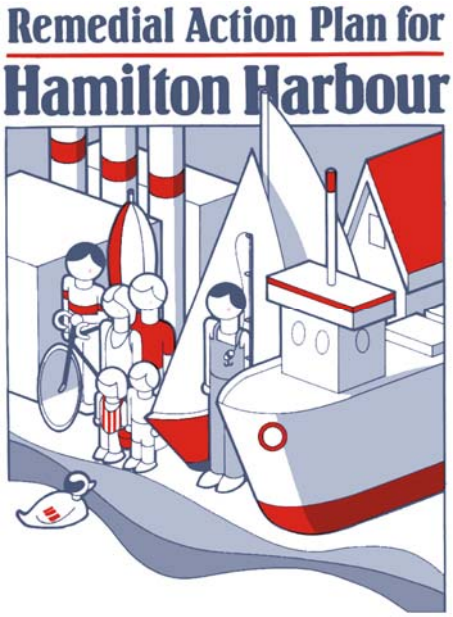
Recommended Total Phosphorus Target for the Dundas Waste Water Treatment Plant:

Towards Achieving a Healthy Cootes Paradise Marsh and Delisting as an Area of Concern



Prepared for the City of Hamilton by the Cootes-Grindstone Water

Quality Targets Subcommittee

July 19, 2017

This document summarizes recommendations from the Cootes-Grindstone Water Quality Targets Subcommittee who had the effect of potential Dundas Waste Water Treatment Plant (WWTP) upgrades on West Pond, the receiving waterbody in Cootes Paradise, mathematically modelled. The group recommends that the Dundas WWTP Total Phosphorus (TP) target represents the lowest end of a threshold associated with a shift to a more desirable state – a tipping point to a healthy, resilient, and aesthetically pleasing marsh.

Remedial Action Plan Recommended Target

Dundas WWTP target: 0.05 mg/L TP effluent concentration calculated as a 6-month average (May – October and November – April, inclusive).

Benefits of Delisting Cootes Paradise Marsh

Delisting Cootes Paradise marsh as part of the Hamilton Harbour Area of Concern will require meeting habitat targets (BU xiv), which are dependent on water clarity and quality. Better quality effluent will give native plants a chance to regrow and help create the underlying conditions necessary for marsh restoration and creating a sustainable marsh. Cootes Paradise is the largest remaining coastal marsh in western Lake Ontario, and together with the Grindstone marsh comprise >98% of the remaining Hamilton Harbour wetlands. Cootes Paradise marsh has a number of designations that recognize its ecological significance to both the local area and the province:

- Provincially Significant Wetland and Area of Natural and Scientific Interest (Province of Ontario)
- Class 1 Wetland (Ministry of Natural Resources and Forestry)
- Environmentally Sensitive Area (City of Hamilton)
- Nationally Important Bird Area (Birdlife International) and Important Amphibian and Reptile Area (Canadian Amphibian and Reptile Conservation Network).

Achieving a healthy and sustainable marsh will be of great public interest for the cities of Hamilton and Burlington. Beyond the significant benefits the wetlands provide for coping with the rapidly changing climate, a healthy functioning marsh the size of Cootes Paradise will provide huge economic benefits and major increases in tourism and recreation. Fish, bird, and reptile populations are a draw for eco-tourism in Hamilton Harbour, Lake Ontario, and North America.

Relevance of West Pond to Cootes Paradise Marsh

West Pond is part of the larger Cootes Paradise marsh, downstream of the old Desjardins Canal and Dundas WWTP. West Pond receives treated effluent first and the effluent does not meet mixing water until it joins with Spencer Creek more than 1.5 km downstream. As such, the pond experiences the cumulative effects of year-round effluent loading. Cooler, deeper habitat in the adjacent old Desjardins Canal serves as thermal refuge for fish in the marsh, but populations in West Pond remain indicative of a stressed system. Excessive nutrient inputs, phosphorus-laden sediment, subsequent algal growth, and oxygen depletion impact the aquatic biota and aesthetics of the area.

Improvements in Cootes Paradise and West Pond marsh habitat have been astounding over the past five years with large increases of marsh vegetation. Water lilies have begun to thrive in West Pond, which can help to suppress algal blooms through competition for nutrients and providing shelter for zooplankton grazers, such as *Daphnia,* that provide top-down control on algae. The main body of Cootes now supports dense plant growth until the onset of summer. However, the plant community is dominated by one species which becomes smothered by algae, breaks down, and dies in early July, thus the benefits of submergent plants are only observed for a short time. These marsh improvements also coincide with recent and cumulative improvements at the WWTP and a decrease in effluent phosphorus concentration (i.e. sand filter refurbishment). Results from a nutrient model indicate the Cootes Paradise marsh is near the threshold of being in an improved state and needs a push in the right direction. The recent increase in submergent plant community has demonstrated that marsh water quality targets can be met through further reductions in phosphorus loading. Increasing abundance of submergent plant growth will provide a positive feedback to further enhance water clarity and provide conditions conducive for additional submergent plant growth. Improvements in the inflowing waters are therefore necessary to push the system toward one which supports a more diverse plant community, which will sustain these clear water conditions throughout the year and build resilience into the ecosystem.

Net Loading of Total Phosphorus and Relationship to Water Quality Impairment

The rationale for the WWTP target requires distinction be made between the total phosphorus load and net phosphorus load to the system. When investigating the effects of TP inputs on a body of water, net loadings is the driving factor. It takes into account the flow and concentration of water sources, and the residence time in the receiving water body. Cootes Paradise marsh is relatively shallow with a short hydraulic residence time compared to larger bodies of water such as lakes. Essentially, Cootes Paradise marsh acts like a river during rain events, whereby increased flow from the tributaries flushes phosphorus loads into Hamilton Harbour. During low flow (dry weather), the marsh functions more like a pond and concentrated effluent becomes predominant. Net loading values clearly suggest that point sources always make a greater positive contribution (i.e. raise concentrations), while the net tributary loads have mostly been negative (flushing effect). This is because point source inputs, coupled with internal loading from the sediments, typically elevate TP concentrations in the system far above the tributary levels. Hence, tributary inputs actually flush some of the excess loading, thereby alleviating the impact of point source loads (note that this pattern is primarily based on annual/seasonal averages and may not hold true in shorter time scales i.e., 10-15 days, especially during the summer period). In addition to the Dundas WWTP and tributaries, the marsh receives phosphorus input from urban runoff, combined sewer overflows (CSOs), and groundwater. Of these sources, only the Dundas WWTP has a relatively consistent flow and total phosphorus concentration in the effluent. The other sources are largely governed by seasonal variation in hydrology and episodic wet weather events. If a 0.05 mg/L TP effluent concentration is achieved, the Dundas WWTP would be a negative net load contributor, especially during wet weather events.

Drivers of Total Phosphorus Concentration in Marsh (West versus Centre) and Manageability of Drivers

Total Phosphorus loadings from the Dundas WWTP are a major contributor to TP concentrations in West Pond. A modelling exercise, with water quality data from 2004 to 2013, showed a strong and statistically significant relationship between TP concentration in Dundas WWTP effluent and the ambient TP level in West Pond. Phosphorus at the center marsh station (the HHRAP water quality delisting station, CP2) is driven in part by inputs from the WWTP as well as three tributaries, Spencer Creek, Borers Creek, and Chedoke Creek, with internal processes contributing to the recycling of phosphorus stored in the sediment. However, the WWTP is the most manageable source of net phosphorus loading to the marsh, as phosphorus from creeks is highly variable and depends on precipitation events and hydrology. Modelling exercises indicate that if phosphorus from the Dundas WWTP can be reduced to 0.05 mg/L, it will bring the system closer to the "tipping point" that triggers a shift to an alternative, more desirable state; one that favors submergent plant over algal growth, and improves the likelihood of a healthy sustainable marsh. A TP concentration of 0.05 mg/L is also being considered for a Cootes Paradise marsh objective.

Bioavailability of Total Phosphorus Sources

Phosphorus from WWTPs is more bioavailable than phosphorus from other sources (including creeks, agriculture, and precipitation) because a higher proportion is in the soluble rather than the particulate form. This means that phosphorus from sewage effluent is readily accessible to algae and will induce blooms. Modelling analysis predicted dramatic short-term changes in the water quality, such as 5-15% increase of chlorophyll *a* and up to 50% likelihood of compositional shifts in the algal assemblage, depending on the relative fraction of soluble reactive to particulate phosphorus in the WWTP effluent and the hydrodynamics in Cootes Paradise marsh.

Timeframe for Achievability

Due to a long history of elevated phosphorus inputs, the marsh also has an internal pool of phosphorus in the sediments, which requires time to flush out after loadings from all other sources have been reduced. After carp exclusion, internal loading due to resuspension, mineralization, and reflux contributes approximately 35-40% of the total TP load to Cootes Paradise, or an average of 7.5 mg m^{-2} day^{-1} during the growing season. From a management standpoint, the presence of a positive feedback loop suggests that the anticipated benefits may be delayed, but there is hope that the timeframe documented in the literature will be replicated here (approx. 10-15 years). The apparent stability of the turbid-phytoplankton state in shallow systems has often been attributed to hysteresis – the inability of a system to be restored to its clear state once the external drivers that triggered a switch to a turbid state have been removed or reduced. Managing the phosphorus-laden sediment in the old Desjardins Canal may allow the full benefit of the upgrades to be realized sooner. Restoring the plant community is a critical factor that will also determine the recovery rate of the system. The Royal Botanical Gardens' staff are planting aquatic vegetation on a yearly basis to reduce wind and wave sediment resuspension, reduce shoreline erosion, increase diversity in the plant community, and to rebuild creek channels which

help divert stormwater from the main body of the marsh. In summary, there is every reason to expect a favourable response in 10 to 15 years but the actual response cannot be predicted precisely.

Mixing Zone Requirements

Given that the scope of the recommended changes result in a decrease in the overall loading and effluent limits for the Dundas WWTP from the current Environmental Compliance Approval, the requirement to complete a mixing zone assessment is not triggered by the proposed revisions for the Dundas WWTP. The information that has been collected to date to support the assessment of impacts on Cootes Paradise provides base information that supports this determination.

Impact of 0.1 mg/L versus 0.05 mg/L Effluent Phosphorus on the Marsh

The modelling exercise projected that if effluent phosphorus is reduced from 0.1 mg/L to 0.05 mg/L, ambient TP will be reduced by 20% in West Pond and < 10% in Cootes Paradise marsh (CP2). While this potential improvement on its own may not be enough to trigger a shift to an alternative state, it is one of the essential requirements to create conditions conducive to faster and more reliable restoration over the long term. West Pond would show the first response to a decrease in effluent TP loads.

Impact of Complete Removal of the WWTP from Cootes Paradise

The removal of this phosphorus source entirely from Cootes Paradise was run as a scenario in the model. A decrease by 15% in phosphorus concentration at CP2 was predicted. Delisting can be achieved with keeping the WWTP outlet at its existing location, as long as the WWTP effluent phosphorus targets can be met and support a macrophyte-dominated marsh. An effluent concentration of 0.05 mg/L is substantially less than the current summer mean TP concentration at the delisting station and the flow-weighted mean concentration for Spencer Creek and other tributary inputs. This effluent limit would make the WWTP a negative net load contributor (particularly during wet weather events) and is probably why the WWTP diversion assessment shows no significant ancillary benefit. Taking the WWTP offline would not produce significantly better results as flow from the WWTP represent a major fraction of the hydraulic loading in West Pond during the summer months and prolonged droughts.

Concluding Remarks

Hamilton Harbour and Cootes Paradise marsh are complex systems. Modelling exercises have demonstrated a clear link between the quality of Dundas WWTP effluent, and water quality at West Pond with a weaker relationship progressing eastward into the marsh. The best chance at delisting and achieving a healthy, resilient marsh includes a Dundas WWTP TP target that matches the lowest end of a threshold associated with a shift to a more desirable state. Overall, the 0.05 mg/L target will not be the sole solution to restoring Cootes Paradise or delisting, but the best scientific knowledge suggests that it is a crucial component in the transition to an alternative, clear-water state. The Royal Botanical Gardens is working to plant native aquatic vegetation in the marsh and Conservation Authorities are implementing best management practices to reduce tributary phosphorus loads. Thus improving WWTP effluent is part of a multi-pronged approach to reduce phosphorus loading to the maximum extent

possible and is a necessary step in improving and restoring eutrophic waterbodies. The timing of upgrades in conjunction with Cootes Paradise marsh being near a tipping point presents a unique opportunity that could mutually benefit the City and the marsh.

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