

Toronto and Region Remedial Action Plan

Degradation of Aesthetics Beneficial Use

Technical Summary Report

2012-2015

- Final -

Prepared by: Shari Dahmer

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Executive Summary

Toronto and Region was designated a Great Lakes Area of Concern (AOC) in 1987 due to significant degradation of environmental quality and impaired beneficial uses, including Degradation of Aesthetics. The AOC includes 42 km of Lake Ontario waterfront and six watersheds that extend from Etobicoke Creek in the west to the Rouge River in the east. Historically overflows of combined sewers, direct discharge of poorly treated industrial wastewater, contaminated stormwater, and litter contributed to excessive floating debris, odour and unnatural turbidity along parts of the waterfront and in some sections of AOC watersheds. Significant progress has been made within the AOC to abate the impacts of human activities and development on water quality and environmental condition, however, monitoring for aesthetic condition has been limited due to the challenge of reporting aesthetics in a quantifiable, unbiased manner.

In order to assess the Degradation of Aesthetics beneficial use, an Aesthetic Quality Index (AQI) developed for use by AOCs was adapted by taking advantage of existing monitoring programs and local expertise. Aesthetic conditions were assessed in terms of water clarity, water colour, water odour, and the presence of debris. This report presents a summary of the results from aesthetics monitoring that was conducted throughout AOC watersheds and along the waterfront during 2012, 2013, and 2015.

The aesthetic condition of Toronto's waters were generally considered excellent or good, and no differences were observed between watercourses in the AOC compared to regional watershed and waterfront sites outside of the AOC boundary. Results indicated that that no persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour were present in the Toronto Region during the period of study, indicating that the Degradation of Aesthetics beneficial use is not impaired for the Toronto and Region AOC.

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Introduction

Toronto and Region was designated a Great Lakes Area of Concern (AOC) in 1987, under the Great Lakes Water Quality Agreement (GLWQA). AOCs are areas where water quality and ecosystem health are considered to be severely degraded as a result of local sources of pollution caused by human activities. A Remedial Action Plan (RAP) was developed for each AOC to guide restoration and protection efforts with the goal of restoring local Beneficial Use Impairments (BUIs) and ultimately having Toronto and Region removed from the list of AOCs.

Over the last 30 years implementation of remedial and management actions have led to significant and demonstrable improvements. The Toronto and Region RAP is currently in the process of completing remedial actions and monitoring the recovery of environmental conditions in the AOC, with the goal of completing the remaining restoration actions by 2020 in order to move toward delisting.

Degradation of Aesthetics was one of 11 beneficial uses that were identified as impaired in the Stage 1 RAP Report *Environmental Conditions and Problem Definition* (RAP, 1989). Historically overflows of combined sewers, direct discharge of poorly treated industrial wastewater, contaminated stormwater, and litter contributed to excessive floating debris, odour and unnatural turbidity along parts of the waterfront and in some sections of AOC watersheds. Considerable efforts to improve the management of municipal stormwater and sewage, and increased public education have led to improved aesthetic conditions throughout the Toronto and Region AOC, however, monitoring of aesthetic condition has been limited due to the challenge of reporting aesthetics in a quantifiable, unbiased manner. This report describes the aesthetics monitoring program developed to assess the Degradation of Aesthetics BUI in the Toronto and Region AOC, and summarizes the results from aesthetics monitoring conducted during 2012, 2013, and 2015.

Background

Toronto and Region Area of Concern

The Toronto and Region AOC extends along the north shore of western Lake Ontario from Etobicoke Creek in the west to the Rouge River in the east. The AOC covers a total area of 2000 km², including 42 km of waterfront and six watersheds (Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek, and Rouge River; Figure1). Rural landscapes comprise more than 40% of these watersheds. In contrast, the AOC also includes the City of Toronto, which is one of the most densely urbanized areas in the Great Lakes with a population of 2.8 million (7 million in the Great Toronto and Hamilton Area, or GTHA).

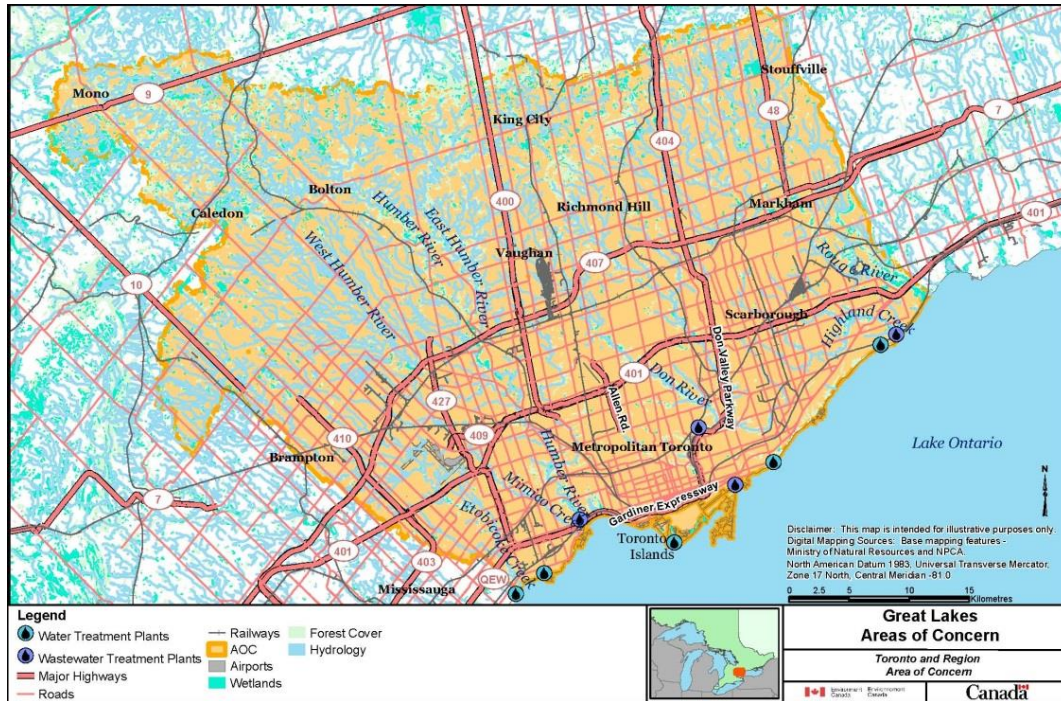


Figure 1 Map of the Toronto and Region Area of Concern (AOC) which extends from Etobicoke Creek to the Rouge River, and includes 42 km of waterfront.

Degradation of Aesthetics Beneficial Use Impairment

The Stage 1 RAP Report (1989), *Environmental Conditions and Problem Definition*, recognized Degradation of Aesthetics as one of the impaired beneficial uses contributing to degraded environmental quality in the Toronto Region, stating:

“Aesthetic concerns relate primarily to debris and litter. Turbidity is also a concern near river mouths and in the vicinity of lakefilling operations. Weed growth is a concern along the western shoreline”
(RAP, 1989)

Subsequently, the Toronto and Region RAP adopted the International Joint Commission’s (IJC) delisting objectives for the Degradation of Aesthetics BUI when it was developing restoration targets for the Stage 2 RAP Report (1994) *Clean Waters, Clear Choice*. The delisting objective states that the Degradation of Aesthetics beneficial use will no longer be considered impaired when:

“Waters are free of any substance that produces a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour (for instance oil slick or surface scum)”
(IJC, 1991; RAP, 1994)

Aesthetics Monitoring Program

In order to assess the Degradation of Aesthetics beneficial use for the Toronto and Region AOC, an assessment protocol was developed that utilized existing monitoring programs and local expertise within the Toronto and Region Conservation Authority (TRCA). The objective of the aesthetics monitoring program was to identify substances that produce persistent objectionable or unnatural debris, turbidity, colour, or odour in local watersheds or along the waterfront, and to compare aesthetics within the AOC to regional conditions.

Methods

The sampling and analytical methodologies for assessing the Degradation of Aesthetics BUI were adapted from similar work conducted by Heidtka and Tauriainen (1996) in the Rouge River AOC in Detroit, Michigan.

During 2001 and 2002 a pilot study was conducted to assess aesthetic conditions of Toronto watersheds using community volunteers (TRCA, 2003). Recommendations from the pilot study were used to refine the sampling methodology for the Toronto RAP aesthetics monitoring program. For example, because aesthetic condition is a subjective determination, the aesthetics monitoring program provides clear guidelines on how to identify natural vs. unnatural conditions, and also included in-person training at the beginning of each field season to ensure aesthetic condition of sites were comparable between different field crews. Additionally, sampling locations for the pilot study were left to the discretion of volunteers, leading to an unequal distribution of sites throughout the watershed and also introduced the potential to bias site selection toward areas that tended to be aesthetically unpleasing. By leveraging existing TRCA monitoring programs, sampling sites are distributed throughout the entire RAP area, and also cover Non-RAP watersheds (Petticoat Creek, Duffins Creek, Carruthers Creek, and Frenchman's Bay) within TRCA's jurisdiction.

Study Area

Samples (i.e., observations) were collected from nine watersheds across TRCA's jurisdiction, as well as from Frenchman's Bay and the Lake Ontario waterfront. The watersheds range in size from 27 to 911 km² and all drain into Lake Ontario. The jurisdiction was divided into the "RAP area" and "Non-RAP area" to allow a comparison of conditions within the AOC, compared to regional conditions. The RAP area includes the six watershed from Etobicoke Creek to the Rouge River – and corresponding 42 km of waterfront – along the western portion of the jurisdiction, while the Non-RAP area includes the watersheds and waterfront to the east of the Rouge River.

Sample Collection

The aesthetics monitoring program was implemented during 2012, 2013 and 2015 as part of TRCA's waterfront and watershed monitoring activities, which monitors fish and benthic macroinvertebrate communities, as well as aquatic habitat conditions (i.e., water quality, stream discharge, and channel morphology). Aesthetics observations were recorded each time a site was visited by field crews. Observations were made during daylight hours and not during heavy rain. Because aesthetics data was collected in conjunction with ongoing monitoring programs, the

number of samples collected varied by site, and the number of sampling sites varied by watershed (Figure 2). In the case where a monitoring site was visited by more than one sampling crew on a given day, duplicate records were removed from the dataset. In 2012 and 2015 both stream and waterfront sites were sampled; However during 2013 only stream sites were sampled.

Environmental Endpoints

At each site observations were recorded for four endpoints: water clarity, water colour, water odour, and the presence of debris at the site. Observations were matched to a pre-defined descriptor for each category (Table 1). Detailed methodology can be found in *Method to Assess Beneficial Use Impairment (BUI) Degradation of Aesthetics (Toronto)* (Mutton, 2012).

Briefly, a water sample was collected in a 500 mL clear sample bottle to determine clarity (based on the visibility of a pre-identified symbol on the data sheet; Figure 3), colour, and odour. For debris, observations were made based on the presence of anthropogenic, non-natural materials that had accumulated in large or unusual quantities at each site. If debris was detected at a site, staff determined which descriptor definition best fit the observed debris; if they were unsure a photograph was taken so the debris descriptor could be determined later in comparison to other site photographs.

The list of category descriptors (Table 1) used for the aesthetics monitoring program were expanded beyond those suggest by Heidtka and Tauriainen (1996) to account for the expected range of conditions observed in the Toronto Region. Additions included a yellow/amber colour, petroleum odour (transitory or spill), and the presence of non-natural foam or oil films/sheens.

Clarity

One of three levels of clarity (i.e., clear, cloudy, opaque) were used to describe each sample, based on the visibility of a pre-identified symbol when a bottle filled with 500 ml of water from the sampling site was held up to the data sheet.

Colour

Water colour can be highly variable, and is influenced by a number of natural and non-natural factors. Samples were described as colourless, green, yellow/amber, brown, grey or black, with colours most likely to have resulted from anthropogenic sources scoring lower than those resulting from natural processes (e.g., algal growth).



Figure 2 Example of clear, colourless (left) and opaque, brown (right) water samples collected for aesthetics monitoring

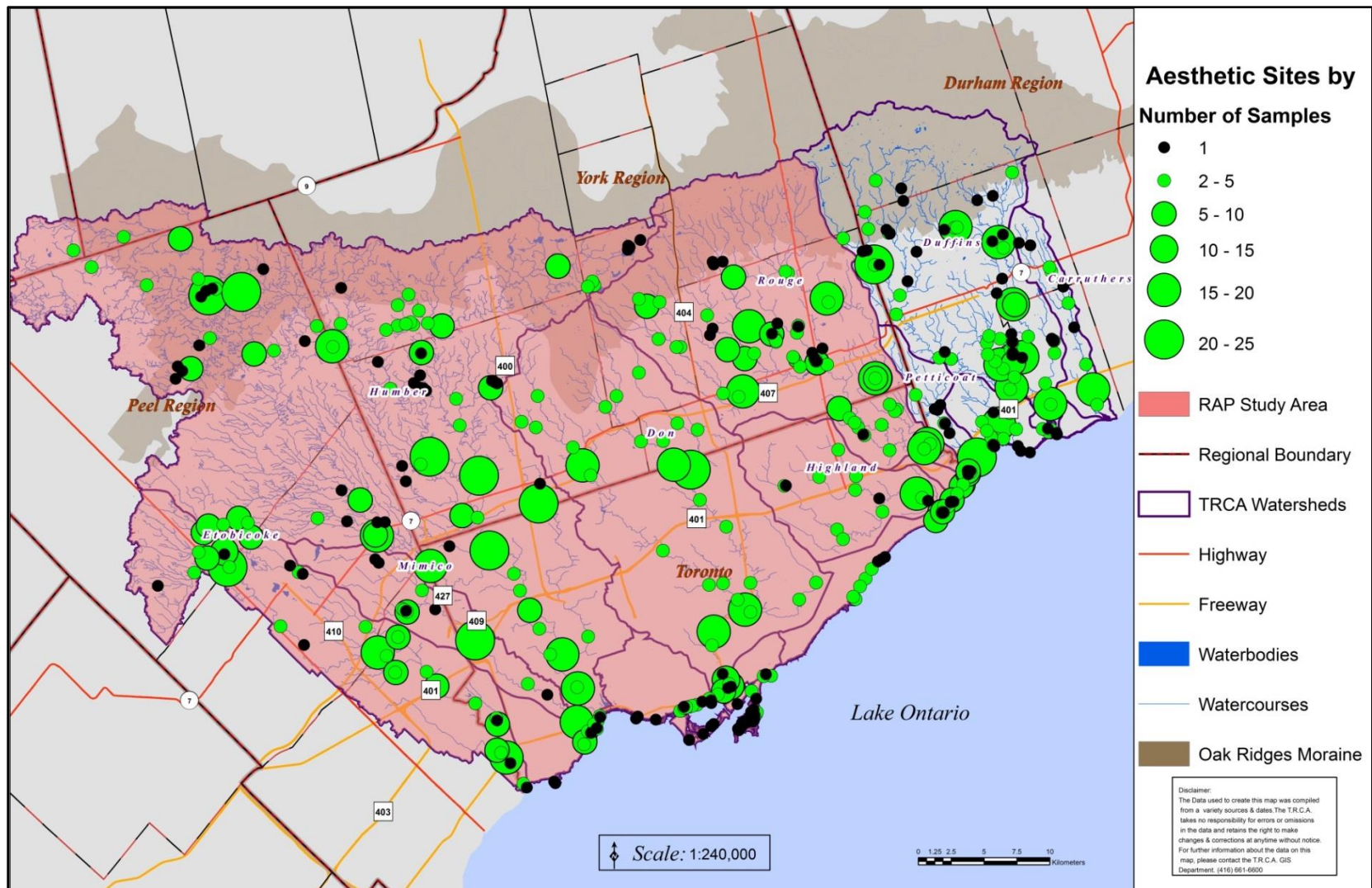


Figure 3 Location of sampling sites throughout RAP (pink) and Non-RAP watersheds. Marker size identifies the number of times each site was sampled during the study period (2012, 2013, and 2015 field seasons).

Odour

When determining aesthetic condition of a sample the primary concern related to odour was the presence of unnatural odours (for example, an oil slick or raw sewage). Odours from decaying natural materials such as algae, fish, or zebra mussels were considered natural.

Debris

Observations were made at each site to identify the presence of anthropogenic, or non-natural, materials that had accumulated in large or unusual quantities. Small amounts of isolated and non-recurring debris (e.g., plastic bags) may be acceptable and would not necessarily constitute aesthetically poor conditions at a particular site. In some cases, the debris may be man-made but have become part of the natural environment over the years (such as concrete slabs) and were not considered when determining the debris score for the site. The level of trash recorded was intended to reflect a qualitative first impression of the sampling site, therefore the “Trash (large amount)” descriptor is indicative of a site where trash was one of the first things noticed upon arriving at the sampling site. In these cases the trash could be considered harmful to aquatic life (e.g., items that could cause entanglement, etc.) or a threat to human life (e.g., medical waste, diapers, human or pet waste, etc.) or there is evidence of illegal dumping.

Table 1 Environmental endpoints (clarity, colour, odour, debris) with descriptors and assigned scores for determining overall aesthetic condition. Adapted from Heidtka and Tauriainen (1996).

Environmental Endpoint	Descriptor	Score
Clarity	Clear	10
	Cloudy	7
	Opaque	0
Colour	Colourless	10
	Green	7
	Yellow/Amber	6
	Brown	5
	Grey	2
	Black	0
Odour	None	10
	Musty	6
	Petroleum (<i>transitory</i>)	5
	Sewage	2
	Petroleum (<i>spill</i>)	0
	Anaerobic	0
Debris	None	10
	Natural (<i>unusual accumulation</i>)	8
	Oil film (<i>non-natural</i>)	3
	Trash (<i>large amount</i>)	2
	Foam (<i>non-natural</i>)	2
	Sewage	0

Aesthetic descriptors were then converted to an aesthetic score for each category (Table 1). The scores ranged from 0 (the aesthetically worst condition) to 10 (the aesthetically best condition). If more than one descriptor was present, the lowest score was recorded.

Aesthetic Quality Index

An index value for aesthetic condition – referred to here as Aesthetic Quality Index (AQI) and originally developed by Heidtke and Taurianinen (1996) – was calculated using the scores from the clarity, colour, odour, and debris observations at a given time and location. The AQI for the Toronto and Region AOC aesthetics monitoring program was calculated by giving an equal weighting to each of the four environmental endpoints, as follows:

$$AQI = \frac{\text{colour score} + \text{clarity score} + \text{odour score} + \text{debris score}}{4}$$

AQI values were converted to an aesthetic condition of poor, fair, good, or excellent (Table 3) according to Heidtke and Taurianinen (1996). If a sample was assigned the lowest score for any of the four endpoints it could not attain an AQI value above 8. An AQI score of 9 or greater was considered representative of excellent aesthetic condition, while samples with an AQI score below 6 were assessed as poor and considered to have unacceptable aesthetic condition.

Table 2 Aesthetics Quality Index (AQI) values and corresponding aesthetic condition based on methodology developed by Heidtka and Tauriainen (1996).

AQI Range	Aesthetic Condition
$AQI \geq 9$	Excellent
$8 \leq AQI < 9$	Good
$6 \leq AQI < 8$	Fair
$AQI < 6$	Poor

Data Analysis

Because aesthetics data was collected in conjunction with ongoing monitoring programs, the number of samples (i.e., observations) collected varied by site, and the number of sampling sites varied by watershed. In the case where a monitoring site was visited by more than one sampling crew on a given day, duplicate records were removed from the dataset. Samples with missing observations for clarity, colour, odour, or debris were also removed.

In total, 2177 aesthetic observations (1667 RAP and 510 Non-RAP) were collected from 427 unique sites (320 RAP and 107 Non-RAP) throughout Toronto Region. The number of times a particular site was sampled for aesthetics condition ranged from 1 to 29 over the three year period (Figure 2).

A subset of the data, herein called “repeat sites subset”, was used to assess persistence of aesthetic conditions, whereby the beneficial use would be considered impaired if an AQI value below 6 (i.e., poor aesthetic condition) was observed multiple times at a particular location over

2 or more years of monitoring. The repeat sites subset included only monitoring sites that were assessed for aesthetic impairment during all three years of monitoring (2012, 2013, and 2015) and that were sampled at least five times per year.

Spatial and temporal variability in aesthetics were assessed using a Kruskal-Wallis (non-parametric) one-way Analysis of Variance (ANOVA), followed by Dunn's post-hoc analysis, to test for differences ($\alpha = 0.05$) in median AQI, clarity, colour, odour, and debris scores between watersheds, and years using the repeat sites subset.

Results

Environmental Endpoints

The majority of water samples collected at RAP sites were clear (90%), colourless (91%), odourless (96%), with no debris (91%) present during sampling (Table 3). Similar observations were made at sites throughout Non-RAP watersheds (Appendix, Table A1). Aesthetically unpleasing conditions for each category were observed at sites in both the RAP and Non-RAP areas.

Clarity

Of the 1667 samples collected from RAP watersheds, 90% were clear (Table 3). The majority of clear samples were rated as excellent (1428), however clear samples were also assessed as having good (60), fair (16) and poor (1) aesthetic condition.

Cloudy samples (108) were collected from all of the RAP watersheds. Similar to clear samples, cloudy samples tended to have overall good or excellent aesthetic condition. Only four cloudy samples – three from the Don River and one from Highland Creek – were assessed as having poor aesthetic condition.

The remaining 54 RAP samples (from all watersheds, except for Highland Creek) were assessed as having opaque water clarity and an overall aesthetic condition considered poor or fair. Similarly, opaque water samples collected from the Duffins Creek (5) and Carruthers Creek (1) watersheds (Appendix, Table A1) in the Non-RAP area were assessed as having poor or fair aesthetic condition.

Colour

The majority (91%) of water samples collected from the RAP area were colourless (Table 3), with 94% of those rated as having excellent aesthetic condition overall.

Only four water samples collected from RAP watersheds (Mimico Creek, Don River, Highland Creek) had a green colour; however, 57 samples (31%) collected along the RAP waterfront were green.

Yellow or amber samples were collected in Etobicoke Creek (4), Mimico Creek (1), Don River (2), and along the waterfront (4), and represented a mix of overall aesthetic conditions ranging from poor to excellent.

A total of 64 samples (4%) from the RAP area were reported as having a brown colour, including 11 samples each from the Humber and Rouge Rivers, 15 samples from the Don River, and 14 waterfront samples. Samples with a brown colour were generally rated as having good or fair overall aesthetic condition.

In terms of colour, grey samples tended to have the worst (fair or poor) aesthetic condition. More than half of the grey samples were collected from the Don River, with most of those from locations along the lower Don River. Of the samples collected in the RAP area, only one grey sample from the Don River (near Steeles Ave.) was considered to have good aesthetic condition.

Odour

Over the study period 96% of water samples collected from the RAP area and 99% of Non-RAP samples had no odour (Table 3; Appendix, Table A1). Of the samples with no odour reported, 88% of samples from the RAP area, and 94% of samples from the Non-RAP area, had an overall excellent aesthetic condition during sampling.

A musty odour was reported in 47 samples (3%) from the RAP study area, with the majority of those collected in the Don River watershed or along the waterfront. Samples with a musty odour from the Don River were generally collected during 2012 and tended to have poor or fair overall aesthetic condition.

A sewage odour was reported in 10 RAP samples, with similar distribution across each of the RAP watersheds (1 or 2 samples per watershed) except for the Rouge River which had no instances of sewage odour reported. Of the RAP samples with sewage odour reported only one (HL011WM) was rated as having poor overall aesthetic condition, and none appear to be persistent.

There was an anaerobic odour associated with less than 1% of RAP samples. These samples were collected from Don (1), Etobicoke (2), Rouge (3), and waterfront (1) sites and had poor or fair overall aesthetic condition.

Debris

The majority of samples collected from both RAP (91%) and Non-RAP (88%) areas had no debris reported (Table 3; Appendix, Table A1). A large number of samples (> 10%) in the Don River and Highland Creek watersheds, as well as along the waterfront, had natural debris present.

Large amounts of trash were reported at one or more sites in all RAP watersheds (33 samples total) with the largest number of samples recorded in the Don River watershed. Don River samples with large amounts of trash ranged in aesthetic condition from poor (2 samples) to good (3 samples). Of these samples, all but one site ("Lower Don 1") were sampled multiple times over the course of this study and included sampling dates when no debris was reported. In the Non-RAP area large amounts of trash were reported in the Carruthers Creek, Duffins Creek, and Frenchman's Bay watersheds.

Unnatural foam was reported for 2 samples in the RAP area; however, it is unclear whether one of these was unnatural or naturally derived. The site which reported unnatural foam was assessed

as having excellent aesthetic condition during two additional sampling occasions spanning multiple years.

The presence of an oil film was reported at 2 RAP sites and 2 Non-RAP sites. The Frisco US site located in the Duffins Creek watershed (Non-RAP study area) was the only site that consistently reported the presence of an oil film (on three sampling dates between July and September 2015). This spill was reported to the Ministry of the Environment and Climate Change's (MOECC) Spills Action Centre and was subsequently tracked back to the source and remediated.

Aesthetic Condition

Acceptable aesthetic conditions (i.e., Excellent, Good, or Fair) were reported for the majority of observations from both the RAP (88% of samples) and Non-RAP (94% of samples) areas (Figure 4, Appendix, Table A2). A similar distribution was found when assessing median AQI scores for each site (Figure 5).

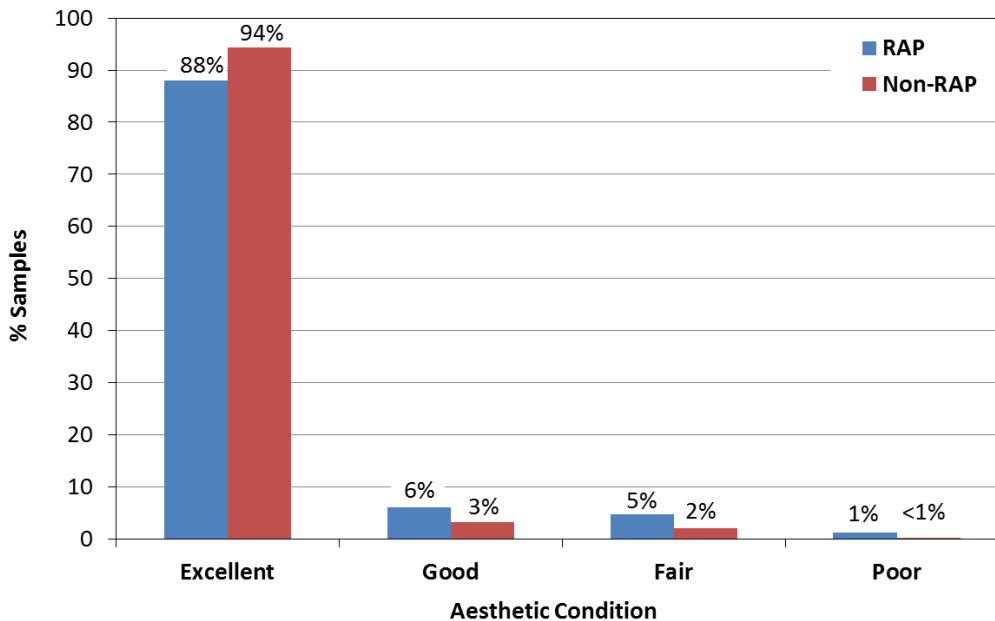


Figure 4 Percentage of samples assessed as having Excellent, Good, Fair, or Poor Aesthetic Condition in the RAP (blue) and Non-RAP (red) study areas during the study period (2012, 2013, and 2015).

Table 3 Number (percent) of samples collected in the RAP study area by watershed during the study period (2012, 2013, and 2015).

		Etobicoke (n = 233)	Mimico (n = 79)	Humber (n = 534)	Don (n = 183)	Highland (n = 67)	Rouge (n = 385)	RAP Waterfront (n = 186)	Total
Clarity	Clear	214 (92%)	71 (90%)	487 (91%)	149 (81%)	63 (94%)	362 (94%)	159 (85%)	1505 (90%)
	Cloudy	10 (4%)	5 (6%)	35 (7%)	17 (9%)	4 (6%)	12 (3%)	25 (13%)	108 (6%)
	Opaque	9 (4%)	3 (4%)	12 (2%)	17 (9%)	0	11 (3%)	2 (1%)	54 (3%)
Colour	Colourless	226 (97%)	73 (92%)	521 (98%)	154 (83%)	61 (91%)	374 (97%)	107 (58%)	1516 (91%)
	Green	0	1 (1%)	0	1 (1%)	2 (3%)	0	57 (31%)	61 (4%)
	Yellow/Amber	4 (2%)	1 (1%)	0	2 (1%)	0	0	4 (2%)	11 (1%)
	Brown	2 (1%)	2 (3%)	11 (2%)	15 (8%)	4 (6%)	11 (3%)	14 (8%)	64 (4%)
	Grey	1 (<1%)	2 (3%)	2 (<1%)	11 (6%)	0	0	4 (2%)	20 (1%)
	Black	0	0	0	0	0	0	0	0
Odour	None	225 (97%)	77 (97%)	527 (99%)	160 (87%)	65 (97%)	376 (98%)	173 (93%)	1603 (96%)
	Musty	4 (2%)	1 (1%)	5 (1%)	20 (11%)	0	6 (2%)	11 (6%)	47 (3%)
	Petroleum (transitory)	0	0	0	0	0	0	0	0
	Sewage	2 (1%)	1 (1%)	2 (<1%)	2 (1%)	2 (3%)	0	1 (1%)	10 (1%)
	Petroleum (spill)	0	0	0	0	0	0	0	0
	Anaerobic	2 (1%)	0	0	1 (1%)	0	3 (1%)	1 (1%)	7 (<1%)
Debris	None	221 (95%)	71 (90%)	519 (97%)	155 (85%)	50 (75%)	359 (93%)	144 (77%)	1519 (91%)
	Natural	7 (3%)	2 (3%)	10 (2%)	21 (11%)	10 (15%)	20 (5%)	41 (22%)	111 (7%)
	Oil Film (unnatural)	1 (<1%)	0	0	0	0	1 (<1%)	0	2 (<1%)
	Trash (lrg amount)	4 (2%)	5 (6%)	5 (1%)	7 (4%)	6 (9%)	5 (1%)	1 (1%)	33 (2%)
	Foam (unnatural)	0	1 (1%)	0	0	1 (1%)	0	0	2 (<1%)
	Sewage	0	0	0	0	0	0	0	0

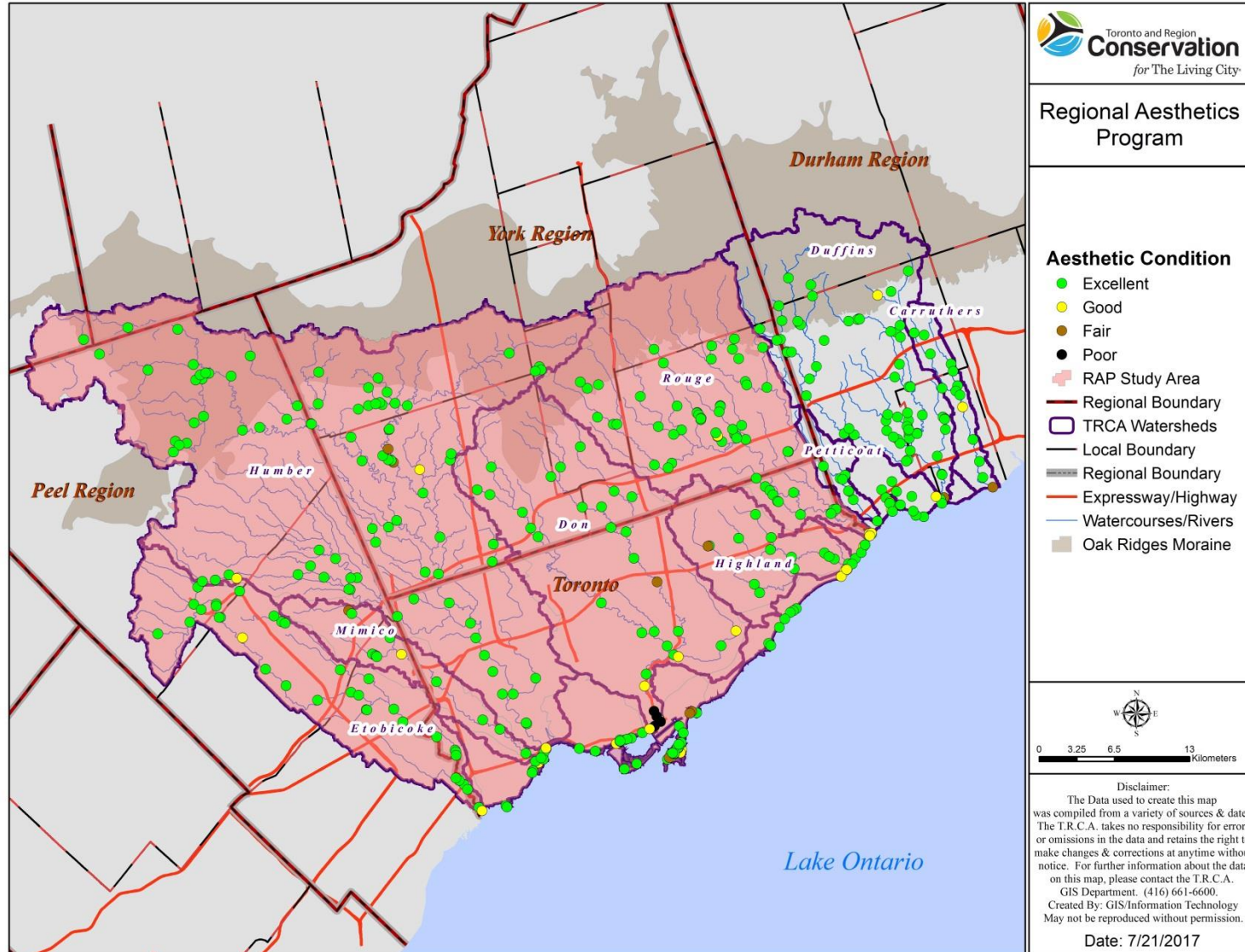


Figure 5 Aesthetic condition (excellent, good, fair, poor) for sites located in RAP (shaded) and Non-RAP (unshaded) watersheds, represented as median Aesthetic Quality Index (AQI) score over the study period (2012, 2013, and 2015).

Poor Aesthetic Condition

A total of 20 samples (1% of observation) from the RAP area were assessed as having poor aesthetic condition over the three years of sampling (Appendix, Table A2), with the lowest AQI scores reported during 2012 (Figure 6). The 11 sites where poor aesthetics were observed tended to be located near the mouth of a river or along the waterfront.

The majority of poor samples in the RAP area were collected from the lower Don River, with 7 samples collected from the Keating Channel site (Table 4). In the Rouge River watershed 3 samples were identified as having poor aesthetic condition – two samples collected east of the parking lot at the mouth of the Rouge River, and one from a site (NCD30-1) in an industrial area in the south end of Markham.

All sites which reported poor conditions, except for Cell 1 at Tommy Thompson Park (RAP Waterfront) and sites in the lower Don River, were assessed as excellent and/or good on multiple occasions throughout the study period. However, many sites assessed as poor during 2012 were not sampled in subsequent years due to the structure of the monitoring program. These sites were therefore excluded when evaluating persistence of aesthetic conditions using repeat sites subset but were assessed using expert judgement to determine whether they constituted an impaired beneficial use.

Table 4 Number of sites assessed as having poor aesthetic condition during 2012, 2013, and 2015. Totals are presented for the RAP and Non-RAP areas as number (percentage) of sites assessed in a given year, and are further identified by watershed and site name.

	2012	2013	2015	Total
RAP Total	18 (3%)	1 (<1%)	1 (<1%)	20 (1%)
Mimico Creek	1	0	0	1
MM005WM	1	0	-	
Don River	13	0	0	13
6008500402	1	0	0	
Lower Don 1	1	-	-	
Lower Don River - Keating Channel	7	-	-	
Lower Don River – North	1	-	-	
Lower Don River – South	3	-	-	
Highland Creek	1	0	0	1
HL011WM	1	0	-	
Rouge River	1	1	1	3
NCD30-1	-	1	-	
Rouge River Mouth – East of Lot	1	-	1	
Waterfront	2	-	0	2
Port Union East Point Boat Launch	1	-	0	
Tommy Thompson Park Cell 1	1	-	-	
Non-RAP Total	0	0	1 (1%)	1 (<1%)
Duffins Creek	0	0	1	1
Frisco US	-	-	1	

Spatial and Temporal Variability in Aesthetic Condition

When separated by monitoring year, an excellent aesthetic condition was found in $\geq 80\%$ of samples collected during 2012, 2013, and 2015 in both the RAP and Non-RAP areas (Table 5). Because of the variable sampling frequency for each site and watershed over the course of the three years of monitoring, the repeat sites subset was used to assess persistence of aesthetic conditions.

Table 5 Total number (percentage) of samples assessed as having Excellent, Good, Fair, or Poor Aesthetic Condition in the RAP and Non-RAP watersheds during 2012, 2013 and 2015.

		Excellent	Good	Fair	Poor	Total
RAP	2012	498 (80%)	73 (12%)	37 (6%)	18 (3%)	626
	*2013	701 (95%)	13 (2%)	27 (4%)	1 (<1%)	742
	2015	271 (91%)	16 (5%)	11 (4%)	1 (<1%)	299
Non-RAP	2012	206 (94%)	10 (5%)	4 (2%)	0	220
	*2013	166 (97%)	1 (<1%)	5 (3%)	0	172
	2015	109 (92%)	6 (5%)	2 (2%)	1 (<1%)	118

*In 2013 no aesthetics samples were collected from waterfront sites in the RAP or Non-RAP areas

When the repeat sites subset was analyzed for aesthetic condition, there was little apparent difference in AQI scores between watersheds or among years (Figure 6). The lowest AQI scores, including one sample that was assessed as having poor aesthetic condition, were observed in the Don River watershed during 2012.

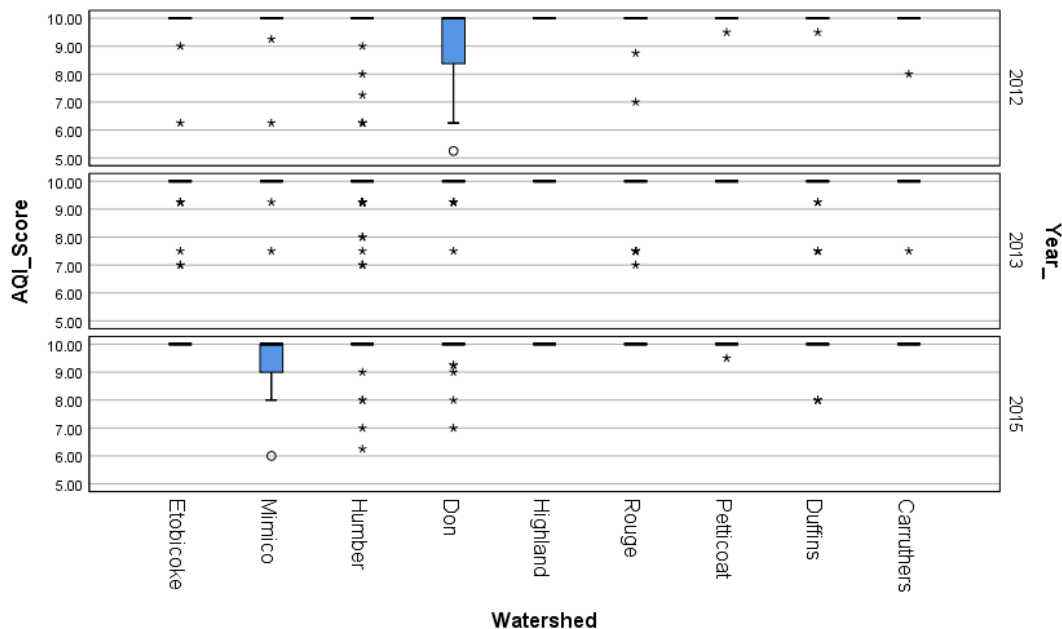


Figure 6 Box plots of site AQI values for RAP (Etobicoke, Mimico, Humber, Don, Highland, Rouge) and Non-RAP (Petticoat, Duffins, Carruthers) watersheds during 2012 (upper panel), 2013 (middle panel) and 2015 (lower panel). Data represent the repeat sites subset.

Spatial and temporal variability was assessed using a Kruskal-Wallis non-parametric ANOVA to determine whether there was a difference between observed aesthetic condition between watersheds or years for the repeat sites subset. A statistically significant difference was found between median AQI values ($H = 25.319$, $P < 0.001$, d.f. = 7), colour scores ($H = 25.671$, $P < 0.001$, d.f. = 7), and clarity scores ($H = 18.110$, $P = 0.011$, d.f. = 7) reported for each watershed. Dunn's test was subsequently run to determine which watersheds differed in terms of aesthetic conditions, however, due to the conservative nature of the post-hoc test compared to the Kruskal-Wallis analysis, no significant differences were found between watersheds.

When the repeat sites subset was analyzed for differences between sampling years, significant differences were found in the colour ($H = 42.613$, $P < 0.001$, d.f. = 2), clarity ($H = 19.217$, $P < 0.001$, d.f. = 2), and odour scores ($H = 11.161$, $P = 0.004$, d.f. = 2). Specific differences between years were not able to be teased out using Dunn's test. However it appears as though the differences may be driven by a difference among RAP samples, rather than between RAP vs. Non-RAP sites. It is not known whether this is related to local conditions within the AOC, or due to the larger area and number of sampling sites in the RAP area.

Discussion

Aesthetic condition of watercourses is difficult to measure in a quantifiable, unbiased manner, in part because it is subjective. For example, one person's "natural" shoreline can be "unattractive" to others due to the presence of natural woody debris. The aesthetics monitoring program developed by the Toronto and Region RAP allowed for an assessment of aesthetics in the AOC in a less subjective manner by leveraging existing monitoring programs and training technical staff members to survey sites for aesthetic endpoints in a comparable and standardized manner.

Aesthetic Condition

Overall, the majority of samples collected throughout the RAP and Non-RAP areas were indicative of excellent aesthetic condition. A number of observations throughout the monitoring period were indicative of poor aesthetic condition at sites in the lower Don River, however these were not considered persistent or indicative of an impaired beneficial use.

The assessment of poor aesthetic condition at sites in the vicinity of the lower Don River and Keating Channel may be related to factors such as precipitation. Increased flows following wet weather events can carry large amounts of natural woody materials and debris/litter downstream, and increase turbidity in rivers. On the other hand, low flow conditions may cause odours and debris to be readily perceived by the public. The Don River drains a large urbanized watershed; It is expected that water quality conditions at the most downstream end of the river flowing into Lake Ontario will reflect its drainage through extensive urban areas. D'Andrea and Anderton (1996) have shown that the Don River contributes high loadings to Toronto Harbour. It is therefore not surprising that a large amount of debris (natural and man-made) and high levels of turbidity were observed in the lower Don River and Keating Channel. Ports Toronto has installed a log boom at the location of the Keating Channel sampling site (between the mouth of the Don River and Toronto Harbour) to collect and dispose of debris that is swept downstream, preventing it from entering the harbor where it could becoming a potential navigational hazard.

There were no reports of sewage debris or petroleum odour at any sites during the aesthetics monitoring program, however the presence of an oil film or sheen was reported on multiple occasions. Upon further investigation it was determined that the majority of reports were likely natural oil-like films produced by bacteria – as described by the Michigan Department of Environmental Quality (2016) – emphasizing the role that staff training, quality assurance, and site characterization can play in interpreting qualitative observations for aesthetic condition.

At one location (in the Non-RAP area) the observed oil film was immediately identified by field staff as unnatural and was reported to the MOECC's Spills Action Centre. The spill was subsequently tracked back to the source and the site was remediated. Although the spill was located outside of the AOC, it illustrated the effectiveness of the aesthetics monitoring program as a screening level assessment for identifying the presence of substances that may produce a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour.

The repeat samples subset was able to tease out some differences in AQI values, colour, and clarity between watersheds. These differences were not necessarily indicative of poor, or unacceptable, aesthetic condition. For example, water clarity can vary depending on the location within the watershed and site-specific factors. In some instances an ambient level of turbidity (cloudiness) may be natural. Turbidity can also increase following heavy precipitation. One possibility for the observed differences in aesthetic observations and resultant AQI values may be variability in meteorological conditions among years. When compared to 30 year climate normal data for the period of 1981–2010 (852.9 mm average annual precipitation at Environment and Climate Change Canada's Toronto Buttonville Airport climate station), total precipitation during 2012 was average, while 2013 was considered a wet year (1026.7 mm), and 2015 was slightly below normal precipitation values. Future considerations may include evaluating relevant stream flow hydrographs for each sampling site to define wet and dry weather sampling conditions.

Along the waterfront, a number of sampling locations included embayments and wetlands and therefore could not be directly compared to watershed sites. It is important to consider site specific conditions when evaluating whether observed aesthetics are within the range of expected conditions or may constitute impairment. For example, the low AQI value at the Cell 1 sampling site in Tommy Thompson Park was attributed to the presence of turbidity, woody debris, and a musty odour. Turbidity at this site is a reflection of the fetch of the wetland and the fine bed material used to create this high quality coastal wetland habitat, by capping a confined disposal facility, and not an indication of impairment.

Future aesthetics monitoring should consider classifying sites based on land-use (e.g., agricultural, industrial, urban) to help identify where differences may exist and the impact of local conditions on aesthetics. Additional considerations for standardizing site selection within each watershed may include the size of the watershed, the variability in stream order and flow conditions represented by sampling sites.

Assessment of the Degradation of Aesthetics BUI

Overall, aesthetic monitoring found that RAP and Non-RAP watersheds and the Lake Ontario waterfront were free of substances which produced a persistent, objectionable deposit, colour, or

odour during 2012, 2013, and 2015. No areas or individual sites demonstrated persistent aesthetic conditions, and there did not appear to be a difference in aesthetic condition within the RAP area compared to Non-RAP sites within the region.

AQI values reported for each site were assessed against the BUI criteria to determine whether poor aesthetic conditions were persistent – defined as occurring on multiple occasions over at least 2 years of sampling – in the RAP area. Within the repeat sites subset, there was only one instance where a poor aesthetic condition (i.e., AQI < 6) was observed (Figure 6). The poor AQI score obtained at this site, located in a highly urbanized portion of the Don River watershed, was attributed to opaque, brown water with a musty odour. A number of environmental factors, such as increased runoff following precipitation, may have contributed to the degraded aesthetic condition during the time of sampling in July 2012; The poor aesthetics did not appear to be due to an oil slick, surface scum, or unnatural foam. Further, over the three year period of this study 91% of observations at this site were indicative of excellent aesthetic condition, therefore it was not considered to have a persistent poor aesthetic condition.

Conclusions

The AQI provides a framework for characterizing aesthetic condition that is easy to integrate with existing monitoring programs while allowing for adaptation to account for variability in local watershed conditions and assessment or program goals, as demonstrated by its application for assessing the status of the Degradation of Aesthetics BUI in the Toronto and Region AOC.

Recommended Status of Degradation of Aesthetics Beneficial Use

Overall the aesthetic condition of Toronto's waters was generally considered excellent or good throughout the period of this study. Observations recorded during aesthetics sampling conducted in 2012, 2013, and 2015 found that waters of the Toronto and Region AOC were free of substances which produced persistent, objectionable deposits, unnatural colour or turbidity, or unnatural odour. It is therefore recommended that the Degradation of Aesthetics beneficial use be considered not impaired for the Toronto and Region AOC.

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Appendix

Table A1 Number (percent) of sample collected in the Non-RAP study area by watershed during the study period (2012, 2013, and 2015).

		Petticoat (n = 39)	Frenchman's Bay (n = 35)	Duffins (n = 369)	Carruthers (n = 52)	Non-RAP Waterfront (n = 15)	Total
Clarity	Clear	39 (100%)	34 (97%)	356 (96%)	46 (88%)	12 (80%)	487 (95%)
	Cloudy	0	1 (3%)	8 (2%)	5 (10%)	3 (20%)	17 (3%)
	Opaque	0	0	5 (1%)	1 (2%)	0	6 (1%)
Colour	Colourless	39 (100%)	35 (100%)	363 (98%)	49 (94%)	9 (60%)	495 (97%)
	Green	0	0	0	0	2 (13%)	2 (<1%)
	Yellow/Amber	0	0	1 (<1%)	0	3 (20%)	4 (1%)
	Brown	0	0	4 (1%)	3 (6%)	1 (7%)	8 (2%)
	Grey	0	0	1 (<1%)	0	0	1 (<1%)
	Black	0	0	0	0	0	0
Odour	None	39 (100%)	34 (97%)	367 (99%)	52 (100%)	15 (100%)	507 (99%)
	Musty	0	0	2 (1%)	0	0	2 (<1%)
	Petroleum (transitory)	0	0	0	0	0	0
	Sewage	0	1 (3%)	0	0	0	1 (<1%)
	Petroleum (spill)	0	0	0	0	0	0
	Anaerobic	0	0	0	0	0	0
Debris	None	36 (92%)	30 (86%)	326 (88%)	46 (88%)	13 (87%)	451 (88%)
	Natural	3 (8%)	2 (6%)	34 (9%)	5 (10%)	2 (13%)	46 (9%)
	Oil Film (unnatural)	0	0	4 (1%)	0	0	4 (1%)
	Trash (lrg amount)	0	3 (9%)	5 (1%)	1 (2%)	0	9 (2%)
	Foam (unnatural)	0	0	0	0	0	0
	Sewage	0	0	0	0	0	0

Table A2 Total number (percentage) of samples assessed as having Excellent, Good, Fair, or Poor Aesthetic Condition in the RAP and Non-RAP watersheds during the study period (2012, 2013, and 2015).

		Excellent	Good	Fair	Poor	Total # Samples
RAP	Etobicoke	212 (91%)	6 (3%)	15 (6%)	0	233
	Mimico	67 (85%)	6 (8%)	5 (6%)	1 (1%)	79
	Humber	504 (94%)	12 (2%)	18 (3%)	0	534
	Don	145 (79%)	11 (6%)	14 (8%)	13 (7%)	183
	Highland	54 (81%)	8 (12%)	4 (6%)	1 (1%)	67
	Rouge	356 (92%)	15 (4%)	11 (3%)	3 (1%)	385
	RAP Waterfront	132 (71%)	44 (24%)	8 (4%)	2 (1%)	186
	Total (RAP)	1470 (88%)	102 (6%)	75 (4%)	20 (1%)	1667
Non-RAP	Carruthers	48 (92%)	2 (4%)	2 (4%)	0	52
	Duffins	350 (95%)	10 (3%)	8 (2%)	1 (<1%)	369
	Frenchman's Bay	32 (91%)	2 (6%)	1 (3%)	0	35
	Petticoat	39 (100%)	0	0	0	39
	Non-RAP Waterfront	12 (80%)	3 (20%)	0	0	15
	Total (Non-RAP)	481 (94%)	17 (3%)	11 (2%)	1 (<1%)	510