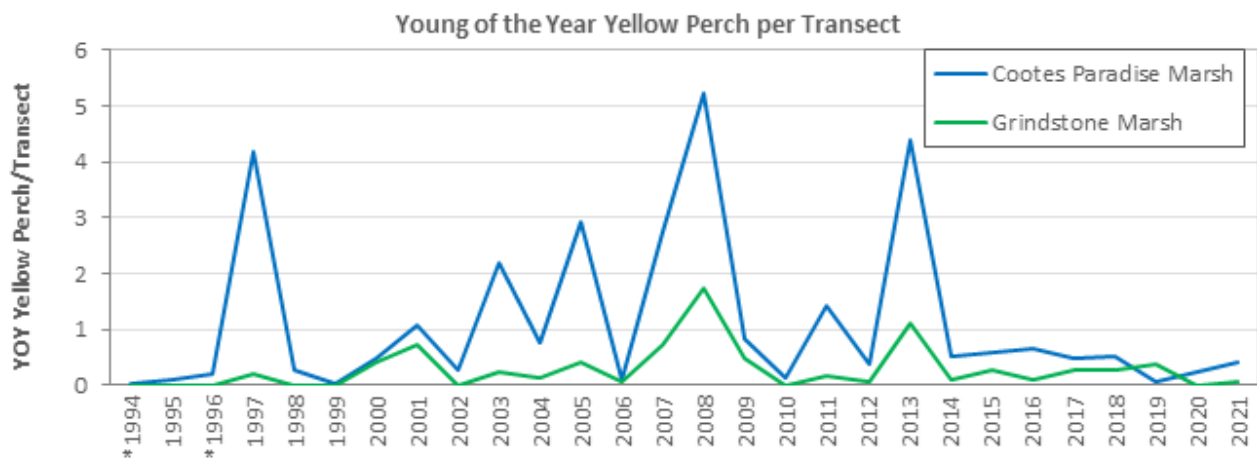


Figure 13. Trends in Yellow Perch young abundance at Cootes Paradise and Grindstone Marsh from August electrofishing monitoring (22 transects – Cootes Paradise, 10 transects Grindstone Marsh).

Table 16. Overall success rating of exclusion of Carp (*Cyprinus carpio*) within Cootes Paradise and Grindstone Marsh. (G=Good, S=satisfactory, F = flooded & failed, V= Vandalized & failed).

Year	Cootes Paradise Marsh	Grindstone Marsh						
		Sunfish Pond	Long Pond	Blackbird Marsh	Osprey Marsh	Pond 1	Pond 2	Pond 4
1996	F*	-	-	-	-	-	-	-
1997	S							
1998	G	-	-	-	-	-	-	-
1999	S	-	-	G	-	-	F	S
2000	S	-	-	S	S	-	F	F
2001	G	V	V	S, V	S	-	G	G
2002	G	G	S	G	V	V	G	G
2003	G	S	S	S	S	G	S	G
2004	G	G	S	G	S	S	G	G
2005	G	S	S	S	G	G	G	G
2006	S	S	S	G	G	S	F	F
2007	S	G	S	G	G	G	G	G
2008	G	G	S	G	G	G	S	G
2009	G	S	S	V	F	S	G	G
2010	S	S	S	S	F	S	S	G
2011	S	F	F	F	F	F	F	F
2012	S	S	S	S	F	S	S, F	S, F
2013	G	S	S	S	S	G	G	G
2014	G	G	S	S	S	G	G	G
2015	G	G	S	S	F	G	G	G
2016	G	S	S	S	F	G	G	S
2017	S	S	S	F	F	F	F	S
2018	S	S	S	F	F	G	G	S
2019	S	S	S	F	F	S	S	S
2020	S	S	S	S	S	G	S	S
2021	S	F	S	V	F	G	G	G

- **Good** = maintained carp densities under 20 kg/ha.
- **Satisfactory** = maintained carp densities between 20 and 50 kg/ha. or less than 20 kg for part of the season and greater than 50 kg for part of the season.
- **Failed** = greater than 50 kg/ha throughout the season.
- **Vandalized/Failed** = greater than 50 kg/ha throughout the season.

## ***Principle Highlights of the previous 5 years with Photos***

Highlights during the previous 5-year period were limited due to large scale challenges with record water levels and sewage spills, however several major successes were achieved with a focus shifted from aquatic plant restoration to meadow marsh area due to the challenges that occurred.

Highlights include

- Establishment of emergent plants in nearly half of the Spencer Creek Delta in 2021 low water
- Elimination of most of the Phragmites found in both Cootes Paradise and Grindstone Marsh
- Reintroduction of plants including Southern Wild Rice, Hardstem Bulrush, and Swamp Loosestrife at several locations
- Transformation of Presidents Pond in Cootes Paradise to a healthy and diverse habitat.
- Bioengineering and stabilization of several sections of collapsing shoreline including sites at Cootes Paradise and a large scale rebuild of the Western shore of outer Grindstone Marsh.
- Record high lake levels leading to emergency carp exclusion actions in 2017 and 2019.
- Large scale loss of plant community due to sewage spills most noteworthy in 2018 and 2020
- Rebuild of carp barriers for higher lake levels at all locations except for Osprey Marsh section of Grindstone Marsh.
- Removal of accumulated carp from the marsh areas to reset recovery conditions throughout the wetland carp exclusion areas.
- Re-establishment of initial populations of yellow water lily in most marsh inlets in Cootes Paradise.
- Initiation of Meadow Marsh Restoration with large scale European Manna Grass elimination initiated in several locations and including propagation of Lake Bank Sedge (*Carex lacustris*), and Giant Burreed (*Sparganium eurycarpum*).

Overall, the most successful outcome was transformation of Presidents Pond in Cootes Paradise. This is a semi-isolated spring feed 3 hectares oxbow pond tied to historical natural channel of Spencer Creek. The pond has undergone a dramatic transformation in recent years from a plantless pond rimmed by invasive Eurasian Manna Grass and patches of Phragmites, to the most diverse wetland area of Cootes Paradise. In 2021 the area naturally regenerated more than 500 Southern wild rice plants. Emergent plants now include a diverse mix of Cattails, Softstem and River Bulrush, Swamp Loosestrife and Giant Burreed aided by plant reintroductions. Aquatic plants include a various Potamogeton species and Yellow Waterlily. Emergent establishment is illustrated in the Appendix maps. Overall, the pond has become the parallel habitat to Grindstone Marshes South Pasture Swamp (pond 4). This pond host the majority of remaining Endangered Blanding's Turtle for western Lake Ontario area. During the record water level years of 2017 and 2019, Presidents Pond was contiguous with the main marsh with the normally exposed adjacent land forming the pond perimeter under 30cm of water for several months. This highwater aiding with the elimination of many invasive meadow plant species.

Secondarily the recovery and reestablishment of emergent marsh plants during low water in 2021 was transformational for the restoration of the marsh. This followed the ongoing challenges with high water and spills that had set back many years of recovery efforts in the previous 4 years. To achieve this success in 2021 1.5km of temporary fence was employed to prevent Canada Geese from browsing the native plant seedlings germinating on the mudflats. The outcome was a net advancement in emergent marsh plant cover for the 5-year period, including recovery of essentially all lost emergent plant coverage due to water quality issues.



Figure 14. Wetland restoration success at Presidents Pond Cootes Paradise (upper) and Grindstone Marsh Pond 4 (South Pasture Swamp), both featuring a diverse mix of plants including abundant Southern Wild Rice (lower).

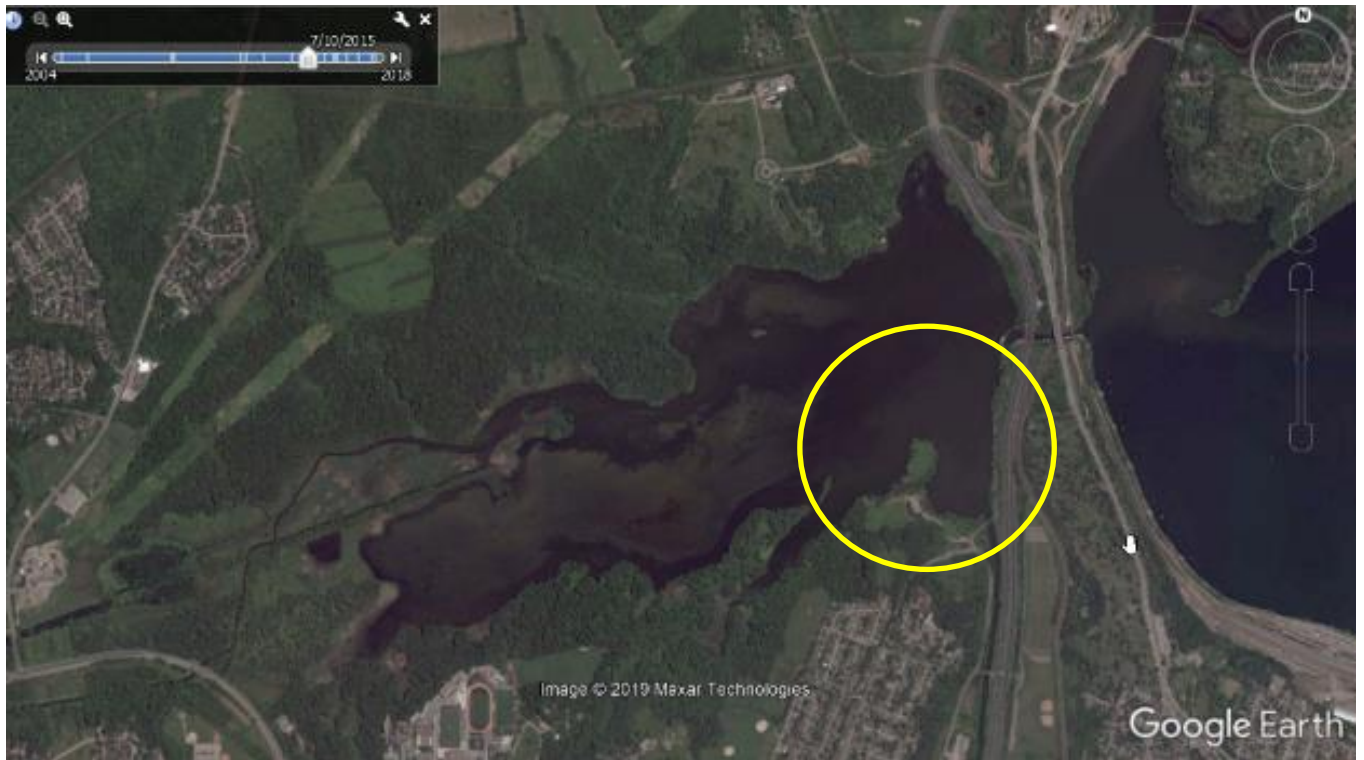


Figure 15. July 10, 2015 Google Earth aerial photo (Photo used in RBG Wetlands Restoration Plan, 2016-2021). Marsh clear and with aquatic plants (other than algae bloom in waters downstream of Chedoke Creek).



Figure 16. July 7, 2018 Google Earth aerial photo – all Cootes Paradise is an algae bloom as water mixes; unmixed Chedoke inflow is notable by Princess Point at the height of the Chedoke sewer gate failure.



Figure 17. Record high lake levels and emergency barrier additions at the Cootes Paradise Fishway (above), and at Grindstone Marsh's Sunfish Pond area. The road to the Fishway has since been raised.



Figure 18. 2021 repair of Hendrie Valley carp exclusion berm by the pond 2 area (above), and 2019 emergency system with temporary fence in place during record high water levels (below).



Figure 19. Aerial Photo of Spencer Creek Floodplain fall 2021 (above) and Giles Restoration onsite with the “Marsh Master” (lower) assisting with European Manna Grass elimination work (late fall after native species are dormant).





Figure 20. European Manna Grass Control site in the Spencer Creek Floodplain. Top post herbicide treatment and lower replanting mixed meadow marsh species with Bay Area Restoration Council Volunteers.



Figure 21. Cockpit Island Cootes Paradise before high water 2016 (above) and example of shore damage from high water in 2017 and 2019 (below). Similar slope failures at multiple locations around Cootes Paradise Marsh.



Figure 22. Shoreline reconstructed at outer Grindstone Marsh restoration site, May 2016 & July 2017 (above), and bioengineering repair of formerly eroded and undercut shore at Princess Point and near the RBG boathouse 2020 (lower).



Figure 23. 2021 emergent marsh regeneration with low water in the Spencer Creek delta, May upper photo and August lower photo (fence illustrates the browse effect of Canada Geese).

## Key Reference Background Monitoring Documents

1. Biological Inventory of RBG Natural Lands (RBG 1985)
2. Past and Present Limnological Conditions of Cootes Paradise (RBG 1985)
3. HHRAP Stage 1 & 2 (1992), and Stage 2 update (2002)
4. HHRAP loadings Reports (1996, 2002, 2009)
5. Water Quality Study of Cootes Paradise (MOE - 1976)
6. Cootes Paradise Study (MOE – 1986)
7. West Pond Study (1999 RBG)
8. Nutrient Status of Cootes Paradise Marsh (RBG 2001)
9. Sediment Quality Review 1 & 2 (RBG 2006, 2008)
10. Bathymetry / Sedimentation (RBG 1999, 2007)
11. Water levels Implications – (RBG 2004)
12. Water levels Scenarios Review – (RBG 2007)
13. Creek loadings Study 2008 (RBG 2009)
14. Project Paradise Season Summaries – (RBG 1999 – 2015)
15. Target Plant Communities of RBG wetlands (RBG 2004)
16. Fish community use of Cootes Paradise Marsh (Master Thesis - Theysmeyer 1999)
17. Carroll’s Bay Recovery Strategy (RBG 2009)
18. Water Quality Characterization of the Main Tributaries of the Garden’s Property (RBG 2009)
19. Ecological Lands Classification of Cootes Paradise Marsh (RBG 2010)
20. Various protocols pertaining to measuring biological communities, sediment, and water quality.
21. Cootes Paradise Marsh Water Quality Review and Phosphorus Analysis (HHRAP 2012)
22. Emergent and Meadow Marsh Assessment of Cootes Paradise and Carroll’s Bay Marsh
23. Ecological Lands Classification of Hendrie Valley Marsh (RBG 2013)
24. 20 Year Trends in Water Quality, Cootes Paradise and Grindstone Marsh (RBG 2012)
25. RBG Turtle Site Specific Plan (RBG 2014)
26. RBG Phragmites Management Plan (RBG 2014)
27. 20 Years of Goose Management Summary at RBG (RBG 2015)
28. RBG Turtle Site Specific Plan (RBG 2014)
29. RBG Eurasian Manna Grass Management Plan (RBG 2016)
30. Summary of Conditions in the West Desjardin Canal (RBG 2016)
31. Lilliput Status Review for RBG Marshes (RBG 2017)
32. Lake Ontario Flooding Impacts to Royal Botanical Gardens (RBG 2020)
33. Chedoke Cr Sewage Spill Impacts to Royal Botanical Gardens (RBG 2020)
34. Phragmites Management 5 Year Summary Report (RBG 2021)
35. Northern Pike Status Review within RBG Marsh Areas (RBG 2022)

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## Appendix A

### Watersheds of RBG Marshes

<i>System</i>	<i>Creek Name</i>	<i>Regulatory Agency</i>	<i>Municipality</i>
Cootes Paradise System	1. Spencer Creek	Hamilton Region CA	City of Hamilton
	2. Ancaster Creek	Hamilton Region CA	City of Hamilton
	3. Borer's Creek	Hamilton Region CA	City of Hamilton
	4. Delsey Creek	Hamilton Region CA	City of Hamilton
	5. Mink Brook	Hamilton Region CA	City of Hamilton
	6. Spencer Oxbow/Presidents Pond	Hamilton Region CA	City of Hamilton
	7. Mac Landing Creek	Hamilton Region CA	City of Hamilton
	8. Double Marsh Springs	Hamilton Region CA	City of Hamilton
	9. Westdale Creek	Hamilton Region CA	City of Hamilton
	10. Chedoke Creek	Hamilton Region CA	City of Hamilton
	11. Corner Brook	Halton Region CA	City of Hamilton
	12. Highland Creek	Halton Region CA	City of Hamilton
	13. Hickory Brook	Halton Region CA	City of Hamilton
	14. Long Valley Brook	Halton Region CA	City of Hamilton
	15. Marsh Boardwalk Brook	Halton Region CA	City of Hamilton
	16. Lilac Dell Brook	Halton Region CA	City of Hamilton
Grindstone Marsh System	17. Grindstone Creek	Halton Region CA	City of Burlington
	18. W1 – Snake Rd 1	Halton Region CA	City of Burlington
	19. W2 – Snake Rd 2	Halton Region CA	City of Burlington
	20. W3 - Cemetery	Halton Region CA	City of Burlington
	21. W4 – Hwy 6	Halton Region CA	City of Burlington
	22. W5 – Upper Long Pond	Halton Region CA	City of Hamilton
	23. W6 – Middle Long Pond	Halton Region CA	City of Burlington
	24. W7 – Lower Long Pond	Halton Region CA	City of Burlington
	25. South Pasture Swamp Spring brook	Halton Region CA	City of Burlington

**Coastal Marsh Meadow Marsh Areas of RBG**

Figure 24. Meadow Marsh location (bright green) in RBG wetlands as derived from 2011-2013 RBG Ecological Lands Classification projects.

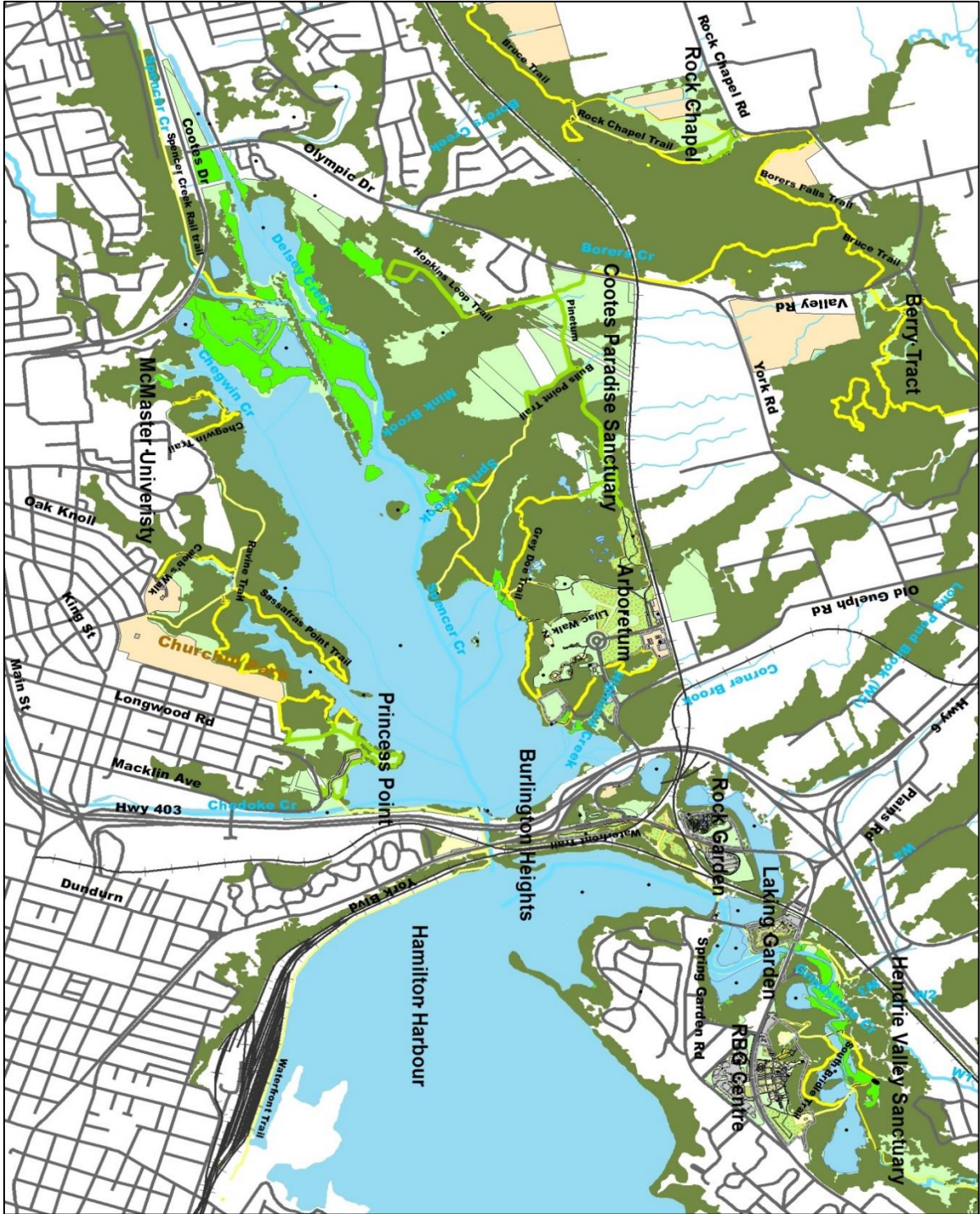




Figure 25. Bathymetry of Cootes Paradise Marsh and associated stream, by stream order size. Average spring high water level in Cootes Paradise is 75.15 msl and the average winter low is 74.45 msl (from Water levels Implications RBG 2004). Peak spring water level generally occurs mid May to mid June.



## Great Lakes Health Environmental Indicators

Table 17. Comparison chart of the International Joint Commission (IJC) Ecosystem Indicators and the State of the Lakes Ecosystem Conference (SOLEC) indicators. Chart is taken from “Great Lakes Ecosystem Indicators Report – A report of the IJC priority assessment of progress towards restoring the Great Lakes” IJC June 2014. A total of 23 of the 41 measure outlined by the IJC are defined differently from the SOLEC indicators (there are highlighted with an \*).

IJC Ecosystem Indicators and Measures	Indicators in 2011 SOLEC Report
1. Coastal Habitat – Shoreline Alteration Index 1) <i>Physical shoreline indicator + Biological shoreline indicator*</i>	1. Hardened Shorelines*
2. Extent, Composition, and Quality of Coastal Wetlands 2) <i>Macroinvertebrates</i> 3) <i>Fish</i> 4) <i>Plants</i> 5) <i>Amphibian (Frogs and Toads)</i> 6) <i>Birds</i> 7) <i>Wetland Area and Extent*</i>	2. <b>Wetland Amphibians</b> 3. <b>Wetland Birds</b> 4. Wetland Fish 5. Wetland Invertebrates 6. <b>Wetland Plants</b> 7. <b>Wetland Extent and Composition*</b>
3. Land Cover and Fragmentation Status* 8) <i>Conversion measures*</i> 9) <i>Fragmentation measures*</i>	8. Land Cover*
4. Seasonal and Long-Term Fluctuations in Great Lakes Water Levels 10) <i>Long-term water level variability*</i> 11) <i>Timing of seasonal water level maximum and minimum*</i> 12) <i>Magnitude of seasonal rise and decline*</i> 13) <i>Lake-to-lake water level difference*</i>	9. Water Levels (deviation from long term mean)*
5. Tributary Physical Integrity 14) <i>Hydrologic Alteration (R-B Flashiness Index)</i> 15) <i>Tributary Connectivity to Receiving Waters</i> 16) <i>Sediment-turbidity measure*</i>	10. <b>Tributary Flashiness</b> 11. <b>Aquatic Habitat Connectivity</b>
6. Water Temperature 17) <i>Annual summer (July-September) surface average temperature*</i> 18) <i>Lake water thermal stratification date</i> 19) <i>Fall lake water turnover date*</i> 20) <i>Maximum and average ice concentrations</i>	12. Surface Water Temperature (date of the onset summer stratification)* 13. Ice Duration
7. Atmospheric Deposition of Chemicals of Mutual Concern 21) SOLEC indicator Atmospheric Deposition of Toxic Chemicals	14. Atmospheric Deposition

8. Chemicals of Mutual Concern in Water 22) Annex 3 subcommittee recommendation	15. Toxic Chemicals in Offshore Waters
9. Contaminants in Groundwater 23) <i>Urban, agriculture, and industrial contaminants*</i>	
10. Persistent, Bioaccumulating, Toxic (PBT) in Biota 24) <i>PBT chemicals in whole fishes</i> 25) <i>PBT chemicals in Herring Gull eggs and in Bald Eagles</i>	16. Contaminants in Whole Fish 17. Contaminants in Waterbirds
11. Phosphorus Loads and In-Lake Concentrations 26) <i>Phosphorus Loads of TP and DRP*</i> 27) <i>In-lake concentrations of TP and DRP</i>	18. Nutrients in Lakes* 19. <b>TP concentration of offshore*</b>
12. Aquatic Invasive Species: Invasion Rates and Impacts 28) <i>Rate of Invasion*</i> 29) <i>Status and impacts*</i>	20. Aquatic Non-Native Species* 21. Sea Lamprey* 22. Dreissenid Mussels*
13. Abundance and Distribution of Fish-Eating and Colonial Nesting Birds 30) <i>Population Status*</i> 31) <i>Health Status*</i>	
14. <u>Lower Food Web Productivity and Health</u> 32) <i>Phytoplankton</i> 33) <i>Zooplankton/Mysis biomass*</i> 34) <i>Benthos*</i> 35) <i>Prey fishes*</i>	23. <b>Diporeia*</b> 24. Zooplankton biomass* 25. <b>Preyfish biomass-9 species*</b>
15. Fish Species of Interest 37) <i>Adult abundance</i> 38) <i>Recruitment*</i>	26. <b>Lake Sturgeon abundance*</b> 27. <b>Lake Trout abundance*</b> 28. <b>Walleye abundance*</b>
16. Harmful and Nuisance Algae 39) <i>Harmful Algal Blooms</i> 40) <i>Nuisance Algal Bloom*</i> 41) <i>Excessive Algal Abundance*</i>	29. Harmful Algal Blooms offshore* 30. Harmful Algal Blooms nearshore*

	31. Benthos as trophic indicator 32. Forest land in tributary buffer 33. Forest land in watershed 34. Air temperature 35. Baseflow due to groundwater discharge 36. Botulism outbreaks 37. Cladophora 38. Contaminants in sediment cores 39. Extreme precipitation events 40. Human population 41. Inland water quality index 42. Phytoplankton 43. Terrestrial non-native species 44. Water chemistry (conductivity, pH, chloride, alkalinity, turbidity, etc.) 45. Water clarity 46. Watershed stressor index
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Note: 1. Shaded boxes indicate matches between IJC and SOLEC indicators  
2. SOLEC indicators listed in bold text are indicators used in SOLEC Highlight Report  
3. \* indicates that the indicator has a different definition than the corresponding indicator in the other column.

Table 18. Comparison of the effect of the Current Lake Ontario Water Level Regulation Plan (1958DD) versus the unregulated situation and the proposed water level regulation Bv7 (essential Plan 2014) on key Environmental Performance Indicators. Chart is taken from the IJC website.

Environmental Performance Indicators		1958DD	Unregulated Levels	Bv7
O n t a r i o	Wetland Meadow Marsh Community	1.00	1.56	1.44
	Low Veg 18C - spawning habitat supply	1.00	0.88	0.96
	High Veg 24C - spawning habitat supply	1.00	1.08	0.99
	Low Veg 24C - spawning habitat supply	1.00	1.11	1.04
	Northern Pike - Young-of-Year (YOY) recruitment	1.00	1.03	0.99
	Largemouth Bass - YOY recruitment	1.00	0.96	0.98
	Least Bittern (IXEX) - reproductive index	1.00	1.13	1.13
	Virginia Rail (RALI) - reproductive index	1.00	1.15	1.15
	Black Tern (CHNI) - reproductive index	1.00	1.16	1.19
	Yellow Rail (CONO) - preferred breeding habitat	1.00	1.01	1.03
	King Rail (RAEL) - preferred breeding habitat	1.00	1.27	1.19
U p p e r  R i v e r	Low Veg 18C - spawning habitat supply	1.00	1.04	1.01
	High Veg 24C - spawning habitat supply	1.00	1.02	1.00
	Low Veg 24C - spawning habitat supply	1.00	1.04	1.02
	Northern Pike - YOY recruitment	1.00	1.06	1.03
	Largemouth Bass - YOY recruitment	1.00	1.00	1.00
	Northern Pike - YOY net productivity	1.00	2.07	1.40
	Virginia Rail (RALI) - reproductive index	1.00	1.33	1.19
	Muskrat (ONZI) - house density in drowned river mouth wetlands	1.00	14.29	2.59
L o w e r  R i v e r	Golden Shiner (NOCR) - suitable feeding habitat surface area*	1.00	1.01	1.00
	Wetlands fish - abundance index (Lower St. Lawrence River)	1.00	0.97	1.03
	Migratory wildfowl - floodplain habitat surface area*	1.00	0.94	0.98
	Least Bittern (IXEX) - reproductive index*	1.00	1.06	1.01
	Virginia Rail (RALI) - reproductive index*	1.00	1.04	1.03
	Migratory wildfowl - productivity*	1.00	1.02	1.01
	Black Tern (CHNI) - reproductive index*	1.00	1.01	1.00
	Northern Pike (ESLU) - suitable reproductive habitat surface area*	1.00	1.01	0.99
	Frog sp. - reproductive habitat surface area*	NA	NA	NA
	Eastern Sand Darter (AMPE) - reproductive habitat surface area*	1.00	1.00	1.00
	Map Turtle (GRGE) - reproductive habitat surface area*	1.00	1.01	0.99
Bridle Shiner (NOBI) - reproductive habitat surface area*	1.00	0.97	0.96	
Muskrat (ONZI) - surviving houses*	1.00	1.05	0.94	
*(Lake St. Louis to Trois-Rivières)				

## Related Strategies of Partners

In planning for the future, Royal Botanical Gardens has identified a number of Strategies and Plans that align with the mandate of Gardens and may help guide stakeholders in relation to their involvement.

1. Great Lakes Water Quality Agreement
2. Canada-Ontario Water Quality agreement
3. Federal Biodiversity Strategy
4. Lake Ontario Binational Biodiversity Conservation Strategy
5. Federal Invasive Alien Species Strategy
6. Lake Ontario Lakewide Action and Management Plan
7. Federal Great Lakes Wetlands Conservation Action Plan.
8. Species at Risk Recovery Strategies – various
9. Provincial Biodiversity Strategy
10. Provincial Great Lakes Protection Act
11. Provincial Invasive Species Act
12. Provincial Lake Ontario Management Plan
13. Provincial Pollinator Strategy
14. City of Hamilton Storm water Master Plan
15. City of Hamilton Wastewater Master Plan
16. City of Hamilton Chedoke Creek Water Quality Improvement Framework
17. City of Burlington Stormwater Management
18. Halton CA Grindstone Creek Watershed Plan
19. Hamilton CA Subwatershed Action Plans - various
20. MNR Hamilton Area Fisheries Management Plan
21. North American Waterfowl Management Plan
22. North American Shorebird Management Plan
23. Niagara Escarpment Plan
24. The Greenbelt Plan
25. Cootes to Escarpment Ecopark System
26. Canadian Biosphere Network
27. Grindstone Creek Municipal Natural Assessment