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20 Year Trends in Water Quality

Cootes Paradise and Grindstone Creek Marsh

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Introduction

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In Hamilton, coastal wetland impairment came as a result of many factors, including land use changes, fertilizer and sediment runoff, ditching of tributaries, poorly treated sewage, and arrival of non-native species. As of 1990, virtually no wetland plants or associated species existed within the regularly flooded portion of the areas coastal wetlands. Water clarity averaged less than 30 cm and Carp (*Cyprinus carpio*), introduced to Lake Ontario in the 1870's, was the dominant species. Loss of wetlands along the shores of the lower great lakes is not unique to this area and is well documented, with upwards of 80% either lost or degraded.

Rehabilitation of the 400 hectares of rivermouth wetlands of Cootes Paradise and Grindstone Marshes within Royal Botanical Gardens Nature Reserves has been a key focus of the Hamilton Harbour Remedial Action Plan. Over the last 20 years, City of Hamilton infrastructure projects to the sewer system have been a major factor improving the inflowing water quality to these wetlands. This report updates the current state of wetland water quality using ongoing monitoring data, highlighting the effect of these projects as well as carp exclusion. Water quality indicators summarized include water clarity, phosphorus, suspended sediment, and *E.coli* levels. In addition to the major infrastructure projects, many smaller scale stewardship projects continue in the watersheds. The ultimate goal is to restore the underpinning conditions of water quality, allowing the overall aquatic system to again be self-sustaining.

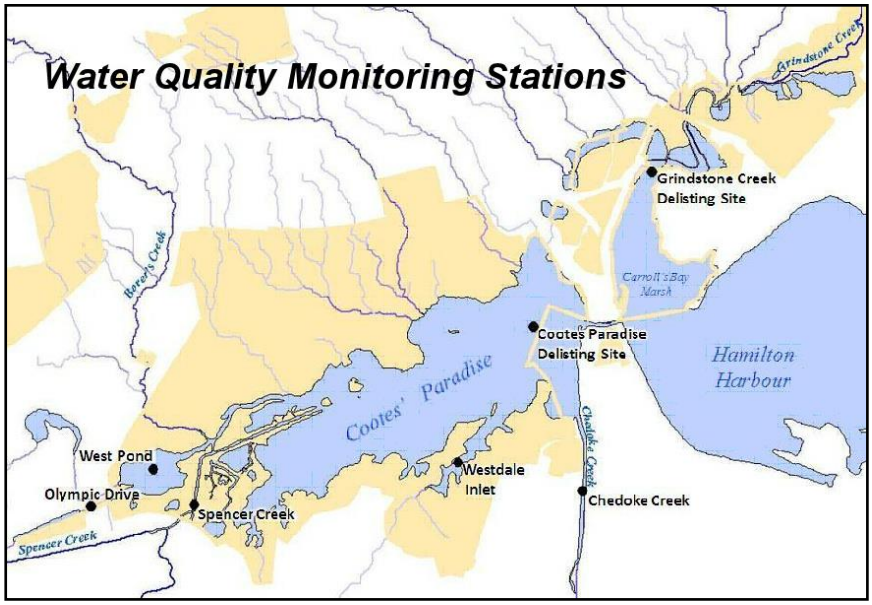
Table 1: Major infrastructure upgrades improving water quality in Cootes' Paradise and Grindstone

Year	Watershed	City Infrastructure Upgrades for RBG marshes	Graph ID
1997	Cootes Paradise	Main King CSO (Combined Sewer Overflow) Tank Operational - Chedoke Cr	1
1997	Cootes Paradise	Carp Exclusion Barrier Operational	2
2002	Cootes Paradise	Dundas WWTP Flow Equalization Tank Operational	4
2003	Cootes Paradise	Spencer Creek Flood Plain Connected to West Pond	5
2005	Cootes Paradise	CSO Mitigated for Westdale Creek	6
2008	Cootes Paradise	Stroud CSO Tank Operational for Chedoke Creek	7
2008	Cootes Paradise	Kaydrage Landfill Leachate Containment for Chedoke Creek Operational	8
2009	Cootes Paradise	CSO Outfall Rebuilt for Westdale Creek	9
2000	Grindstone Marsh	Carp exclusion operational in upper marshes	11
2002	Grindstone Marsh	Broken Sanitary Sewer at Long Pond Repaired	3
2010	Grindstone Marsh	Waterdown WWTP Offline from Grindstone Creek	10

The watershed of Hamilton Harbour drains over 500 square kilometers, with approximately 75% of this first passing through the wetland systems under RBG management. The main rivers of this system are Spencer Creek draining to Cootes Paradise Marsh, and Grindstone Creek draining to Grindstone Marsh. However, direct rain to the watershed only provides about 50% of the water entering Hamilton Harbour, with the other 50% from Lake Ontario water cycled through urban system and released through four Waste Water Treatment Plants (WWTP) that service Burlington, Dundas, Hamilton, and formerly Waterdown, and combined sewer overflows. The Waterdown effluent was relocated from Grindstone Creek to the main Hamilton Waste Water Plant at Woodward Ave in 2010.

Monitoring Protocols

To maintain information on the state of water quality in Cootes Paradise and Grindstone Marshes, samples have been collected annually on a bi-weekly basis at Royal Botanical Gardens between May and September during the past 20 years. Support has been provided by Ministry of Environment, Environment Canada, HRDC and City of Hamilton. Samples are transported to a lab for analysis with results returned to RBG. Over the past 20 years, lab analysis has been completed by Hamilton's Environmental Lab (2002- '11), Zenon (1996-2001), McMaster University (1994 – '95) and Ministry of Environment (1991 – '92). McMaster was responsible for gathering of samples in 1994 and 1995.



Parameters Discussed

Water Clarity **-** Water clarity represents how far light can penetrate into the water column. The remediation goal is consistent clarity to the bottom in the deepest areas of the marshes = 150cm.

Total Phosphorus **-** Phosphorus is the primary nutrient limiting aquatic plant growth in fresh water. Excess phosphorus causes algal to outgrow and smother other species. The Provincial Water Quality Objective for Aquatic Life is < 30µg/L. Sources; human and animal waste and fertilizers.

Total Suspended Sediment **-** Suspended sediment represents particulates that do not immediately settle out of the water such as silt, clay, and organic particles (i.e. plant fragments). The goal is levels < 25mg/l. Sources; urban and agriculture runoff, and in marsh re-suspension by waves or carp foraging.

E.coli bacteria – An indicator of untreated sewage or agriculture runoff. Recreational guidelines for water are less than 100 *E.coli*/100ml (provincial), and a 200 *E.coli* /100ml (federal).

Precipitation significantly affects the quality and quantity of the waters through sewer overflows, urban and agricultural runoff, and creek flows. Prior to sewer overflow tank construction even minor rain events (less than 5mm) caused sewer overflows to local waters. Sewer overflow tanks are designed to contain all sewage in rain events of up to about 25mm, and overall reduce overflows by 90%, capturing about 1.5 million litres annually. A trend of increasing frequency of large rains has occurred.

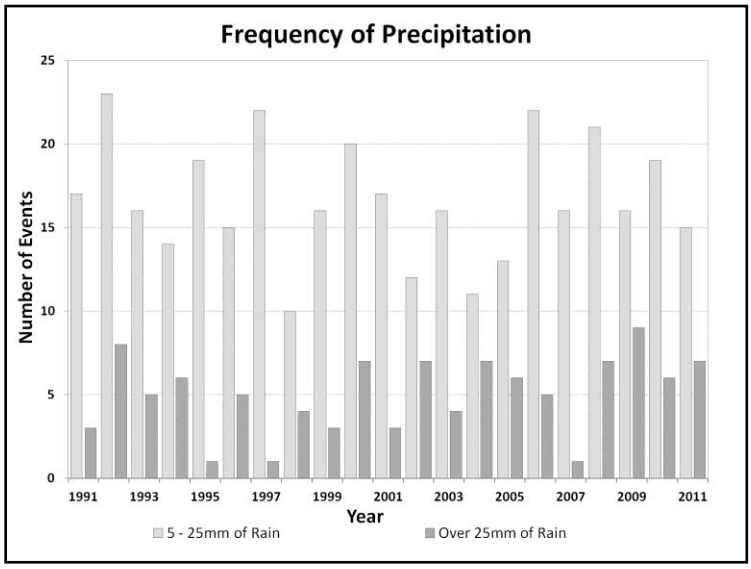


Figure 2. Summary of annual rain events based on level of intensity of the rain. Data summarized from the Hamilton Airport Environment Canada Weather Station.

Hamilton Harbour Remedial Action Plan Delisting Sites (Cootes Paradise & Grindstone Marsh)

A number of regularly monitored water quality stations are located within the harbour, marshes and tributaries. For the marshes one location was chosen in each as the delisting site at the outset of the HHRAP. These sites are used to index the water quality conditions on a year of year basis. Delisting refers to the Remedial Action Plan specifically, with water quality targets at these index sites to be meet for the area to be removed from the Great Lakes Areas of Concern list. Water quality delisting targets include water clarity, phosphorus, suspended sediment, ammonia, and algae levels.

Cootes Paradise Delisting Site

Site Description: Open water, mid-marsh location, near the outflow located at the East end of the marsh. The bulk of the water flowing through Cootes' Paradise mixes before passing this site.

Purpose: The water sampled at this site represents the overall state of water quality with the various inflowing waters mixed, as well reflects the water entering Hamilton Harbour from the marsh

***Summary*:** Overall this site demonstrates the water quality of Cootes Paradise is much improved and is improving on an ongoing basis. The exclusion of carp from Cootes Paradise, along with the infrastructure upgrades to the sewer overflow system is leading to better water quality at this site. Water clarity has more than doubled although needs to more than double again to reach the target. Carp exclusion is the most significant factor to date. The total suspended sediment levels are approaching the objective, although continues to limit water clarity and affect phosphorus concentrations. Phosphorus, while now less than half of what is was 20 years ago, is still high and reflective of a hypereutrophic environment, and needs to be reduced by half again. A hypertrophic environment is one in which algae outgrows and suppress other forms of plant growth.

It is important to note that strong winds continue to periodically impact water clarity levels by re-suspending bottom sediment, and will continue to do so until wetland plants dominant again and break the waves. During storm events water flowing in from Chedoke creek rarely reaches this delisting station. This water flows along the eastern shore, exiting directly into the harbour. A significant highlight is that many of the more sheltered inlets have improved to the point where the marsh bottom is often visible.

Grindstone Marsh Delisting Site

Site Description: Open water site, located at the mouth of Grindstone creek within Carroll's Bay Marsh

Purpose: The water sampled at this site represents the oval quality of water in the Grindstone Marsh area, and reflects the water entering Hamilton Harbour from this watershed.

***Summary*:** Grindstone Marsh has a watershed of approximately 1/3 that of Cootes Paradise, with this monitoring site having no direct carp exclusion. As a result this location serves as both a delisting site and comparison site for improvements at Cootes Paradise. To date the infrastructure improvements related to this marsh have had no measurable impact on the water quality at the site. The improved water quality in Cootes Paradise is now better than at this location. The information illustrates that suspended sediment is controlling both water clarity and phosphorus levels. The two infrastructure improvements so far completed in the Grindstone watershed; the repair of a broken sewer in 2002, and the 2010 removal of the Waterdown WWTP are expected to result in a gradual decline in the phosphorus levels over several years. In Grindstone Marsh rehabilitation areas (data not shown here) the water regularly has visibility to the bottom, as inflowing sediments are restricted and the excluded carp are not able to re-suspend the sediment. Twenty hectares of the 60 hectares of this marsh is under rehabilitation.

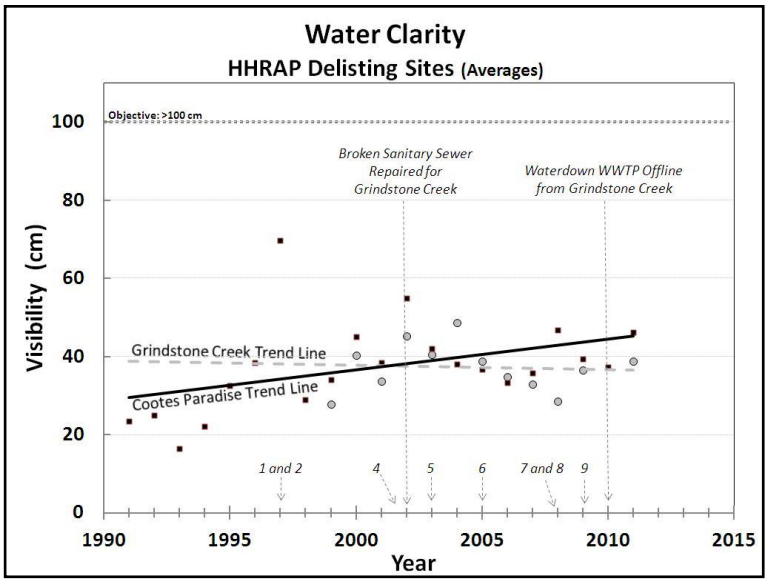


Figure 3: The average water clarity from each season of water quality sampling. Note the improving visibility of the water in Cootes Paradise, while Grindstone marsh remains fairly consistent. *(See Table 1, "Graph ID" column for the Cootes Paradise infrastructure upgrade associated with the number).*

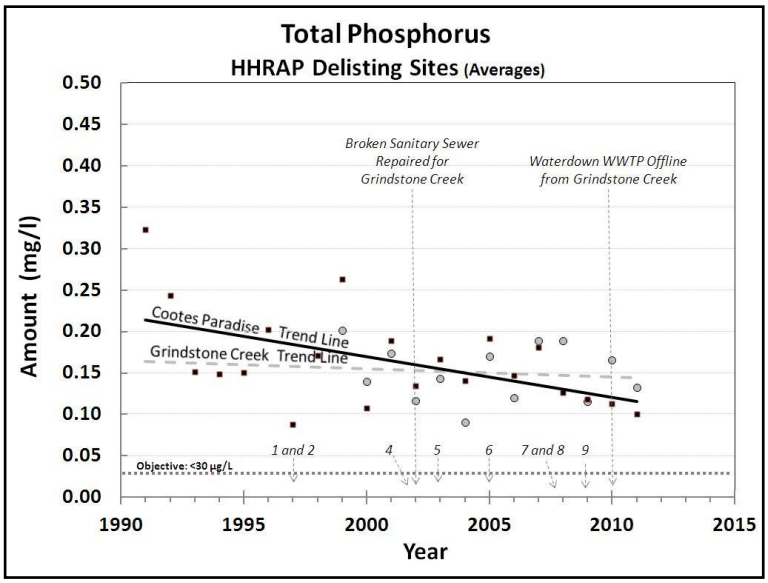


Figure 4: The average total phosphorus amount from each summer of water quality sampling. Note the decreasing trends in Cootes Paradise, especially since 2008. Cootes Paradise is moving towards the water quality objective, whereas Grindstone marsh has remained consistently high with some fluctuations. *(See Table 1, "Graph ID" column for the Cootes Paradise infrastructure upgrade associated with the number).*

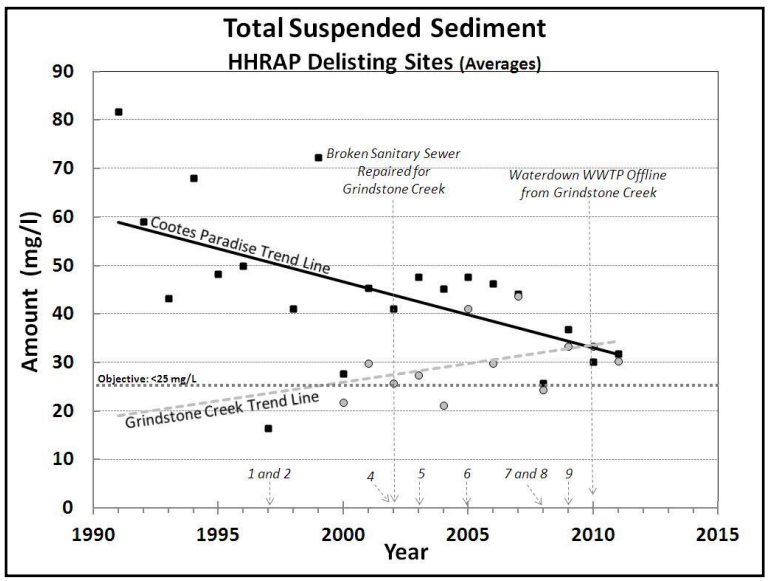


Figure 5: The average total suspended sediment amount from each summer of water quality sampling. Note the consistent decline in the Cootes Paradise levels since the carp barrier became operational and the infrastructure upgrades have been made. The suspended sediment levels in Grindstone marsh are not showing improvement. *(See Table 1, "Graph ID" column for the Cootes Paradise infrastructure upgrade associated with the number).*

Cootes Paradise Inflowing Water Sites (Chedoke Creek, Spencer Creek, Olympic Drive)

Chedoke Creek

***Site Description*: S**ampling site located approximately 200 meters upstream from the mouth, but downstream of the adjacent KayDrage landfill. Chedoke Creek has a highly urbanized 20 km^2 watershed.

Summary: While both suspended sediment and phosphorus levels have improved by almost 50% average water clarity has not shown an improving trend. Chedoke Creek periodically receives sewage from several CSO's and the increased precipitation in recent years is negatively affecting the creek, causing additional sewer overflows and urban runoff. Of the major inflowing water sources, Chedoke Creek is the poorest water entering Cootes Paradise Marsh, and substantial improvements continue to be needed.

Spencer Creek

Site Description: The monitoring site is located approximately 250 meters downstream from the Spencer Creek bridge on Cootes' Drive. Spencer Creek is the largest of the rivers of Cootes Paradise Marsh and Hamilton Harbour. The watershed is mostly rural and covers over 235 km^2.

***Summary*:** Spencer creek is consistently the best quality water entering the marsh and has improved by about 50% in the past 20 years. Suspended sediment and phosphorus dropped dramatically at this site once carp were excluded although then began to elevate again. During this time, Ancaster creek, a tributary of Spencer Creek has undergone a change from a rural to urban land use type. During heavier rains water quality temporarily declines due to both runoff from the land and a sewer overflow connection. A sewer overflow tank will be completed upstream of this site in 2011, with the creek water quality expected to continue to improve once the tank becomes functional. A highlight for this region was a project in 2003 reconnecting Spencer Creek to its floodplain. This reconnection helps to prevent flooding in nearby areas, catches sediment being washed downstream during floods, and most importantly has allowed waters to again reach an area of Cootes Paradise known as West Pond

Olympic Drive

Site Description: Open water sampling site, located 650m downstream from the Dundas Waste Water Treatment Plant, immediately east of Olympic Drive within the Desjardins Canal. The vast majority of the water which passes this station originates at the Dundas WWTP.

***Summary*:** This inflowing water site has shown about a 50% improvement in water quality and with the aid of infrastructure work has kept pace with the increasing population of Dundas. The waste water treatment process leaves the water with very little suspended solids, and existing suspended sediment at the site in the past is considered to have been the result of carp foraging. The overall result has been a consistent supply of clear water. However phosphorus levels are much higher than natural waters, despite being 95% cleaner than sewage, and generate substantial algae blooms. The continuous supply of water and growth of algae then flows downstream to West Pond and out into the main body of Cootes Paradise Marsh.

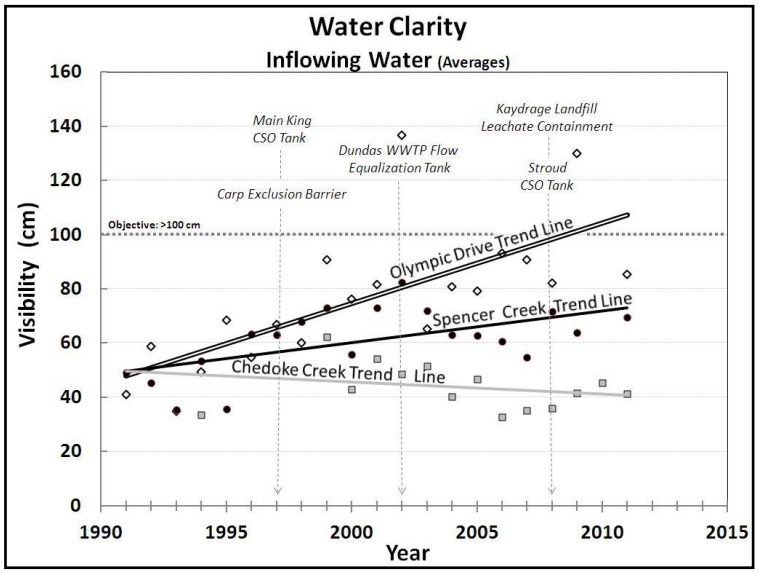


Figure 6: The average summer water clarity from three inflowing water sources of Cootes Paradise. Spencer Creek continues to improve, while Olympic Drive fluctuates near the objective. Chedoke Creek's water continues to have low levels of visibility. However, water clarity has been an improving slightly since 2006.

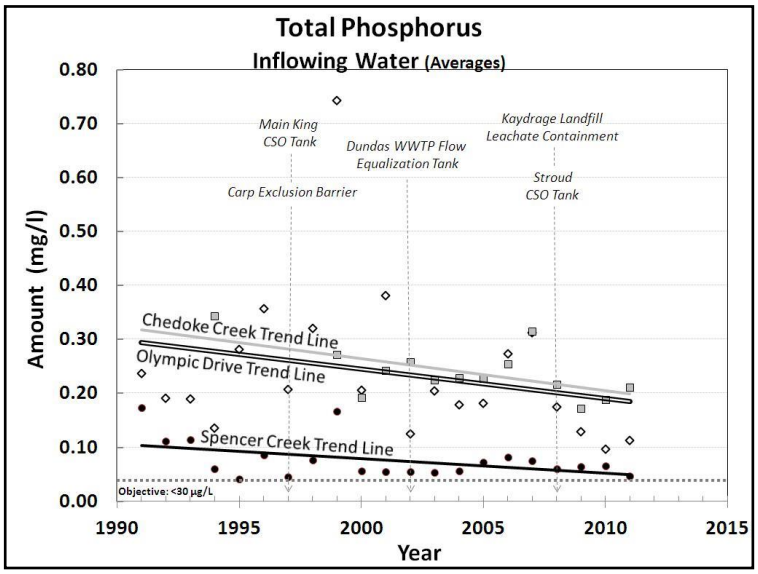


Figure 7: The average summer amount of total phosphorus from three inflowing water sources of Cootes Paradise. All sites are showing an improvement overall. The infrastructure improvements for Chedoke Creek and the Dundas WWTP have made significant contributions to the quality of water at their respective sites.

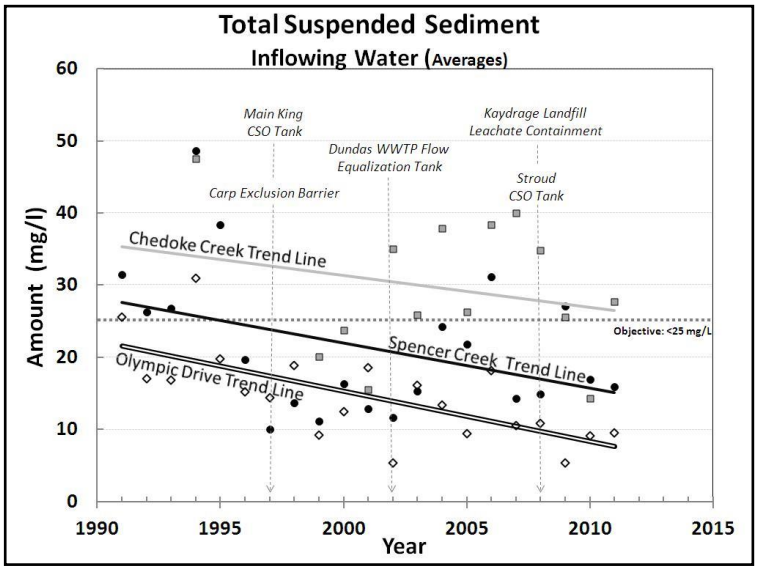


Figure 8: The average summer amount of total suspended sediment from three inflowing water sources of Cootes Paradise. All sites are continuing to improve with Spencer Creek and the Olympic Drive sites already below the objective value noted. Although there is some variability in Chedoke year to year, the averages are approaching the objective as well.

Sites Specific Areas (West Pond & Westdale Inlet)

West Pond

Site Description: A shallow floodplain pond of Spencer Creek at the Western end of Cootes Paradise, approximately 7 hectares in size and less than 50 cm deep. West Pond receives the majority of its water from the WWTP, located 1.2 kilometers upstream.

***Summary*:** West Pond, once the most polluted part of Cootes Paradise Marsh, has shown the most dramatic improvements within marsh. Water quality in the pond is 2 to 3 times better than conditions 20 years ago. Water clarity in particular is often better than many other areas of Cootes Paradise, and reflects the effect of the carp exclusion effort, and the clarity of the effluent water from the Dundas WWTP. Conditions in the pond now mirror the flow of the water leaving the WWTP. The improved clarity in combination with the elevated phosphorus levels causes a dramatic growth of filamentous algae often smothering all other plant growth, although the annual extent of these algae rafts are observed to be decreasing. A significant contributor to West Ponds improvement was the reconnection of the Spencer Creek floodplain to the pond. This occurred in 2003 after a period of 150 years of isolation from most flood events. This has allowed creek water and fresh sediment to enter the pond during bank full flood events diluting and burying the highly enriched sediments that had develop during the period of isolation.

Westdale Inlet

Site Description: A sheltered inlet site located along the south side of Cootes Paradise Marsh, receiving water from Westdale creek. Westdale creek is a spring feed creek, located east of McMaster University, within the community of Westdale, and having a sewer overflow location at its headwater.

Summary: Westdale inlet is consistently the best region of Cootes Paradise Marsh. The trend line information shows dramatic improvements in phosphorus and suspended sediment levels. Water clarity does not reflect the true pattern of improvement due to the lack of pre-restoration monitoring data (limited to 1994). Westdale Inlet's water clarity has benefited most from reduced total suspended sediment levels brought about by the carp exclusion project. However the CSO improvement projects have improved the sediment, and have reduced the overflows from over 30 times per year to an average of less than 1 per year as observed by RBG staff. The enriched sediments while improving do continue to cause algae blooms and enrich the water column with phosphorus. This condition is expected to continually improve as aquatic plants remove the accumulated nutrients and the creek continues to provide clean water.

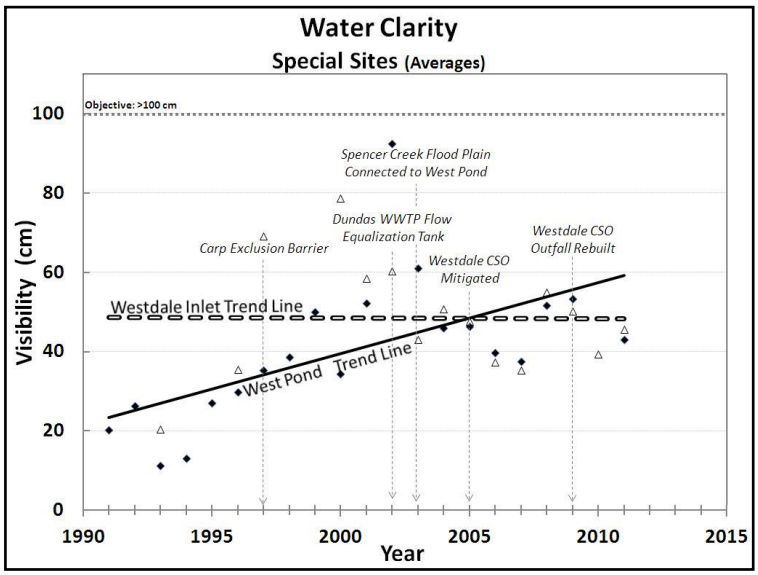


Figure 9: The annual summer water clarity averages from West Pond and Westdale Inlet. In 1996 Westdale was the site of an experimental carp exclusion barrier improving clarity. Recently water clarity has been fairly stable at both sites.

**The data point for Westdale Inlet in 1996 was from a set of data with only 4 entries between July and September. The 1997 value for the same site is from 5 entries from May to September.*

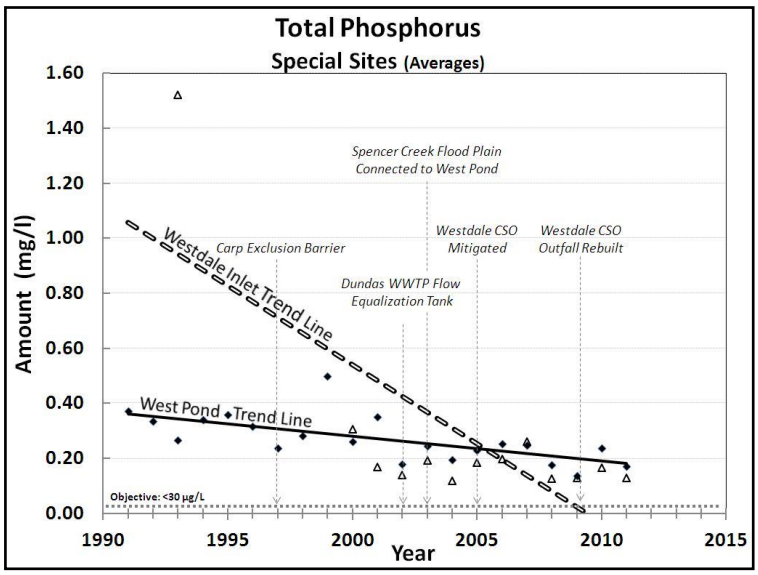


Figure 10: The annual summer total phosphorus averages from two sheltered sites; West Pond and Westdale Inlet. Both sites show decreasing total phosphorus levels.

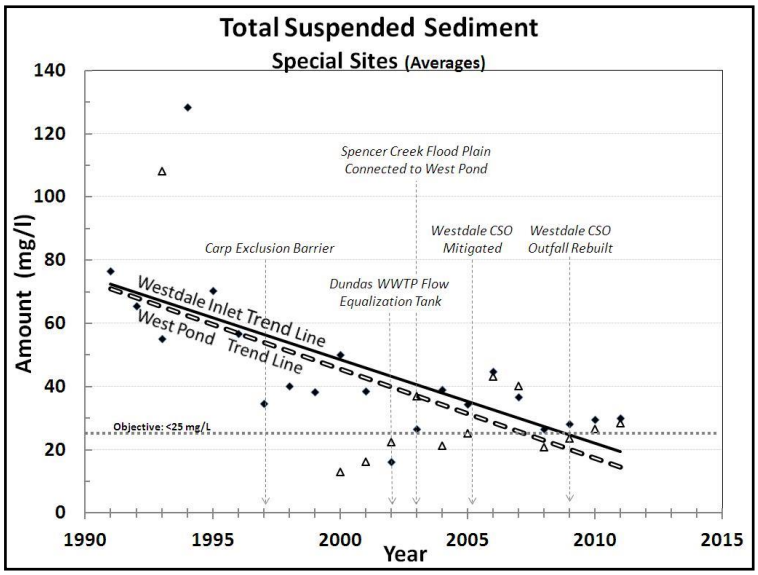


Figure 11: The annual summer total suspended sediment averages from two sheltered sites; West Pond and Westdale Inlet. Notice the elevated levels of sediment in the water before the carp barrier was operational. More recently, both sites have been consistently near or below the objective value.

Bacteria Sampling (Cootes Paradise & Grindstone Marsh Delisting Sites and Inflowing Water Sites)

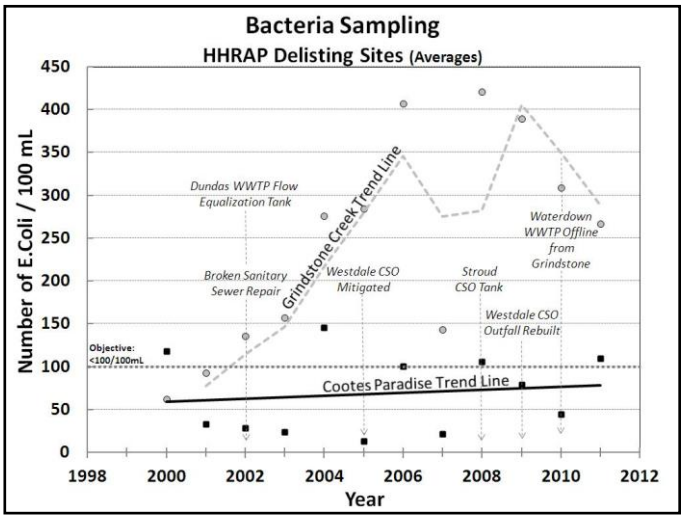


Figure 12: Average amount of *E.coli* present at the two delisting site. Note that Grindstone creek was once lower than the objective.

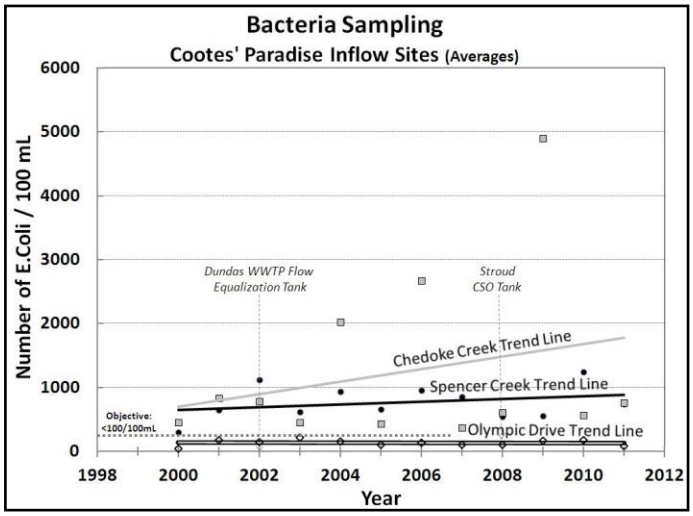


Figure 13: Average amount of *E.Coli* bacteria present in the water quality samples from the inflowing sites.

Average *E.coli* bacteria levels within the marsh have not shown an improvement over the duration of monitoring despite the projects that have been undertaken. Bacteria objectives are not part of the HHRAP delisting criteria for the marsh areas. Recreational use of water as a delisting criteria is measured at the designated beaches of the harbour.

At the Cootes Paradise Marsh site, average bacteria levels were generally not poorer than the recreational guidelines and have not declined despite the increasing frequency of heavier rain events (Figure 1), demonstrating that the overflow tanks are improving the conditions. Also influencing this monitoring site is the sewer overflow on Spencer Creek (Ancaster tributary). The holding tank for this site began construction in 2009 and is expected to be operational in 2012. The annual pattern of bacteria levels in the marsh reflects the pattern of rain events and intensity, and the need to complete the tank.

In the case of Grindstone Marsh, conditions have worsened during the period with conditions often poorer than would be recommended for swimming. No CSO sites are part of the watershed, and like Cootes Paradise Marsh, the variable pattern of concentrations is reflective of the pattern of increasing rain events of higher intensity.

The Chedoke Creek *E.coli* trend is reflecting the influence of heavy rains in recent years (Figure 2). Table 2 provides a more detail view of the data. The influence of the rain and sewer overflow events are illustrated in the variability and scale of the results found for the creek. While Chedoke Creek occasionally has levels below recreational guidelines, it consistently has elevated levels of *E.coli* indicating sources beyond the CSO's.

Table 2: Chedoke Creek *E.coli* bacteria levels (May to September biweekly monitoring).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Minimum	40	10	96	30	60	10	50	50	20	50	60	20
Average	449	837	786	449	2,027	427	2669	369	605	4,899	570	762
Maximum	4,000	70,000	150,000	26,200	260,000	13,000	210,000	200,000	35,900	190,000	6,700	560,000

Summary

Over the last 20 years water quality within Cootes Paradise has significantly improved demonstrating the effect of the water quality improvement work done to date. Overall, water clarity improvements throughout the marsh areas are primarily the result of carp exclusion, reducing levels of suspended sediment. This is emphasized by the Grindstone Marsh were the lack of carp exclusion has resulted in no measurable improvement in its water quality despite improvements to the inflowing water. For Cootes Paradise Marsh, significant reductions to inflowing contaminants have been accomplished through the municipal infrastructure upgrades. These upgrades have eliminated the frequent smaller sewer overflows at several locations. Currently in a typical rainfall year, due to the upgrades it's estimated that 90% of the sewer overflows will no longer occur. This represents an estimated 1.5 billion liters of contaminated water that no longer enters Cootes Paradise Marsh (HHRAP Contaminant Loadings Report 2009). However, large storm events are still causing untreated sewage to enter the marsh with measurable results.

Continued effort and support is needed for the water quality of Cootes Paradise Marsh and Grindstone Marsh to reach the final objectives. Reduction of inflowing sediment is the key for Grindstone Marsh. The future challenge for the water quality of Cootes Paradise Marsh is a combination of refinements to existing sewer overflow tanks, to the Dundas Waste Water Treatment Plant, climate change, and the many smaller scale localized locations throughout the watershed. These localized effects are particularly relevant for the historical stormwater and wastewater systems within the urban area of the City of Hamilton. Undertaking these challenges in the context of climate change is important as this has the potential to generate more intense rains, subsequently overwhelming the treatment system and further increasing creek erosion rates.

Acknowledgments

The RBG would like to thank the City of Hamilton, Environment Canada, and the Ontario Ministry of the Environment for their contributions toward the sewer infrastructure upgrades and supporting the water sampling to monitor water quality. We would like to thank all of the various RBG staff members who have contributed to the data collection and general improvements across the RBG wetlands. We would like to thank the Hamilton and Halton Conservation Authorities and the Ministry of Natural Recourses for their watershed stewardship programs and the ongoing small scale improvements occurring in the rural portion of the watersheds.

Partners

Bay Area Improvement Team: *ArcelorMittal Dofasco , City of Burlington, City of Hamilton, Conservation Halton, Fisheries and Oceans Canada, Environment Canada, Hamilton Conservation Authority, Hamilton Halton Home Builders' Association, Hamilton Harbour RAP Office, Hamilton Port Authority, Hamilton Waterfront Trust, McMaster University, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, Regional Municipality of Halton, U. S. Steel Canada, Royal Botanical Gardens and the Bay Area Restoration Council.*

Additional Information

Royal Botanical Gardens-*Conservation Projects* - http://www.rbg.ca/projectparadise

Hamilton Harbour Remedial Action Plan -*Home Page* - www.hamiltonharbour.ca

Environment Canada - *Great Lake's Areas of Concern* - http://www.ec.gc.ca/raps-pas/