Hutchinson
Environmental Sciences Ltd.

Humber River Assimilative Capacity Study

2017-2018

Prepared for: Black and Veatch
Job #: J170008

January 17, 2020

1-5 Chancery Lane, Bracebridge ON, P1L 2E3 | 705-645-0021
Suite 202 – 501 Krug Street, Kitchener, ON N2B 1L3 | 519-576-1711

Hutchinson
Environmental Sciences Ltd.

Suite 202 – 501 Krug Street, Kitchener, ON N2B 1L3 │ 519-576-1711
www.environmentalsciences.ca

January 17, 2020 HESL Job #: J170008

Mr. Zhifei Hu, P. Eng.
Client Service Manager, Water
Black & Veatch
50 Minthorn Blvd, Suite 501
Markham, ON L3T 7X8

Dear Mr. Hu:

Re: Assimilative Capacity Study for Humber River, 2017 - 2018

We are pleased to submit the assimilative capacity study report in support of the Class Environmental Assessment (Class EA) for expansion the existing Nobleton Water Resource Recovery Facility (WRRF). We have summarized baseline data on water quality and flow collected in the study area, predicted effects to downstream water quality with the expansion and recommended effluent limits that will meet all required water quality objectives and provide ongoing protection of the Humber River.

This report incorporates comments received from York Region on the May 2018 draft report, and input received from our August 23 meeting, and edits received from Black and Veatch on November 6, 2019, and January 14, 2020. We thank you for the opportunity to work on this project. If you have any questions, please do not hesitate to contact me.

Sincerely,
Per. Hutchinson Environmental Sciences Ltd.

Deborah L. Sinclair

Deborah Sinclair
Deborah.sinclair@environmentalsciences.ca

Signatures

Report Prepared by:

Deborah Sinclair, M.A.Sc.
Senior Aquatic Scientist

Christine Geiger, M.Sc.
Aquatic Scientist

Brent Parsons, M.Sc.
Senior Aquatic Scientist

Report Reviewed by:

Neil Hutchinson, Ph.D.
President

Table of Contents

Transmittal Letter
Signatures

1. Introduction and Background 1
1.1 Study Area 3
1.2 Previous Studies 3
1.3 Regulatory Context 4
1.4 2017 Assimilative Capacity Study Workplan 5

2. Water Quality Characterization 5
2.1 Existing Water Quality Information 6
2.2 7Q20 Statistic 7
2.3 Methods 7
2.3.1 2017 Water Quality Characterization 7
2.3.2 2018 Additional Phosphorus and TSS Sampling 8
2.3.3 Diurnal DO and Temperature Surveys 9
2.3.4 River Flow 9
2.4 Results 10
2.4.1 Precipitation 10
2.4.2 Flow 11
2.4.3 2017 Water Quality Characterization 12
2.4.4 Diurnal Dissolved Oxygen and Temperature Surveys 22
2.4.5 2018 Additional Phosphorus and TSS Sampling 25
2.4.6 Wetland Assimilation 26
2.5 Policy Designation 29
2.5.1 Total Phosphorus 29
2.5.2 Un-Ionized Ammonia 33
2.5.3 Nitrate 33
2.5.4 Chloride 33
2.5.5 Dissolved Oxygen 33
2.6 Summary 33

3. Water Quality Modelling 34
3.1 Nobleton WRRF Effluent Quality 34
3.2 Mass Balance Modelling 35
3.2.1 Methods 36
3.2.2 Results 37
3.3 Far-Field Modelling 39
3.3.1 Stream Survey 40
3.3.2 Dye Study 45
3.3.3 QUAL2K Model Calibration and Validation 52
3.3.4 QUAL2K Future Scenario: ADF of 3,996 m^3/d 58
3.4 Summary 63

4. Aquatic Biota 64
4.1 Methods 64
4.1.1 Periphyton 64

4.1.2 Benthic Invertebrates ... *67*
4.1.3 Fisheries ... *68*
4.1.4 Aquatic Habitat ... *68*
4.2 Results ... 68
4.2.1 Periphyton ... *68*
4.2.2 Benthic Invertebrates ... *71*
4.2.3 Fisheries ... *74*
4.2.4 Aquatic Habitat ... *75*
4.3 Summary ... 76

5. Summary and Recommendations ... 76
5.1 Water Quality Characterization ... 76
5.2 Water Quality Modelling ... 77
5.3 Aquatic Biota ... 77
5.4 Conclusions ... 77
5.5 Effluent Limits ... 78

6. References ... 79

List of Figures

Figure 1. Humber River Study Area and surface water sampling stations. ... 2
Figure 2. Upstream total suspended solids versus measured flow. ... 13
Figure 3. TSS Concentrations in the Humber River. ... 14
Figure 4. Total Phosphorus Concentrations in the Humber River. ... 16
Figure 5. Total Phosphorus and Total Suspended Solid Concentrations in the Humber River. ... 17
Figure 6. Average Total Dissolved and Particulate Phosphorus in the Humber River During Dry Events. ... 18
Figure 7. Average Total Dissolved and Particulate Phosphorus in the Humber River During Wet Events. ... 18
Figure 8. Total Kjeldahl Nitrogen Concentrations in the Humber River. ... 20
Figure 9. Un-ionized Ammonia Concentrations in the Humber River. ... 20
Figure 10. Nitrate-Nitrogen Concentrations in the Humber River. ... 21
Figure 11. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River Upstream of the Nobleton WRRF discharge. ... 22
Figure 12. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 30 m Downstream of the Nobleton WRRF discharge. ... 23
Figure 13. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 350 m Downstream of the Nobleton WRRF discharge. ... 23
Figure 14. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 1.7 km Downstream of the WRRF discharge. ... 24
Figure 15. TP Concentrations in WRRF Effluent and Wetland Outlet. ... 27
Figure 16. TSS Concentrations in WRRF Effluent and Wetland Outlet. ... 28
Figure 17. TAN Concentrations in WRRF Effluent and Wetland Outlet. ... 28
Figure 18. Nitrate-N Concentrations in WRRF Effluent and Wetland Outlet. ... 29
Figure 19. Relationship between Flow and Total Suspended Solids. ... 31
Figure 20. Relationship between Total Suspended Solids and Total Phosphorus. ... 32

Figure 21. Daily Average Flow (m^3/s) in the Humber River (2009-2018). 32
Figure 22. Downstream TP at effluent TP concentrations ranging from 0.10 to 0.15 mg/L (effluent flow = 46.3 L/s). 39
Figure 23. Humber River Area Characterization 41
Figure 24. Fluorometer Locations 46
Figure 25. Example Graph of Rhodamine WT Concentration Versus Time for a Slug Injection Test. 49
Figure 26 Humber River Slug Injection Test Results, August 30, 2018. 51
Figure 27. QUAL2K Total Ammonia Nitrogen Calibration and Validation Results. 55
Figure 28. QUAL2K Nitrate-N Calibration and Validation Results. 56
Figure 29. QUAL2K TP Calibration and Validation Results. 57
Figure 30. QUAL2K DO Calibration and Validation Results. 58
Figure 31. QUAL2K Predicted DO concentrations in the Humber River under Future Conditions. 60
Figure 32. QUAL2K Predicted TP concentrations in the Humber River under Future Conditions. 61
Figure 33. QUAL2K Predicted TAN concentrations in the Humber River under Future Conditions 62
Figure 34. QUAL2K Predicted Un-ionized ammonia concentrations in the Humber River under Future Conditions. 62
Figure 35. QUAL2K Predicted NO_3-N concentrations in the Humber River under Future Conditions. 63
Figure 36. Aquatic Biota Sampling Locations. 65
Figure 37. Syringe Sampler for Periphyton Sampling. 66
Figure 38. Application of Syringe Periphyton Sampler in the Field. 66
Figure 39. Periphyton Biomass and Total Dissolved Phosphorus Concentrations in the Humber River August 29th, 2017. 69
Figure 40. Periphyton Composition in the Humber River on August 29th, 2017. 70
Figure 41. Periphyton Metric Results from the Humber River on August 29th, 2017. 70

List of Tables

Table 1. Nobleton WRRF Effluent Objectives and Limits (ECA 8678-B38R26) 1
Table 2. Date and Location of Flow Measurements. 9
Table 3. Total Precipitation (mm) 72 Hours Prior to Sampling. 10
Table 4. Measured Flow (m^3/s) in the Humber River During the 2017 Sampling Program. 11
Table 5. Measured Flow (m^3/s) in Humber River upstream of the WRRF discharge during the Additional Phosphorus and TSS Sampling Program. 12
Table 6. Median Field Measurements of the Humber River (2017). 12
Table 7. Median Water Quality Concentrations (mg/L) of Humber River (2017). 15
Table 8. Minima, Maxima, and 25th Percentile Dissolved Oxygen Concentrations (mg/L). 24
Table 9. Diel Variations in Dissolved Oxygen Concentrations in the Humber River in 2017. 25
Table 10. Minima, Maxima, and 75th Percentile Water Temperatures (°C). 25
Table 11 Additional TSS (mg/L) and Phosphorus (mg/L) Sampling, 2018. 26
Table 12 Comparison of Median WRRF Effluent and Wetland Outlet Concentrations (mg/L). 27
Table 13. 2017 and 2018 TSS and TP data from the Humber River Upstream of the Nobleton WRRF. 30
Table 14. Nobleton WRRF Effluent Quantity and Quality (2014-2017). 35
Table 15. Humber River Mass Balance Modelling Results – Existing Permitted Conditions. 37
Table 16. Humber River Mass Balance Modelling Results – Future Conditions. 38
Table 17. Travel Time (min) Between Injection Point and Fluorometer Stations. 51

Table 18. Humber River Velocity (m/s) between Fluorometer Stations. 52
Table 19. Humber River Longitudinal Dispersion (m^2/min) between Fluorometer Stations. 52
Table 20. QUAL2K Calibration and Validation Inputs. 53
Table 21. QUAL2K Inputs for Future Scenario (ADF 3,996 m^3/d). 59
Table 22. Habitat Characteristics at Sampling Locations. 72
Table 23. Benthic Invertebrate Biological Metric Results. 73
Table 24. Benthic Invertebrate Biological Metric Results 2002 vs. 2018. 73
Table 25. Recommended Effluent Limits for Nobleton WRRF at effluent flow of 3,996 m^3/d. 78

List of Photos

Photograph 1. Gravel and cobble substrates in Reach 1. 42
Photograph 2. Sandy clay banks with evidence of erosion and slumping, Reach 3. 43
Photograph 3. Riparian vegetation along banks, Reach 2. 43
Photograph 4. Large woody debris deflecting flow in Reach 1. 44
Photograph 5. Large woody debris in Reach 4 obstructing flow. 44
Photograph 6. Instantaneous injection of Rhodamine dye in the Humber River. 47
Photograph 7. Humber River immediately following dye injection fully mixed across the river. 48
Photograph 8. Humber River approximately 20 seconds after dye injection. 48
Photograph 9. Humber River 80 m downstream of injection point (looking upstream), three minutes after dye injection. 49

Appendices

Appendix A. 7Q20 Flow Results and ACS Workplan
Appendix B. Water Quality Results
Appendix C. CORMIX Modelling Memo
Appendix D. QUAL2K Inputs and Results

1. Introduction and Background

The Nobleton Water Resource Recovery Facility (WRRF, located at 7277 King Road) provides wastewater treatment for the unincorporated community of Nobleton in the Township of King, York Region, Ontario. The facility is operated by the Regional Municipality of York, became fully operational in 2014 and operates under the Environmental Compliance Approval (ECA) number 8678-B38R26 dated September 20, 2018. It is designed to treat effluent from a population of 6,590 with a rated average daily capacity of 2,925 m^3/d and continuous discharge of treated effluent to the Main Branch of the Humber River via a 4 km force main and a constructed wetland (Figure 1). The Nobleton WRRF consists of the following:

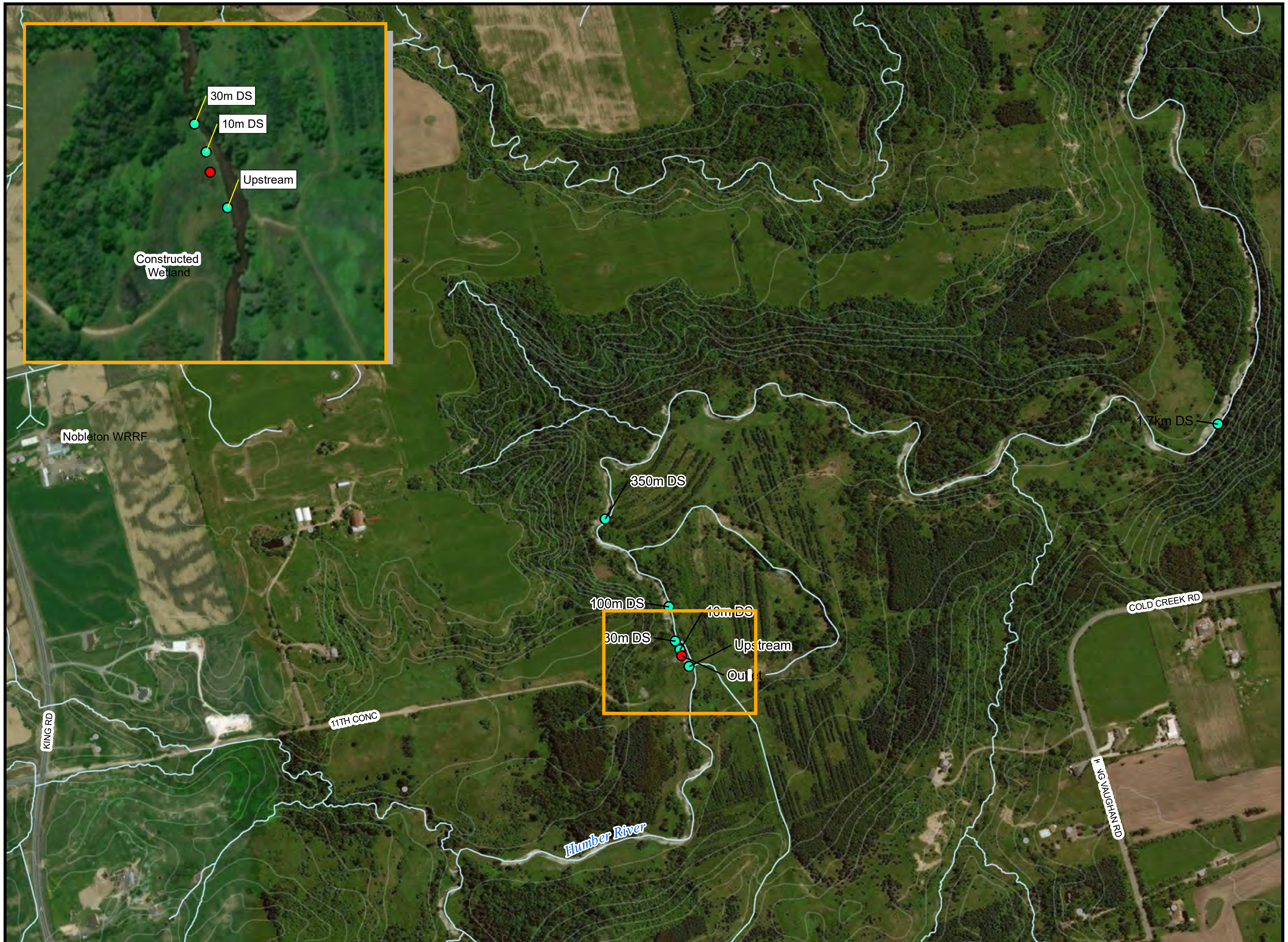
- Screening;
- Grit removal;
- Secondary treatment using extended aeration activated sludge process;
- Tertiary treatment utilizing deep bed granular filters and
- Ultraviolet disinfection.

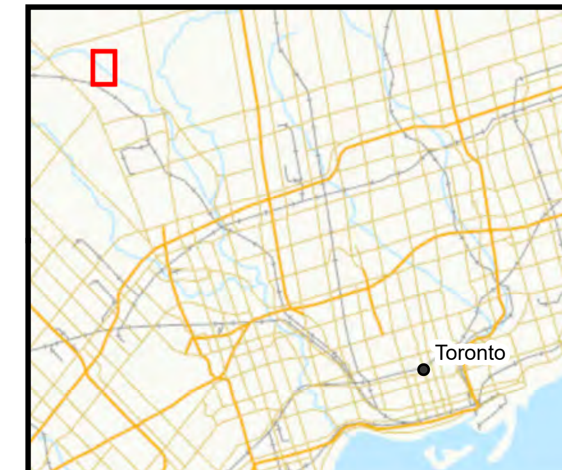
The ECA for the Nobleton WRRF sets the following effluent objectives and limits (Table 1).

Table 1. Nobleton WRRF Effluent Objectives and Limits (ECA 8678-B38R26)

<table>
<tr><th colspan="2" rowspan="2">Effluent Parameter</th><th rowspan="2">Units</th><th rowspan="2">Effluent Objectives</th><th colspan="2">Effluent Limits</th></tr>
<tr><th>Monthly Average Concentration (mg/L)</th><th>Annual Effluent Loading (kg/yr.)</th></tr>
<tr><td colspan="2">5-day Carbonaceous biochemical oxygen demand (cBOD$_5$)</td><td>mg/L</td><td>5</td><td>10</td><td></td></tr>
<tr><td colspan="2">Total Suspended Solids</td><td>mg/L</td><td>7</td><td>10</td><td></td></tr>
<tr><td colspan="2">Total Phosphorus</td><td>mg/L</td><td>0.1</td><td>0.15</td><td>160</td></tr>
<tr><td rowspan="2">Total Ammonia Nitrogen</td><td>May 1 – Oct 31</td><td>mg/L</td><td>0.5</td><td>1.0</td><td></td></tr>
<tr><td>Nov 1 – Apr 30</td><td>mg/L</td><td>2.0</td><td>3.0</td><td></td></tr>
<tr><td colspan="2">E. coli</td><td>CFU/100 mL</td><td>100</td><td>200</td><td>-</td></tr>
<tr><td colspan="2">pH</td><td>n/a</td><td>6.5 – 8.5</td><td>6.0 – 9.5</td><td></td></tr>
</table>

On May 30, 2016, King Council approved a report entitled “Understanding Greenfield Density and Intensification in King Township” which provided the framework for a potential population increase of up to 10,500 people in Nobleton by 2041. Therefore, in 2017 the Regional Municipality of York initiated a Class Environmental Assessment to assess alternative water and wastewater servicing for the expanded population of up 10,800 people. An assimilative capacity study (ACS) was undertaken to characterize the current status of the Humber River, document any effects of the existing Nobleton WRRF discharge, predict the effects of an expanded WRRF on downstream water quality, and recommend effluent limits for the expanded facility. The Class EA included specific provision for the ACS to examine the status of total phosphorus in the Humber River and any need for phosphorus offsetting.





Sampling Stations
Wetland Outlet
Contours
Watercourse

0 50 100 200 300 Meters

N E S W

Figure 1:
Sampling Stations

Project Lead: Deborah Sinclair
Prepared by: Kris Hadley
Data Source: HESL,ESRI Imagery
Coordinate System: NAD 1983 UTM Zone 17N

Hutchinson
Environmental Sciences Ltd.

1.1 Study Area

The Nobleton WRRF discharges treated effluent to the Main Branch of the Humber River. The discharge is located where Concession 11 of King Township ends at the Humber River (Figure 1). The assimilative capacity study area was located within the Bolton to Woodbridge subwatershed of the Main Branch of the Humber River. It included a reference site upstream of the Nobleton WRRF discharge and extended to 1.7 km downstream of the outfall.

The headwaters of the Humber River originate in the Niagara Escarpment and Oak Ridges Moraine. The study area lies within the South Slope physiographic region characterized by a gently sloping glacial till plain. The bedrock in the subwatershed comprises shale of the Georgian Bay Formation and the land use is primarily agriculture with significant natural areas (TRCA 2008). A large fraction of the Main Humber River subwatershed is protected by the Niagara Escarpment, Oak Ridges Moraine and Greenbelt legislation (TRCA 2008). The study area lies at the edge of the Greenbelt.

1.2 Previous Studies

The Class EA for the existing Nobleton WRRF was completed between 1998 and 1999 (Gartner Lee Limited 1999) to identify preferred options for sewage effluent treatment and disposal for the Community of Nobleton. The treatment facility was to service a projected population of 6,590 people and discharge effluent to the Humber River. Follow up studies were completed between 2000 and 2001 (Gartner Lee Limited 2002) in support of the Class EA and a phosphorus offsetting strategy was approved in 2006. Studies completed in support of the Class EA included:

- Review of historic and current water quality conditions in the Main and East Humber River;
- Aquatic biology studies including fish communities, aquatic habitat features including spawning areas and benthic invertebrate communities;
- Terrestrial environment evaluation;
- Predictive water quality modelling;
- Calculation of candidate opportunities to offset phosphorus loadings to the Humber River from the decommissioning of septic systems in Nobleton and land use changes in the watershed.

The main conclusions were:

- Year-round discharge of treated effluent to the Main Branch of the Humber River was preferred over discharge to the East Branch,
- The Main Humber River was designated as a Policy 2 receiver for phosphorus, but as a Policy 1 receiver for dissolved oxygen and un-ionized ammonia.
- The fish community contained both cold and warm water species, fish habitat cover ranged from low and lacking complexity to moderately complex.
- The benthic invertebrate community was rich, diverse and considered resilient to treated sewage effluent inputs.
- The mixing zone for un-ionized ammonia was predicted to be 752 m long and 11.1 m wide under 7Q20 flow conditions.

- Predicted phosphorus loadings from the Nobleton WRRF were to be offset by decommissioning septic systems within the community when municipal servicing was provided, reforestation of agricultural lands and by implementing improved management initiatives on a dairy farm owned by the Toronto Region Conservation Authority (TRCA) (Gartner Lee Ltd. 2006).

1.3 Regulatory Context

Ontario's Ministry of Environment, Conservation and Parks (MECP) has established policies and guidelines that direct the management of surface waters and the discharge requirements for wastewater treatment plants (WWTPs) in the province. In "Water Management Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy" (MOE 1994a) the MOE provides direction on the management of surface water and groundwater quality and quantity for the Province of Ontario. The two policies that relate to the determination of WWTP discharges limits are:

Policy 1 – In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives.

Policy 2 - Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives.

The PWQO (Provincial Water Quality Objectives) are numerical and narrative criteria that serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and where it discharges to the surface, the groundwater of the Province of Ontario. The PWQO are set at a level of water quality, which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water (MOE 1994a).

In Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters (MOE 1994b), the MOECC provides guidance with regard to the requirements for point-source discharges and the procedures for determining effluent limits. For continuous discharges to streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity. The 75th percentile concentration is used to determine background water quality when developing receiver-based effluent limits and is to reflect the existing conditions of the receiver. The 75th percentile background concentrations are also used to determine the Policy status for each of the contaminants expected in the effluent. The following presents MOECC guidance for effluent limits based on receiver Policy Status.

- For Policy 1 receivers, an evaluation is made as to what treatment or other measure is required to maintain water quality at or above the PWQO. Although some lowering of the water quality is permissible, violation of the PWQO is not allowed.
- For Policy 2 receivers no further lowering of water quality is permitted, and all reasonable and practical measures to improve water quality shall be undertaken (MOECC 1994b).

The Humber River was considered Policy 2 for total phosphorus in the 1999 EA, in that total phosphorus concentrations exceed the PWQO of 0.03 mg/L. As such, a Director's Policy 2 Deviation and phosphorus offsetting program (Gartner Lee Ltd, 2006) was required to permit construction of the original Nobleton WRRF.

1.4 2017 Assimilative Capacity Study Workplan

The assimilative capacity study workplan for the current Class EA (Appendix A) was developed by Hutchinson Environmental Sciences Ltd. and provided to the MOECC (now MECP) on July 27th, 2017 by Black and Veatch. The MOECC reviewed the workplan, found it to be comprehensive and approved it.

The study included the following components:

1. Background Data Compilation and Review
2. Characterization of the Main Humber River within the Study Area (including stream physical characteristics and an aquatic habitat assessment);
3. Field monitoring (including flow measurement, water quality monitoring, diurnal dissolved oxygen monitoring, dye tracer study to determine river time of travel and dispersion characteristics);
4. Effluent assimilation and dispersion modelling using mass balance to estimate fully mixed effluent parameter concentrations and QUAL2K for far field assimilation estimates. and
5. Interpretation of the above studies to recommend effluent limits for the expanded WRRF.

The Request for Proposal from the Regional Municipality of York and our original proposal identified the need to summarize the status of the phosphorus offsetting program required under the existing ECA and to investigate other potential sources of offsets in the watershed, should additional offsetting be required to accommodate the expanded discharge. As the project proceeded, however, the monitoring program determined that the Humber River was not a Policy 2 receiver for total phosphorus and so the ACS could be completed without the need for offsetting. This conclusion was confirmed by additional sampling in 2018 and consultation with MECP on March 7, 2019 and is substantiated in Section 2 of this report.

These findings are presented in the report as follows:

- Introduction and background are provided Section 1;
- Water quality characterization and total phosphorus status are described in Section 2;
- Water quality modelling is presented in Section 3;
- Aquatic biota and habitat are summarized in Section 4; and
- Summary and recommended effluent limits are presented in Section 5.

2. Water Quality Characterization

Water quality of the Humber River within the study area was characterized using background water quality data, data collected during the field program of 2017, and additional phosphorus and total suspended solids sampling conducted in 2018.

Water quality data were compared to applicable MECP Provincial Water Quality Objectives (PWQO, MOE 1994) and the most recent version of the Canadian Council of the Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life (CCME, 2014).

.

The CWQG are numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameter of interest and are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term. Ambient water quality guidelines developed for the protection of aquatic life provide the science-based benchmark for a nationally consistent level of protection for aquatic life in Canada (CCME, 2012).

2.1 Existing Water Quality Information

The closest upstream PWQMN station was located at Highway 50, more than 15 km upstream of the Nobleton WRRF, and upstream of the urban area of the Town of Bolton 50 (ID: 06008301802, data collected from 2002 to 2016). The closest downstream station was located at Old Mill Road in Etobicoke, downstream of both Woodbridge and Etobicoke, just upstream of Lake Ontario (ID: 06008301902, data collected from 2000 to 2016).

The median TP concentration at the upstream site was 0.022 mg/L and the 75th percentile was 0.030 mg/L, 25% of samples exceeded the PWQO of 0.03 mg/L. Dissolved oxygen concentrations reflected a healthy aquatic environment with a median concentration of 11.1 mg/L and a 25th percentile concentration of 9.8 mg/L. Only one value (1.47 mg/L) was below the PWQO (between 4 and 8 mg/L depending on species and water temperature) representing less than 1% of measurements. Median nitrate concentration was 0.384 mg/L, below the CWQG of 3 mg/L. Low TSS concentrations (median concentration of 4.6 mg/L and 75th percentile of 7.0 mg/L) indicated clear water at the site. Median total ammonia concentration was 0.022 mg/L and the 75th percentile concentration was 0.034 mg/L. Un-ionized ammonia-N exceeded the PWQO (0.0164 mg/L) on one occasion. The median un-ionized ammonia-N concentration was 0.0012 mg/L and the 75th percentile was 0.0014 mg/L, well below the PWQO.

Water quality conditions were degraded in the lower reaches of the Humber River. Data from the PWQMN station at Old Mill Rd. indicated that the river was nutrient rich with a median TP concentration of 0.035 mg/L and a 75th percentile concentration of 0.078 mg/L. TP concentrations exceeded the PWQO in 68% of samples at this site. Nitrate concentrations were also higher, but below the CWQG, with a median concentration of 0.573 mg/L and 75th percentile value of 0.937. Water was more turbid with a median TSS concentration of 9.9 mg/L. Dissolved oxygen concentrations were higher downstream (median concentration of 13.7 mg/L and 25th percentile of 11.8). This likely reflects increased aquatic plant growth creating higher DO concentrations during the day. This could cause greater DO sags at night and early morning. Un-ionized ammonia exceeded the PWQO twice between 2000 and 2016. The median un-ionized ammonia concentration at this site was 0.0034 mg/L and the 75th percentile concentration was 0.0016 mg/L, below the PWQO.

Gartner Lee Limited (1999) described water quality at four different stations in the Humber River. These included PWQMN sites at (Woodbridge (1978-1997) and Bolton (1978-1988) and sampling by Gartner Lee Ltd. at Nashville Road, Bolton and Old Major Mackenzie Road in the summer of 1998. Mean total phosphorus concentrations ranged from 0.073 mg/L at Old Major Mackenzie Road to 0.114 mg/L at Woodbridge. A significant relationship (R^2= 0.89, $p < 0.00001$) between TSS and TP was identified, indicating that most phosphorus inputs were from erosion from agriculture, stream banks and urban areas. Mean TSS concentrations ranged from 40.8 mg/L at Bolton to 103.1 mg/L at Nashville Road in 1998.

Dissolved oxygen concentrations were high with mean concentrations ranging from 10.8 mg/L at Bolton to 11.2 mg/L at Woodbridge. Average nitrate concentrations ranged from 0.208 mg/L at Bolton to 0.258 at Old Major Mackenzie Road in 1998. Low total ammonia nitrogen values were measured at all sites (average value ranged from 0.032 mg/L (Old Major Mackenzie) to 0.044 mg/L (Woodbridge) with the exception of the historic data at Bolton. Treated sewage effluent was discharged to the Humber River upstream of this site up until the early 1980s at which point discharge ceased. The discontinued release of sewage resulted in decreased ammonia concentrations in the Humber River at Bolton.

2.2 7Q20 Statistic

In Ontario streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity of a stream or river. The 7Q20 flow represents the minimum 7-day average flow with a recurrence period of 20 years. This value determines the 5% chance of there not being adequate streamflow to properly dilute the point source discharge.

The 7Q20 of 510 L/s (0.510 m^3/s) for the Humber River at the wetland outlet was determined by Matrix Solutions (Appendix A) using a Log Pearson Type III regression analysis on a 40+ year record of discharge from the downstream Water Survey of Canada (WSC) station at Elder Mills (station 02HC032). The statistic was prorated from the WSC station (296 km^2) to the existing WRRF discharge at the wetland outlet (270 km^2) based on drainage area.

2.3 Methods

HESL implemented a water quality program in 2017 and 2018 to provide a recent record of water quality in the Humber River near the Nobleton WRRF to a) establish baseline conditions for the ACS and b) assess the response of the river to the existing WRRF discharge.

2.3.1 2017 Water Quality Characterization

Water quality samples were collected upstream of the Nobleton WRRF, at the point of WRRF effluent discharge from the wetland to the Humber River and at 10 m, 30 m, 100 m, and 350 m downstream of the discharge (Figure 1) from May 2017 to February 2018. Samples were collected on:

- May 31st, 2017
- June 27th, 2017
- August 1st, 2017
- August 29th, 2017
- September 20th, 2017
- October 13th, 2017
- February 5th, 2018

Water samples were also collected 1.7 Km downstream of the WRRF during the August 1st and August 29th, 2017 sampling events for the far-field (QUAL2K) model calibration and validation.

During each sampling event surface grab samples were collected for analysis of:

- 5 and 20-day carbonaceous biochemical oxygen demand ($cBOD_5$ and $cBOD_{20}$),
- total phosphorus (TP),
- orthophosphate (PO_4),
- total dissolved phosphorus (TDP),
- total Kjeldahl nitrogen (TKN),
- nitrate (NO_3) and nitrite (NO_2),
- total ammonia nitrogen (TAN),
- total suspended solids (TSS),
- chloride,
- total alkalinity,
- chlorophyll *a* (May and August sampling only), and
- volatile suspended solids (VSS) (May and August sampling only).

After sample collection, water samples were stored in laboratory-provided coolers containing ice packs and shipped to ALS in Waterloo, Ontario for analysis. Field measurements of pH, dissolved oxygen (DO; mg/L and % saturation), temperature (°C) and specific conductivity (µS/cm) were collected with a water quality multi-parameter meter (YSI 600 QS). Field pH and temperature were used to calculate un-ionized ammonia using the equation from Appendix A of MOE's document "Water Management" (MOE 1994). Stream flow was measured during each sampling event (Section 2.3.4).

2.3.2 2018 Additional Phosphorus and TSS Sampling

The water quality results from 2017 (Section 2.4.3) showed that TP concentrations upstream of the WRRF were below the PWQO (i.e. Policy 1) during the summer low flow events, and that high TP (above PWQO) only occurred during high flow conditions, when TSS was also elevated (see Figure 2, below). Additional TP and TSS sampling were therefore completed in summer and fall 2018 to confirm the phosphorus policy designation of the Humber River during summer low flow conditions on which the ACS predictions are based.

Water quality samples were collected from the Humber River upstream and 10 m downstream of the Nobleton WRRF on:

- June 12th, 2018
- July 5th, 2018
- July 17th, 2018
- July 31st, 2018
- August 15th, 2018
- August 30th, 2018
- September 6th, 2018
- September 12th, 2018
- October 4th, 2018
- October 9th, 2018

During each sampling event, grab samples were collected for analysis of:

- TP
- TDP
- TSS

After sample collection, water samples were stored in a laboratory-provided cooler containing ice packs and shipped to ALS in Waterloo, Ontario for analysis. Field measurements of pH, DO (mg/L and %

saturation), temperature (°C) and specific conductivity (µS/cm) were collected with a water quality multi-parameter meter (YSI 600 QS). Stream flow was measured at the upstream station during each sampling event.

2.3.3 Diurnal DO and Temperature Surveys

Dissolved oxygen (DO) loggers (Optical Dissolved Oxygen Loggers, HOBO Model U26-001) were installed in the Humber River at three locations on June 27th, 2017: upstream of the WRRF, 30 m downstream and 350 m downstream of the WRRF. The logger positioned 30 m downstream of the WRRF was removed on August 29th and installed 1.7 km downstream of the WRRF on August 30th, 2017. The DO loggers were calibrated prior to deployment and programmed to measure dissolved oxygen (mg/L) and temperature (°C) every 0.5 hours. All loggers were retrieved on September 20th, 2017. The dissolved oxygen measurements were used as input into the QUAL2K model (Section 3), and to assess diurnal DO conditions in the Humber River.

2.3.4 River Flow

Stream flow was measured during each sampling event using an OTT MF Pro brand flow meter. Stream velocity was measured at a minimum of 10 points across the stream cross-section. At points where the depth was less than 0.75 m the velocity was measured at 0.6 of the depth below the water surface. Where water depths were greater the 0.75 m the velocity was measured at 0.2 and 0.8 of the depth below the water surface and the mean of these values computed. The area-velocity method was used to calculate stream discharge. Manual streamflow measurements are generally accurate to within 6-19% (Harmel et al. 2006) of the actual flow in the watercourse, with lower flows being less accurate.

During the 2017 program flows were measured upstream of the effluent outfall, of effluent at the outlet of the wetland channel and at downstream stations to understand the dilution potential of the river and how flows changed with distance downstream of the WRRF outfall. River flow was measured at the upstream station only during the additional sampling program in 2018 to provide an understanding of how TSS and TP concentrations were related to high and low flows. Flow measurement locations are provided in Table 2.

Table 2. Date and Location of Flow Measurements.

Station	31-May-17	27-Jun-17	1-Aug-17	29-Aug-17	20-Sep-17	13-Oct-17	5-Feb-18	12-Jun-18	04-Jul-18	17-Jul-18	31-Jul-18	15-Aug-18	30-Aug-18	06-Sep-18	12-Sep-18	04-Oct-18	09-Oct-18
Upstream	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Wetland outlet	X	X	X	X	X	X											
DS-10/30m	X	X	X	X	X	X											
DS-100	X	X	X	X	X	X	X										
DS-300	X		X	X	X	X											
DS-1.7 km			X	X													

Note: Due to ice cover flow could only be measured at DS-100 during the February 2018 sampling event.

2.4 Results

2.4.1 Precipitation

Precipitation data (Table 3) was obtained from the Toronto North York Environment Canada climate station (Climate ID: 615S001) 19.7 km from the Nobleton WRRF to establish whether each event represented wet or dry conditions and the influence of runoff.

Generally, more than 5 mm of precipitation produces runoff, however soil conditions (type, cover and moisture content) and the amount of previous precipitation determines how much water will run off during a given event. Less than 5 mm of precipitation recorded in the 72 hours (3 days) preceding sampling, represented "dry" conditions.

During the 2017 sampling program, the May 31st, June 27th, 2017 and February 5th, 2018[1] were considered wet events with 13.6 mm, 7 mm and 6 mm, respectively, of precipitation falling in the 72 hours prior to sampling. An additional 3.2 mm of rain also fell during June 27th, 2017 sampling event. August 1st, 29th, and September 20th were "dry" events, with less than 5 mm of precipitation recorded in advance of sampling (Table 3). Only 4.40 mm of precipitation was recorded on October 13, however, flows on this date are representative of a "wet" event or high flow conditions (Section 2.4.2 Flow).

During the 2018 sampling program, four of the ten events were "wet" (July 17, September 12 and October 4 and 9, 2018) with 5 mm or more of precipitation 72 hours prior to sampling (Table 3).

Table 3. Total Precipitation (mm) 72 Hours Prior to Sampling.

Sampling Program	Sampling Date	Precipitation (mm)	Event Type
2017 Water Quality Characterization	31-May-17	13.6	Wet
	27-Jun-17	7.0	Wet
	1-Aug-17	0.0	Dry
	29-Aug-17	0.0	Dry
	20-Sep-17	0.0	Dry
	13-Oct-17	4.4	Wet
	5-Feb-18	6.0	Dry
Additional Phosphorus and TSS Sampling	12-Jun-18	0.0	Dry
	4-Jul-18	0.0	Dry
	17-Jul-18	39.8	Wet
	31-Jul-18	2.6	Dry

[1] Note: Precipitation prior to February 5, 2018 was recorded as snow, and therefore did not cause runoff on the date of sampling.

Sampling Program	Sampling Date	Precipitation (mm)	Event Type
	15-Aug-18	0.0	Dry
	30-Aug-18	2.0	Dry
	6-Sep-18	1.4	Dry
	12-Sep-18	29.4	Wet
	4-Oct-18	13.6	Wet
	9-Oct-18	10.0	Wet

2.4.2 Flow

During the 2017 sampling program, measured flows in the Humber River ranged from 1.14 m^3/s to 4.96 m^3/s (Table 4). High flows were recorded on May 17th, June 27th and October 13th, 2017, reflecting wet events. Groundwater and tributary inputs within the monitored area were minimal as there were no large increases in flow downstream of the WRRF during dry events.

Upstream background flows were lowest during the August 29 sampling event (1.31 m^3/s), but were more than two-fold the 7Q20 flow of 0.51 m^3/s. Low flows were also recorded during the August 1 (1.97 m^3/s), and September 20 (1.33 m^3/s) sampling events when measured effluent flows at the wetland outlet ranged from 0.004 m^3/s to 0.01 m^3/s The effluent discharge therefore represented less than 1% of the Humber River flow and was diluted 164 to 285 times during these low flows. Measured dilution ranged as high as 1,784 times on May 31, 2017.

Table 4. Measured Flow (m^3/s) in the Humber River During the 2017 Sampling Program.

Watercourse	Station	31-May-17	27-Jun-17	1-Aug-17	29-Aug-17	20-Sep-17	13-Oct-17	5-Feb-18
Humber River	Up-Stream	3.16	4.96	1.97	1.31	1.33	2.31	n/a
	Wetland effluent*	0.002	0.02	0.01	0.005	0.004	0.02	n/a
	DS-10/30m	3.23	4.96	1.97	1.19	1.42	2.28	n/a
	DS-100	3.24	4.11	1.75	1.40	1.14	2.43	1.92
	DS-300	3.71	n/a	1.75	1.41	1.30	2.50	n/a
	DS-1.7 km	n/a	n/a	2.01	1.30	n/a	n/a	n/a
Effluent Dilution		1,784	244	164	285	337	148	n/a
% Effluent		0.1%	0.4%	0.5%	0.4%	0.3%	0.9%	n/a

*Notes: *Measured by HESL at the wetland outlet channel, n/a – not measured*

Upstream flows ranged from 0.95 m^3/s to 1.82 m^3/s during the 2018 summer and fall sampling events (Table 5). The lowest flow (0.95 m^3/s) was recorded on July 4, 2018, and the highest flow was measured on October 9, 2018. The low flow of 0.95 m^3/s was almost two-fold the 7Q20 value of 0.51 m^3/s for the Humber River at the WRRF (Section 2.2). Summer flows (0.95 -1.59 m^3/s) were lower than those measured during the 2017 sampling program (Table 4).

Table 5. Measured Flow (m^3/s) in Humber River upstream of the WRRF discharge during the Additional Phosphorus and TSS Sampling Program.

Sampling Date	12-Jun -18	04-Jul-18	17-Jul-18	31-Jul-18	15-Aug-18	30-Jul-18	06-Sep-18	12-Sep-18	04-Oct-18	09-Oct-18
Flow (m^3/s)	1.29	0.95	1.36	1.06	1.06	1.59	1.03	1.33	1.25	1.82

2.4.3 2017 Water Quality Characterization

This section provides the results of the water quality sampling program undertaken in 2017. Water quality data is presented as summary statistics (median concentrations) in Table 6 and 7 and graphically (Figures 2-10). Boxplots[2] (Figure 3, Figure 4, Figure 8, **Figure 9**, Figure 10) were used to visually summarize median, 25th and 75th percentile concentrations. Raw data are provided in Appendix Tables B1 and B2.

Field Data

Temperature, pH, dissolved oxygen and specific conductivity[3] were measured at each sampling station and in the wetland discharge during each event (Table 6).

Table 6. Median Field Measurements of the Humber River (2017).

Station	Water Temp	Specific Conductivity	Dissolved Oxygen		pH
Units	°C	µS/cm	%	mg/L	
PWQO/CWQG			a	a	6.5-8.5
Upstream	17.4	589	123.6	12.35	8.36
Wetland Outlet	17.3	1945	87.1	8.4	7.57
10 m d/s	17.6	593	118.6	12.3	8.31
30 m d/s	18.2	600	116.7	12.0	8.29
100 m d/s	17.8	606	112.2	12.1	8.26
350 m d/s	17.4	586	121.4	11.7	8.26
1.7 km d/s	N/A				

Notes: PWQO for oxygen is temperature dependent. PWQO/CWQG do not apply to effluent discharge at Wetland Outlet. Median values not calculated for 1.7 km downstream (only 2 sampling events). Refer to Table B1 for sampling event results.

[2] *A box plot is a way of displaying data based on summary statistics. In the box plot the central rectangle spans the first quartile to the third quartile (the interquartile range). The segment inside the rectangle shows the median.*

[3] *Conductivity ratios change with temperature, therefore specific conductance at 25°C is used as a standard for site comparison.*

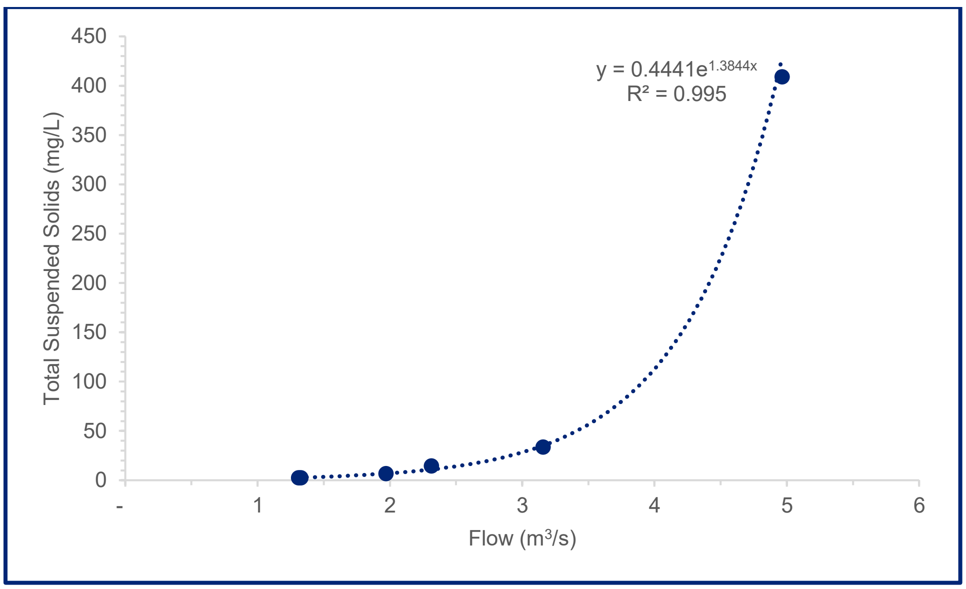
Although the specific conductivity of the effluent was >3 times that of the receiver water, the range in downstream specific conductivity was the same as that upstream with no consistent pattern of increase observed. The background specific conductivity (median value of 589 µS/cm) was similar to downstream specific conductivity which had median values that ranged from 593 µS/cm (DS-10m) to 608 µS/cm (DS-100m). Conductivity was elevated during the winter sampling event at all sites, a likely response to road salt additions in the watershed. pH was below the PWQO of 8.5 at all sites on all sample dates.

The river was well oxygenated at all sites and DO was above the PWQO for warm and cold-water biota. Supersaturated conditions (>100% DO) were recorded at all river stations (including background) during every event except for June, when values were above 95%, but below 100% at all sites. The effluent was well oxygenated at the wetland outlet (dissolved oxygen saturation ranged between 84.4 and 158.6%), before discharging into the Humber River.

Total Suspended Solids and Volatile Suspended Solids

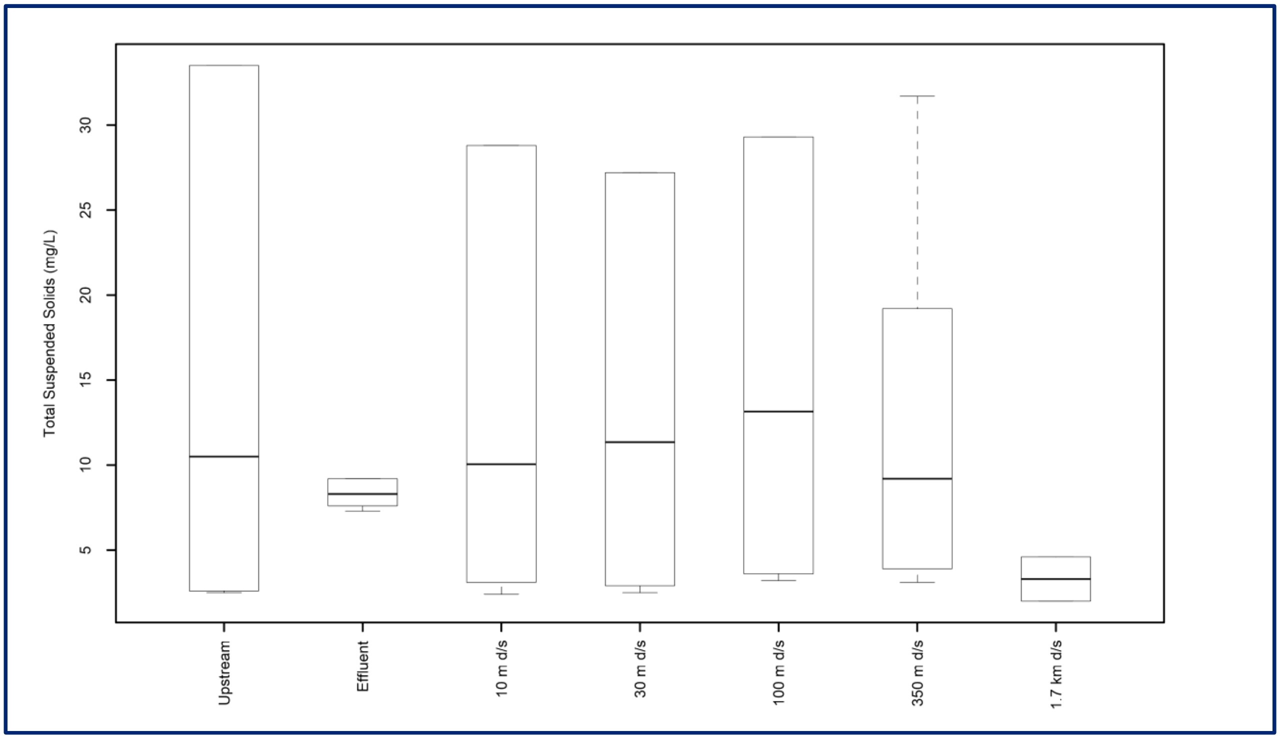
TSS concentrations varied with flow. High TSS concentrations were measured upstream (409 mg/L; Table B2) on June 27th, when measured flow was the highest (4.96 m^3/s). The lowest TSS concentration was measured at the upstream site (2.5 mg/L; Table B2) on August 29th, when measured flow was the lowest (1.31 m^3/s). Upstream TSS concentrations showed a strong positive exponential relationship with flow (Figure 2), indicating that the elevated TSS concentrations in the river are related to runoff and erosion from high flow events. This relationship is only based on five sampling events (flows were not measured in February), and further sampling is needed to confirm the relationship, but the pattern is consistent with that reported in Gartner Lee Ltd. (1999).

Figure 2. Upstream total suspended solids versus measured flow.



During high flow events, TSS concentrations were higher at the upstream station than in the effluent. During dry events, TSS concentrations were higher in the effluent than at the upstream station (Table 7). Median TSS concentrations were relatively consistent downstream ranging from 9.2 mg/L (350 m downstream) to 13.2 mg/L (100 m downstream; Table 7, Figure 3).

Figure 3. TSS Concentrations in the Humber River.



Volatile suspended solids concentrations were frequently below the detection limit at all sites, especially during dry events (Table B2).

Table 7. Median Water Quality Concentrations (mg/L) of Humber River (2017).

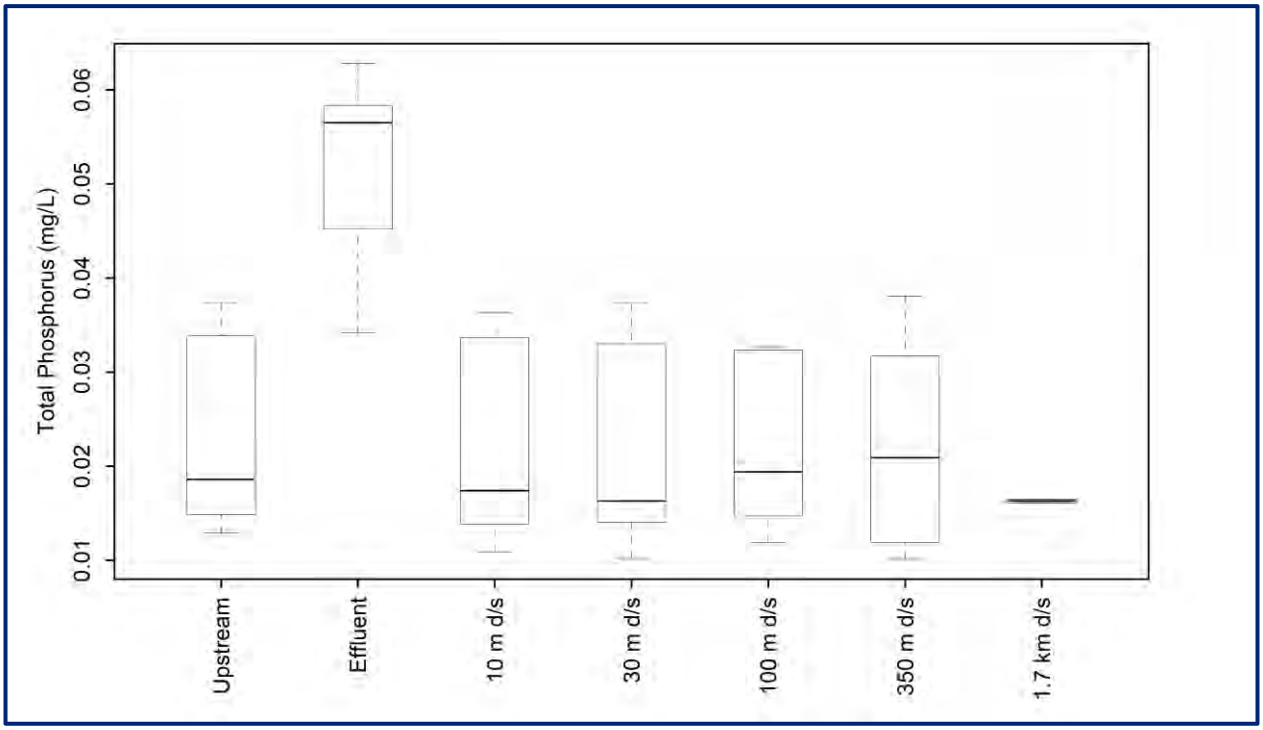
Station	Statistic	TSS	TP	TDP	OrthoP	TKN	TAN	Un-ionized Ammonia	NO_3-N	NO_2-N	Cl	$cBOD_5$	$cBOD_{20}$	Alk
PWQO/ CWQG			0.03					0.0164	3	0.06	120			
Upstream	Median	10.5	0.019	0.009	0.007	0.36	0.056	0.0028	0.30	0.01	50.4	2.0	2.1	237
	75th percentile	127.4	0.037	0.014	0.008	0.65	0.106	0.0041	0.70	0.01	54.9	2.0	2.2	244
Wetland Outlet	Median	8.3	0.057	0.032	0.013	1.02	0.075	0.0011	18.20	0.05	425	2.0	3.3	188
10 m d/s	Median	10.1	0.017	0.009	0.006	0.37	0.048	0.0019	0.33	0.01	50.5	2.0	2.0	231
35 m d/s	Median	11.4	0.016	0.011	0.006	0.36	0.042	0.0025	0.40	0.01	53.4	2.0	2.0	236
350 m d/s	Median	13.2	0.019	0.009	0.006	0.33	0.035	0.0020	0.39	0.01	54.0	2.0	2.1	238
100 m d/s	Median	9.2	0.021	0.007	0.005	0.29	0.056	0.0020	0.35	0.01	53.3	2.0	2.0	233
1.7 km d/s	Median	N/A												

Notes: Median values not calculated for 1.7 km downstream (only 2 sampling events). Refer to Table B2 for sampling event results.

Phosphorus Compounds

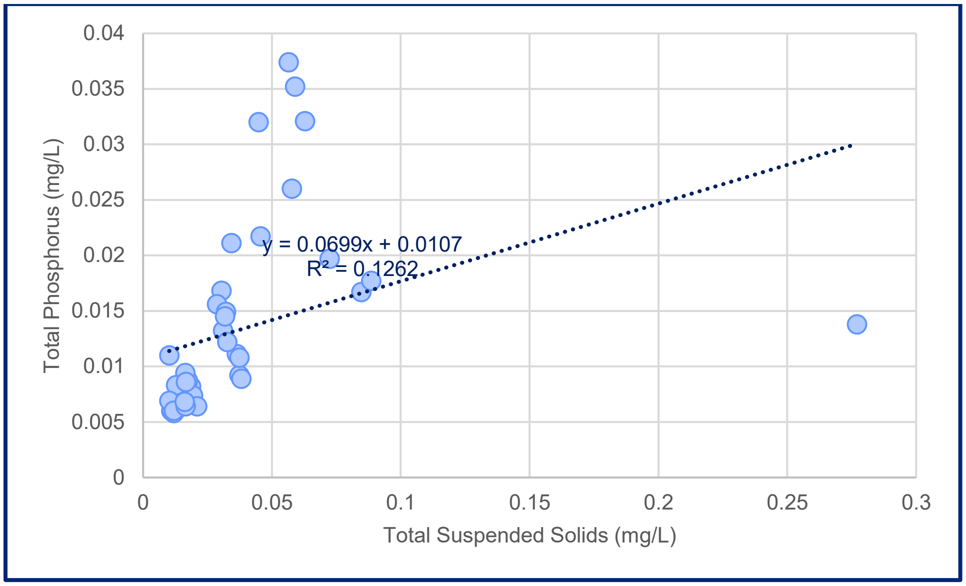
Total phosphorus concentrations in the river were relatively consistent between the upstream and downstream stations with median concentrations ranging between 0.019 mg/L (30 m downstream) to 0.0317 mg/L (350 m downstream; Table 7, Figure 4). Total dissolved phosphorus and orthophosphate concentrations followed a similar pattern to total phosphorus.

Figure 4. Total Phosphorus Concentrations in the Humber River.



Total phosphorus concentrations were highest at the upstream site (0.277 mg/L) on June 27th, when TSS concentrations (409 mg/L) and flow (4.96 m^3/s) were highest. Total phosphorus concentrations were lowest at the upstream site (0.0129 mg/L) on August 29th and September 20th when TSS concentrations were also low (2.5 and 2.6 mg/L, respectively). A strong positive relationship was found between total phosphorus and TSS (Figure 4), consistent with Gartner Lee Ltd (1999).

Figure 5. Total Phosphorus and Total Suspended Solid Concentrations in the Humber River.



The upstream 75th percentile TP concentration was 0.037 mg/L, suggesting Policy 2 status (Table 7). This value was largely influenced by the three high flow/wet events (May, June and October), in which TSS and TP concentrations were elevated. The median TP concentration was 0.019 mg/L (Table 7).The ACS calculations are based on the 7Q20 flow statistic and so TP concentrations should be assessed during low flow periods to determine stream sensitivity and establish protective effluent limits. Additional water quality sampling was therefore undertaken in summer/fall 2018 to further understand the TP/TSS relationship and confirm the Policy status of the Humber River for TP (Section 2.4.5).

Dissolved phosphorus made up a similar proportion of total phosphorus at the upstream site (median proportion 52%) compared to the effluent (median proportion of 55%) and downstream sites (median proportions ranged from 42% at the 100 m downstream site to 47% at the 30m downstream site). Indicating effluent discharge did not influence dissolved phosphorus proportions.

Dissolved phosphorus made up a greater proportion of total phosphorus during dry events (average proportions ranged from 51% at the 100m downstream site to 67% at the 30m downstream site) compared to wet events (average proportions ranged from 31% at the upstream site to 37% at the 100m downstream site; (Figure 6 and Figure 7)[4]. The higher proportion of particulate phosphorus during wet events further validates the relationship between TSS and phosphorus during high flow events.

The proportion of orthophosphate was similar upstream (median 24%), in the effluent (median 28%) and at downstream sites (median proportions ranged from 25% at the 30 and 100 m downstream stations to 28% at the 10m downstream site). Proportions were higher during dry events (average 28% to 30%) compared to wet weather events where proportions ranged from 14% at the upstream site to 20% in the effluent.

[4] *particulate fraction of phosphorus estimated using total phosphorus and total dissolved phosphorus concentrations*

Figure 6. Average Total Dissolved and Particulate Phosphorus in the Humber River During Dry Events.

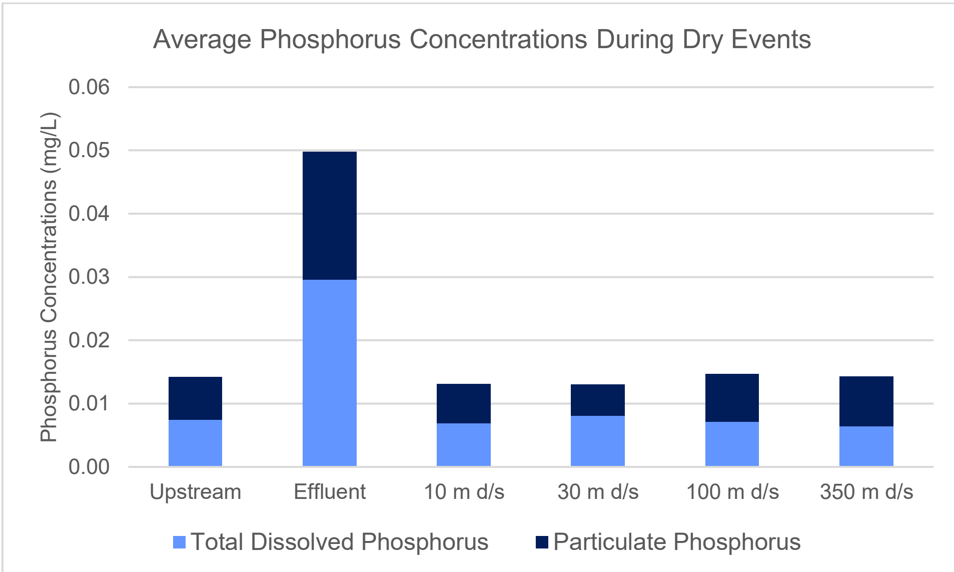
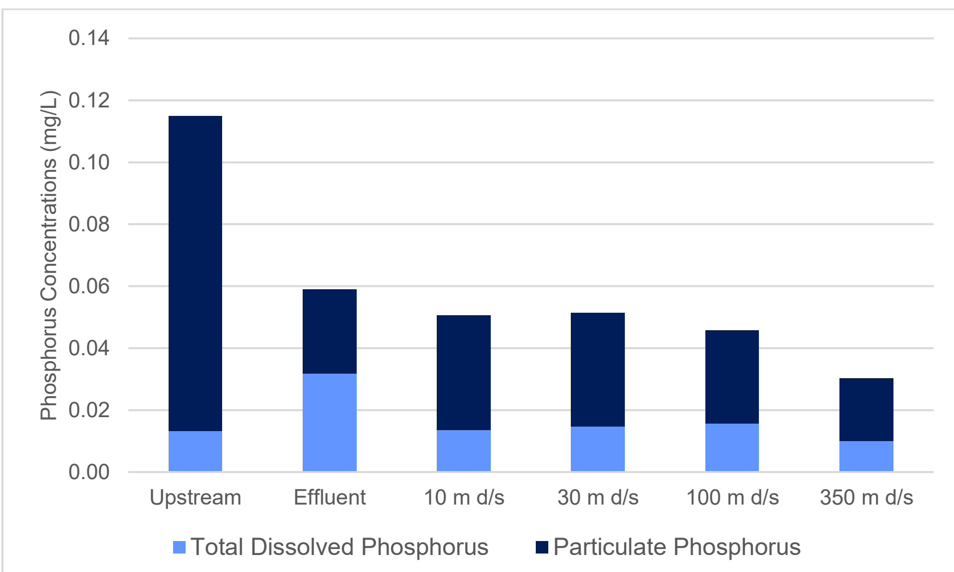


Figure 7. Average Total Dissolved and Particulate Phosphorus in the Humber River During Wet Events.



Chlorophyll-a

Chlorophyll a was sampled twice, May and August 2017. Chlorophyll-a concentrations were higher during the May sampling event under high flows than the August sampling event. Chlorophyll-a concentrations were consistent upstream to downstream with median concentrations of 1.4 µg/L at the 10 m downstream site to 2.57 µg/L at the upstream site, and no significant differences between sites.

Nitrogen Compounds

Total Kjeldahl Nitrogen concentrations were relatively consistent upstream to downstream in the river with median values ranging from 0.29 mg/L (350 m downstream) to 0.37 mg/L (10 m downstream). Concentrations 1.7 km downstream were within the range (<0.15 and 0.26 mg/L) of those measured upstream (<0.15 to 2.02 mg/L; Figure 8). Concentrations were significantly higher in the effluent (median value of 1.02 mg/L) than all other sites (p values ranging from 0.031 to 0.047).

Median total ammonia nitrogen concentrations were higher in the effluent (0.075 mg-N/L) than the river, but the difference was not significant. Concentrations remained similar within the river with median concentrations ranging from 0.035 mg-N/L (100 m downstream) to 0.056 mg-N/L (upstream and 350 m downstream).

Un-ionized ammonia (as N) concentrations were below the PWQO of 0.0164 mg-N/L at all sites on all sampling events. Un-ionized ammonia concentrations were higher upstream (median concentration 0.0028 mg-N/L) than in the WRRF effluent (median concentration 0.0011 mg-N/L; Figure 9). Concentrations were also slightly higher in the Humber River upstream (median value 0.0028 mg/L) of the WRRF discharge, than downstream of the discharge (median values ranged between 0.0019 mg/L 10 m downstream to 0.0026 mg/L 10 m downstream). Concentrations measured 1.7 km downstream of the WRRF discharge (0.0009 and 0.0027 mg/L) were within the range of values measured upstream (Table B2).

Nitrate-nitrogen concentrations were two orders of magnitude higher and significantly different ($p < 0.001$) in the WRRF discharge (median value 18.2 mg/L) compared to the Humber River upstream (median concentrations 0.30 mg/L). Concentrations were higher downstream of the discharge - median concentrations ranged from 0.33 mg/L 10 m downstream to 0.40 mg/L 30 m downstream than upstream (median concentration 0.30 mg/L; Figure 10), however all values were well below the CWQG of 3.0 mg-N/L. Nitrate-nitrogen concentrations measured 1.7 km downstream (0.276 and 0.274 mg/L) were within the range of concentrations measured at other river sites on the same dates.

Nitrite concentrations were below detection at all sites on all dates except at the 100 m downstream station (0.145 mg/L) on February 5th, 2018, and in the effluent in August and October when concentrations ranged between 0.05 and 0.1 mg/L.

Figure 8. Total Kjeldahl Nitrogen Concentrations in the Humber River.

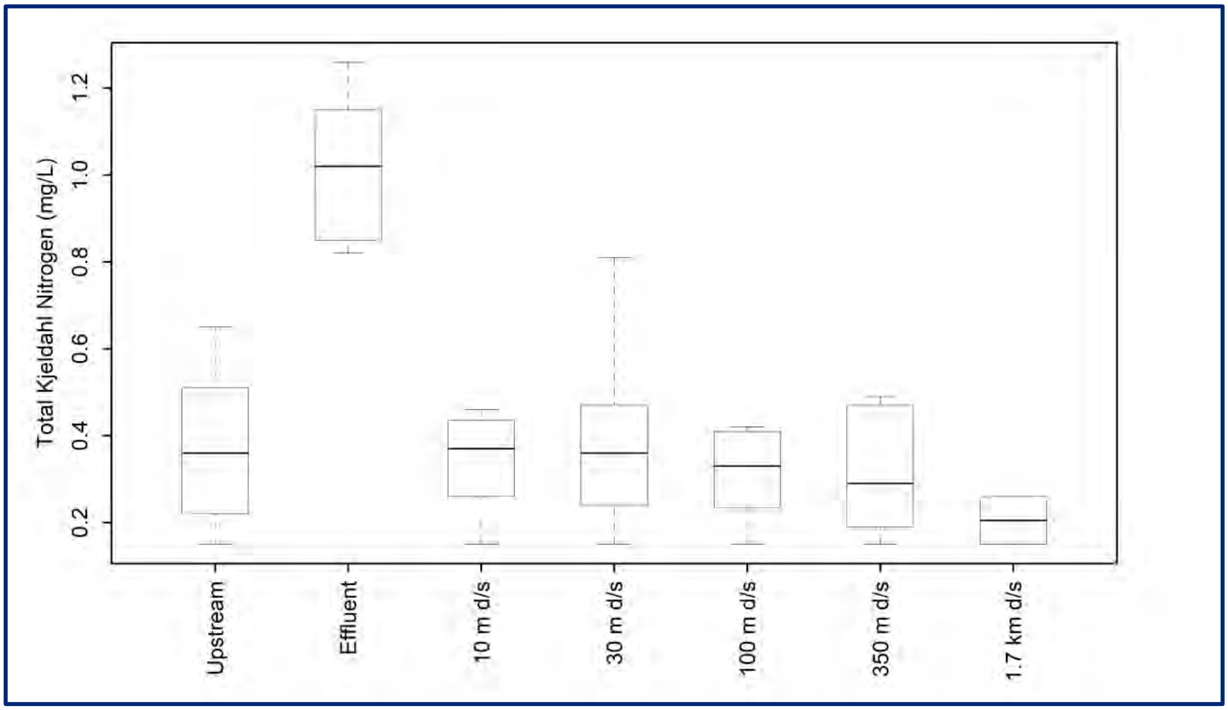


Figure 9. Un-ionized Ammonia Concentrations in the Humber River.

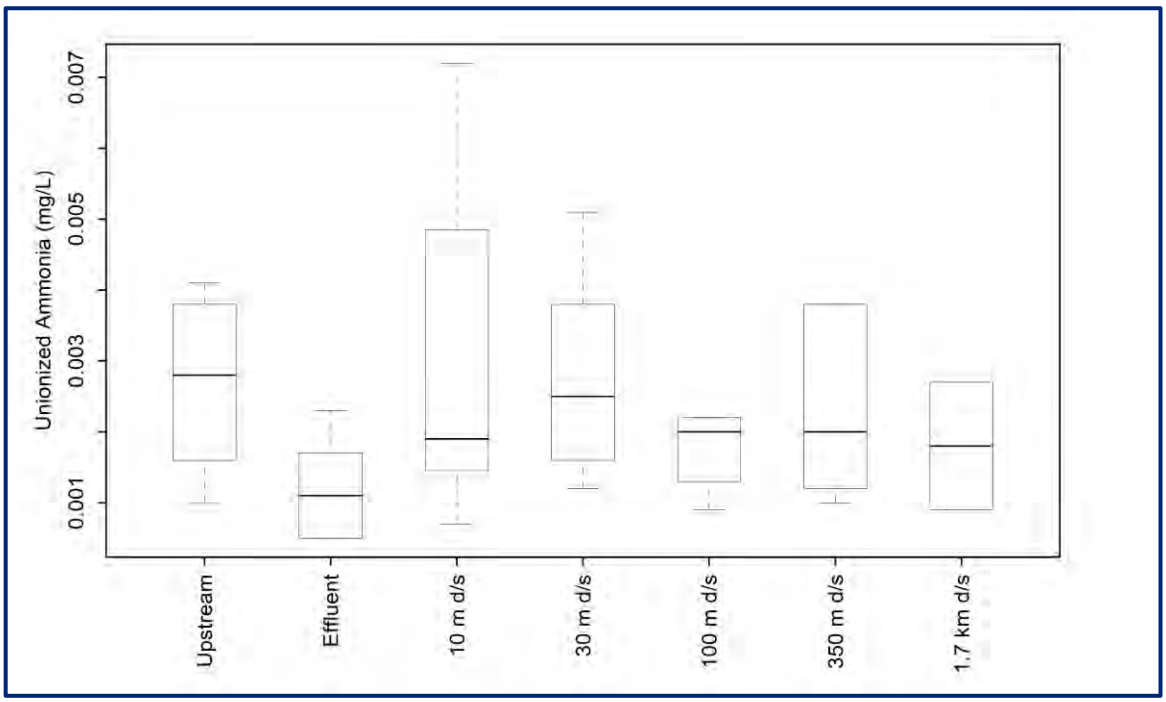
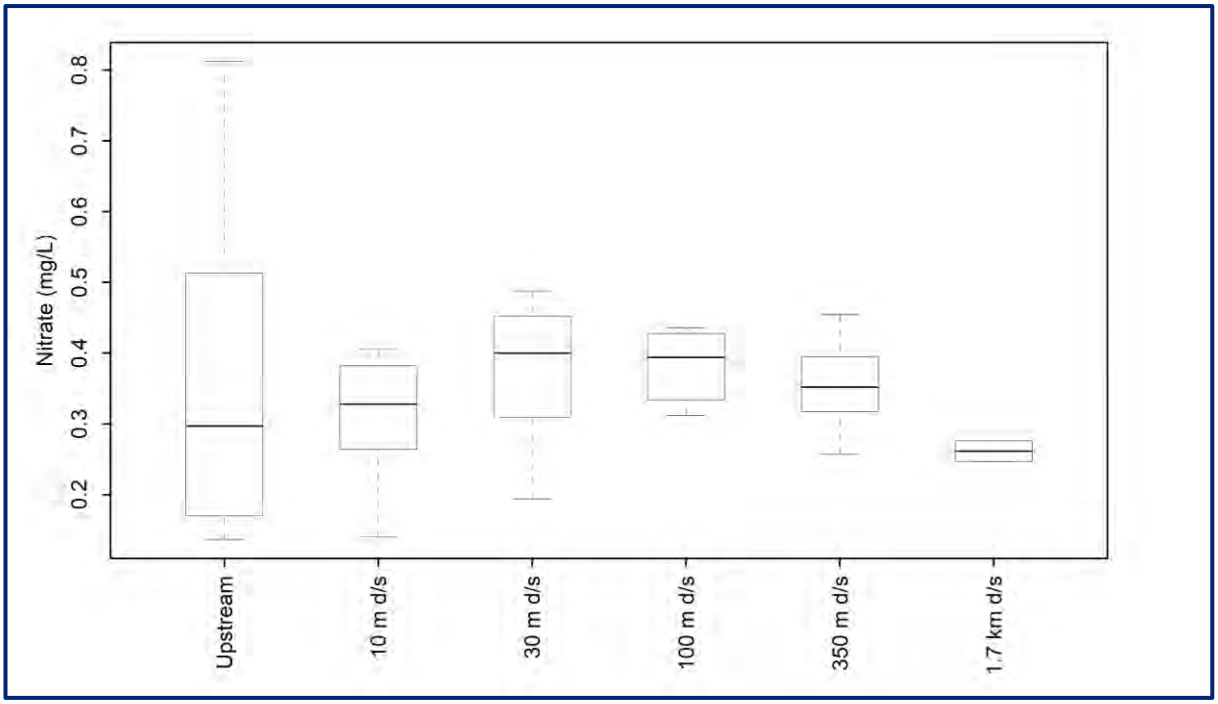


Figure 10. Nitrate-Nitrogen Concentrations in the Humber River.



Note: Effluent box plot out of scale.

Chloride

Chloride concentrations in the effluent were an order of magnitude higher (median value of 425 mg/L) and significantly different ($p < 0.0006$) than upstream concentrations (median concentration 50.4 mg/L) which were, in turn similar to values measured 100 m downstream (median value 53.3 mg/L). The effluent did not have an impact on downstream chloride levels and all downstream river values were below the CWQG of 120 mg/L. Concentrations were highest during the winter sampling ranging from 85.8 mg/L (upstream) to 101 mg/L (30 m downstream). This pattern is likely the result of road salt application during the winter season.

Biological Oxygen Demand

5-day Carbonaceous biological oxygen demand ($cBOD_5$) was below detection (2 mg/L) at all sites on all dates. 20-day carbonaceous biological oxygen demand ($cBOD_{20}$) was regularly below detection (2 mg/L) at all sites. Effluent $cBOD_{20}$ concentrations were higher than stream sites, with a median concentration of 3.3 mg/L.

Alkalinity

Alkalinity was consistent at the river sites with median values ranging from 231 mg/L 10 m downstream to 238 mg/L 100 m downstream, but was slightly lower in the effluent (median concentration of 188 mg/L). In all cases, the alkalinity indicated a well buffered stream.

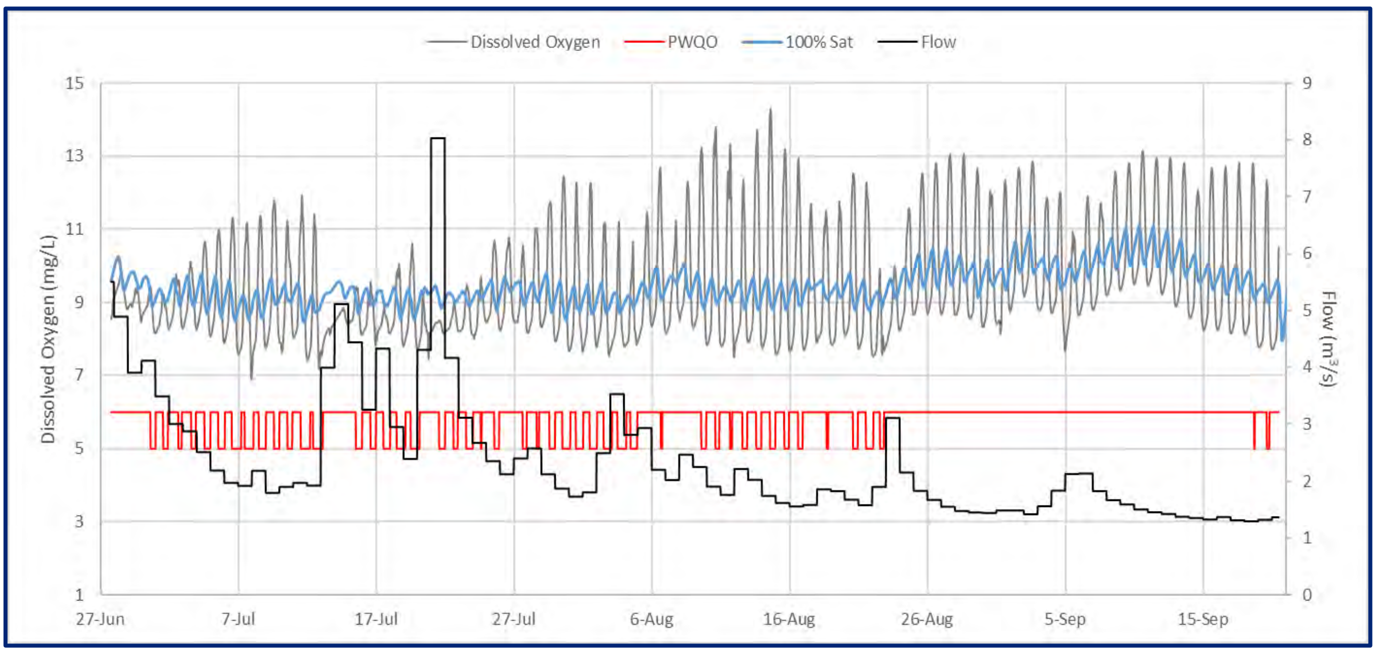
2.4.4 Diurnal Dissolved Oxygen and Temperature Surveys

Diurnal records of temperature and DO were obtained between June 27 and September 20, 2017 upstream of the WRRF discharge, between June 27 and August 29, 2017 350 m downstream of the discharge, and between August 30 and September 30, 2017 1.7 km downstream of the discharge.

DO conditions in the Humber River were excellent during the monitoring period (Figure 11 to 14), and above the PWQO at every site at all times. Minimum nighttime concentrations were 6.89 mg/L upstream of the WRRF, 7.09 mg/L 30 m downstream of the WRRF, 6.93 mg/L 350 m downstream of the WRRF, and 8.02 mg/L 1.7 km downstream of the WRRF (Table 8). Maximum daytime concentrations were 14.30 mg/L, 14.38 mg/L,14.46 mg/Land 14.44 mg/L respectively. Maximum daily DO concentrations were frequently above 100% saturation (Figures 11 to 14) at both the upstream and downstream stations, indicating naturally supersaturated DO concentrations in the river, and confirming field-measurements of DO during the 2017 water quality characterization.

Decreases in dissolved oxygen and temperature were noted between July 13th and 15th and between July 20th and 23rd, 2017 (Figures 11 to 13). These excursions were associated with increases in flow[5] suggesting depressed dissolved oxygen concentrations were the result of storm events.

Figure 11. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River Upstream of the Nobleton WRRF discharge.



[5] *As noted by flows obtained from the WSC guage downstream at Elder Mills 02HC024*

Figure 12. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 30 m Downstream of the Nobleton WRRF discharge.

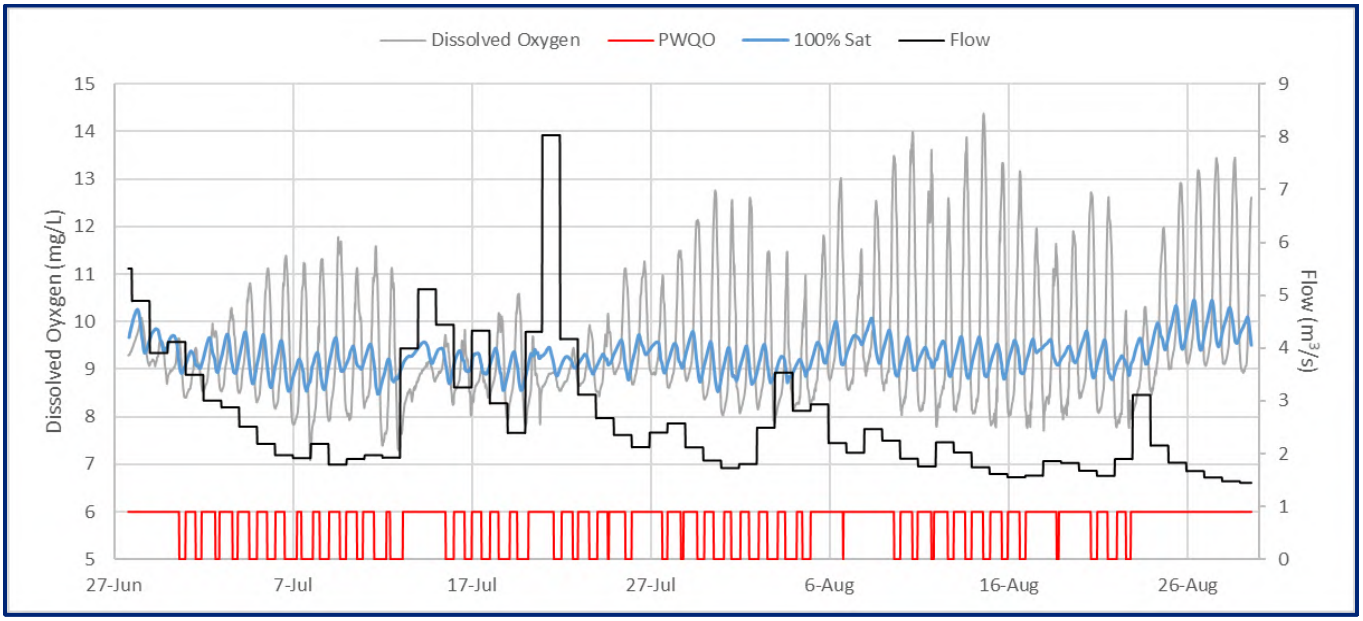


Figure 13. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 350 m Downstream of the Nobleton WRRF discharge.

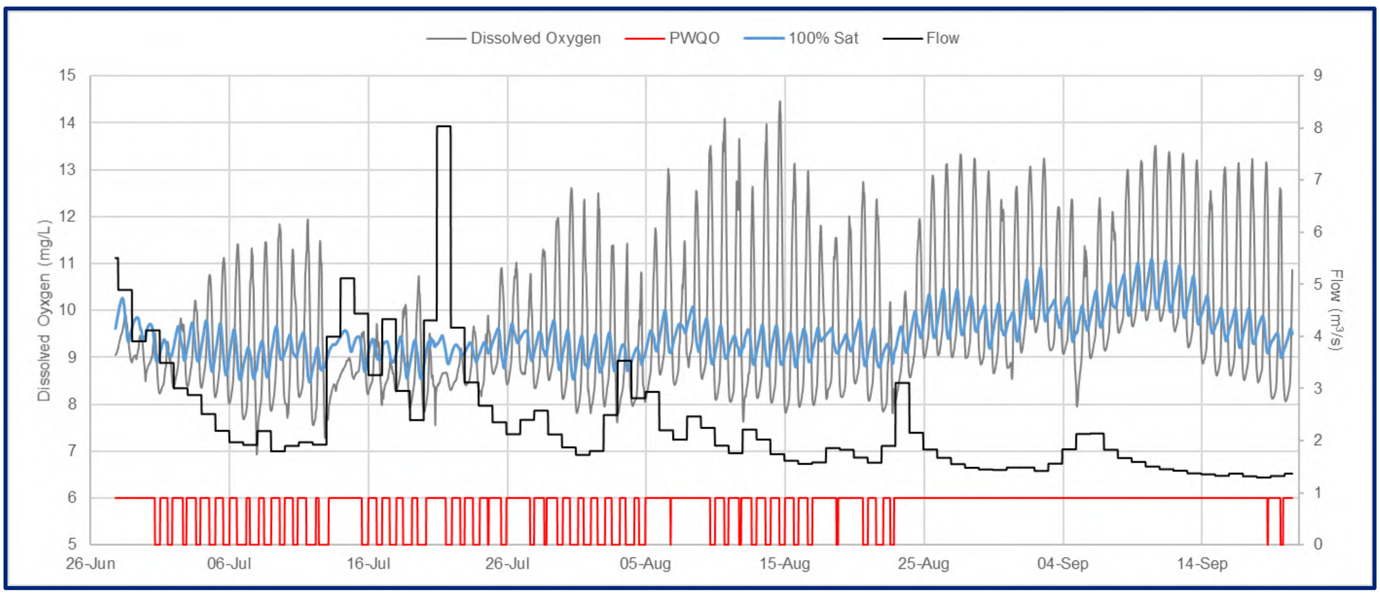
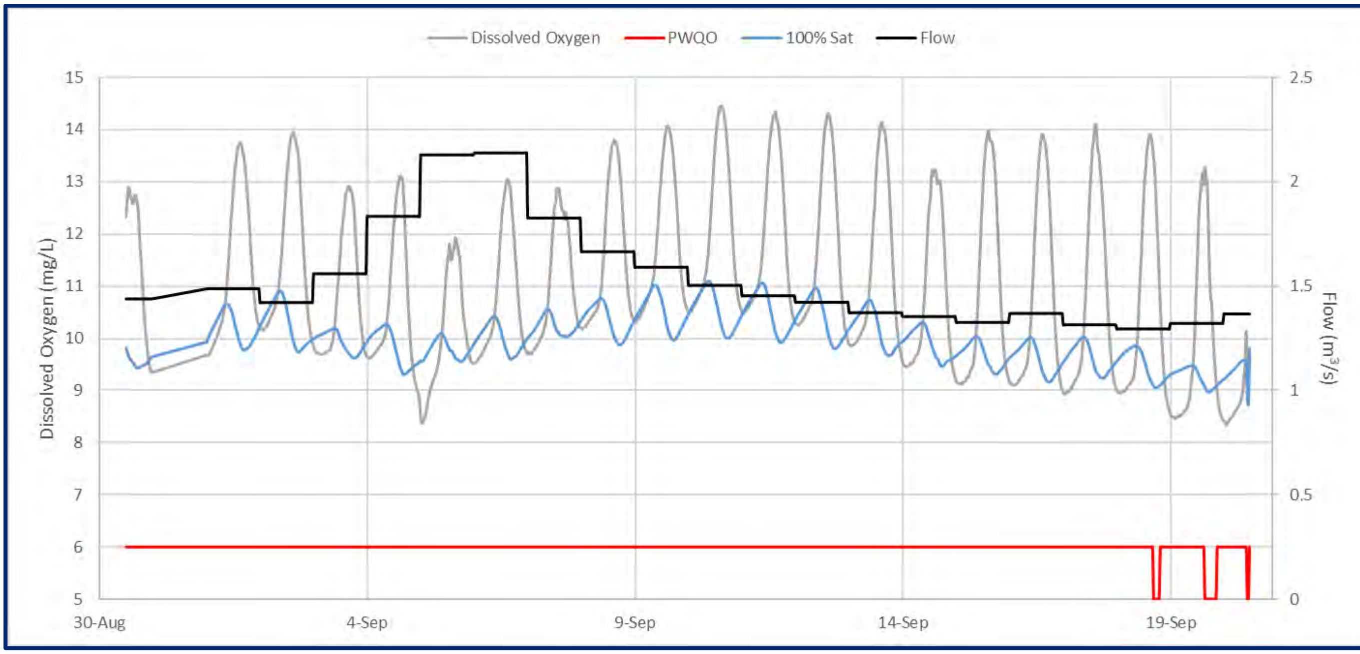


Figure 14. Continuous Dissolved Oxygen and Temperature Measurements in the Humber River 1.7 km Downstream of the WRRF discharge.



Twenty fifth (25th) percentile dissolved oxygen concentrations were calculated (Table 8) for each location to determine the policy status and as input into the modelling. The late summertime period represents the time of lowest stream flow and warm temperatures so the records from this period were used. Concentrations were consistently higher downstream (30 m, 350 m, and 1.7 km) than upstream of the WRRF (Table 8), indicating no downstream oxygen demand from the WRRF effluent.

Table 8. Minima, Maxima, and 25th Percentile Dissolved Oxygen Concentrations (mg/L).

	Upstream			30 m downstream			350 m downstream			1.7 km downstream		
	Min	Max	25%	Min	Max	25%	Min	Max	25%	Min	Max	25%
Jul	6.89	12.44	8.23	7.09	12.76	8.57	6.93	12.61	8.38			
Aug	7.5	14.3	8.21	7.71	14.38	8.51	7.61	14.46	8.49			
Sept	7.37	13.14	8.80				7.57	13.51	9.15	8.02	14.44	9.67
All Data	6.89	14.3	8.32	7.09	14.38	8.57	6.93	14.46	8.54	8.02	14.44	9.64

Diurnal fluctuations in DO were similar between the upstream, 30 m, and 350 m downstream stations over the measurement period (Table 9). Diel variations were low in July (2.47 – 2.55 mg/L), increased in August at the height of the growing season (4.26 – 4.29 mg/L), then diminished in September (3.31 – 3.55 mg/L) as water temperatures cooled, and plant growth decreased (Table 9). Although diel variations in DO were high (~ 4 mg/L in August), concentrations were consistently above the PWQO (Figures 11 – 14)

Table 9. Diel Variations in Dissolved Oxygen Concentrations in the Humber River in 2017.

	Upstream		30 m downstream		350 m downstream		1.7 km downstream	
	Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev
July	2.54	1.35	2.47	1.26	2.55	1.35		
August	4.29	1.06	4.26	1.07	4.27	1.05		
September	3.31	1.44			3.32	1.38	3.55	1.41
All Data	3.31	1.50	3.16	1.54	3.27	1.50	3.53	1.43

Water temperatures ranged from 10.74 to 27.06°C upstream of the WRRF, from 13.36 to 23.64°C 30 m downstream of the WRRF, from 10.74 to 27.28°C 350 m downstream of the WRRF and from 10.78 to 27.46°C 1.7 km downstream of the WRRF. Temperatures between the four sites (when judged on a monthly basis) were similar supporting the conclusion that groundwater inputs are minimal within this reach of the river (Table 10).

Table 10. Minima, Maxima, and 75th Percentile Water Temperatures (°C).

	Upstream			30 m downstream			350 m downstream			1.7 km downstream		
	Min	Max	75%	Min	Max	75%	Min	Max	75%	Min	Max	75%
Jul	16.42	23.72	20.7	16.4	23.64	20.62	16.4	23.66	20.66			
Aug	13.36	22.44	19.74	13.36	22.38	19.8	13.34	22.38	19.685			
Sept	10.74	27.06	17.72				10.74	27.28	17.66	10.78	27.46	17.66
All Data	10.74	27.06	19.88	13.36	23.64	20.24	10.74	27.28	19.84	10.78	27.46	17.7

2.4.5 2018 Additional Phosphorus and TSS Sampling

Additional TP and TSS sampling were completed in summer and fall 2018 to confirm the phosphorus policy designation of the Humber River during summer low flow conditions. Results presented here compare upstream versus downstream water quality to assess the influence of the WRRF on 10 m downstream water quality (nearfield). Results are discussed in Section 2.5.1 as inputs into the TP policy designation.

TSS concentrations were low in the Humber River upstream and 10 m downstream of the Nobleton WRRF during the summer and fall 2018 sampling events. Median TSS was 6.0 mg/L upstream, and 6.3 mg/L downstream (Table 11). In summer/fall 2018 the median upstream total phosphorus concentration was 0.0156 mg/L, well below the PWQO of 0.03 mg/L. Downstream total phosphorus concentrations were higher with a median concentration of 0.0209 mg/L (still well below the PWQO of 0.03 mg/L). Total phosphorus was below the PWQO during all but the August 30, 2018, sampling events both upstream and downstream of the WRRF discharge (Table 11). The higher phosphorus concentration measured on August 30 is indicative of the higher TSS (Table 11) measured during that sampling event. Dissolved phosphorus concentrations were approximately half of the total phosphorus concentrations, indicating that approximately 50% of the total phosphorus concentration was particulate phosphorus, associated with the suspended sediments and not immediately available for plant uptake. There was no significant difference ($p < 0.05$) between the upstream and downstream concentrations for any of the measured parameters.

Table 11 Additional TSS (mg/L) and Phosphorus (mg/L) Sampling, 2018.

	TSS		Total Phosphorus		Dissolved Phosphorus	
Date	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**Downstream**
12-Jun-18	5.2	5.6	0.0151	0.0144	0.0064	0.0077
04-Jul-18	6.7	4.9	0.0161	0.0164	0.0077	0.0078
17-Jul-18	9.7	10	0.0222	0.0240	0.0100	0.0104
31-Jul-18	2.3	2.3	0.0124	0.0129	0.0074	0.0062
15-Aug-18	2.8	7.0	0.0150	0.0254	0.0088	0.0161
30-Aug-18	13.2	10.1	0.0334	0.0310	0.0168	0.0152
06-Sep-18	4.4	4.1	0.0129	0.0123	0.0058	0.0073
12-Sep-18	4	3.1	0.0140	0.0189	0.0090	0.0068
04-Oct-18	11.3	11.9	0.0200	0.0249	0.0090	0.0092
09-Oct-18	9.9	11.3	0.0251	0.0228	0.0091	0.0112
Mean	**9.0**	**9.0**	**0.0186**	**0.0203**	**0.0090**	**0.0098**
Median	**6.0**	**6.3**	**0.0156**	**0.0209**	**0.0089**	**0.0085**
75th Percentile	**9.9**	**10.1**	**0.0217**	**0.0247**	**0.0091**	**0.0110**

2.4.6 Wetland Assimilation

Effluent from the WRRF discharges to a constructed wetland before discharging into the Humber River. The assimilation of nutrients by the wetland was evaluated by comparing median concentrations of nutrients measured in the effluent at the WRRF (by facility staff) to those measured at the outfall of the wetland on the seven days when HESL was completing the routine[6]. Detailed results are provided in Appendix B.

Overall, TP concentrations in the wetland outlet (0.057 mg/L) were significantly lower ($p < 0.05$) than in the WRRF effluent (0.086 mg/L; Table 12). The largest decreases in TP concentrations were observed in the May and September sampling events, when effluent concentrations were high (Figure 15).

[6] WRRF and wetland effluent sampling dates were not coordinated during the study; therefore, WRRF samples taken within 3 days of wetland effluent sampling were used for the analysis. Samples from the WRRF and those from the wetland were also analysed in separate laboratories. Samples should be collected on the same date; however, the analysis does provide insight into the wetland function, and therefore was included in the ACS.

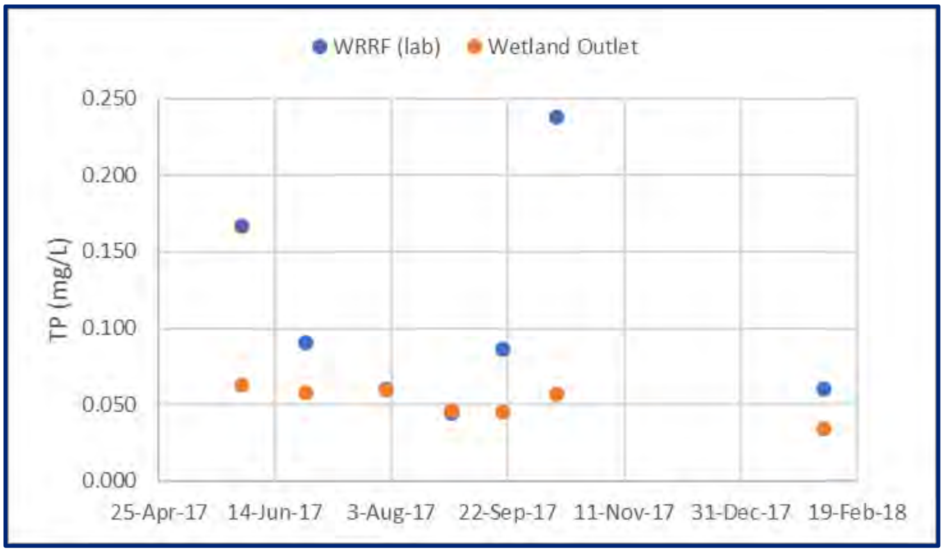
Orthophosphate concentrations decreased through the wetland to a lesser extent, concentrations decreased by 0.003 mg/L (Table 12).

Table 12 Comparison of Median WRRF Effluent and Wetland Outlet Concentrations (mg/L).

Parameter	WRRF Effluent[1]	Wetland Outlet	Median Reduction
TP	0.086	0.057	0.032
Orthophosphate	0.013	0.003	0.019
Total Suspended Solids	5.7	8.3	-4.4
Total Ammonia Nitrogen	0.080	0.075	0.005
Nitrate (as N)	18.5	18.2	1.9
$cBOD_5$	<2	<2	0

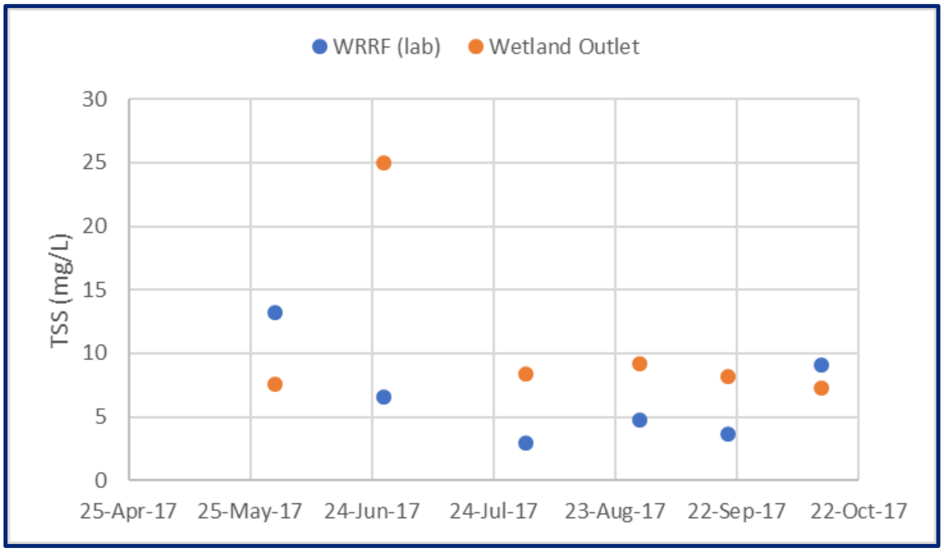
Note: median based on 7 sampling events that correspond to HESL sampling events.

Figure 15. TP Concentrations in WRRF Effluent and Wetland Outlet.



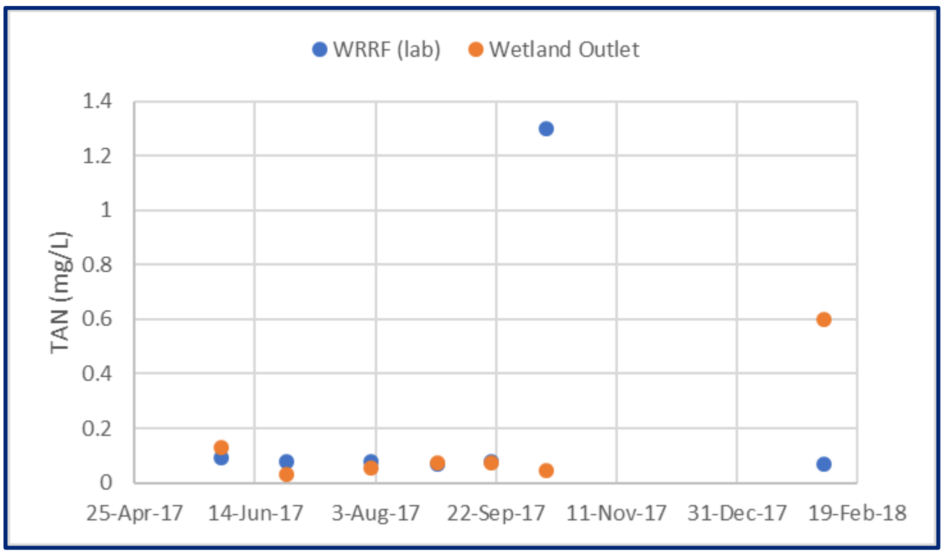
TSS concentrations increased by a median concentration of 4.4 mg/L at the wetland outlet compared to the WRRF effluent (Table 12 and Figure 16), but the difference was not statistically significant. TSS concentrations were appreciably higher (by 18.4 mg/L) at the wetland outlet compared to the WRRF during the June 27 sampling event. This sample is representative of a "wet" event, when the flow and TSS concentration in the Humber River were high (upstream values: 4.96 m^3/s and 409 mg/L), the higher TSS in the wetland outlet during this event is likely due to runoff from surrounding land use.

Figure 16. TSS Concentrations in WRRF Effluent and Wetland Outlet.



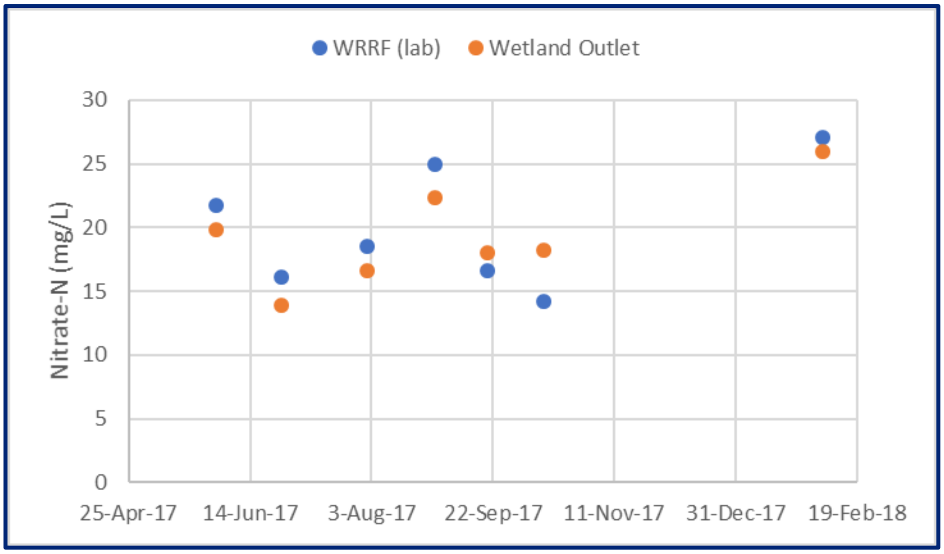
Median TAN concentrations were similar in WRRF effluent (0.08 mg N/L) and the wetland outlet (0.075 mg N/L, Table 12 and Figure 17) except for one measurement of 0.597 mg N/L in February 2018.

Figure 17. TAN Concentrations in WRRF Effluent and Wetland Outlet.



Median nitrate concentrations were similar at the WRRF (18.5 mg/L) and wetland outlet (18.2 mg/L; Table 12, Figure 18), showing that the wetland was not using nitrate as a nutrient for plant growth. $cBOD_5$ concentrations measured at the WRRF and wetland outlet were all <2 mg/L (Table 12) and so the wetland was not introducing any oxygen demand to the effluent before discharge to the Humber River.

Figure 18. Nitrate-N Concentrations in WRRF Effluent and Wetland Outlet.



The sampling showed that the wetland performance varied between sampling events, between parameters. Overall the wetland acted as a sink for phosphorus and a potential source of TSS (but had little to no effect on TAN, nitrate and $cBOD_5$ concentrations. This assessment, however, is based on seven sampling events, when the WRRF and wetland samples may have been taken on different days and were analyzed by different labs. Additional, coordinated sample collection over multiple seasons would be needed to confirm these results.

2.5 Policy Designation

Policy status of the Humber River was determined for TP, un-ionized ammonia, nitrate, chloride and dissolved oxygen. Policy determination for un-ionized ammonia, nitrate, chloride and dissolved oxygen was based on background water quality measured at the upstream station over the 2017 water quality characterization program, and for total phosphorus over the 2017 water quality characterization program and 2018 additional phosphorus and TSS sampling program.

2.5.1 Total Phosphorus

Humber River water quality sampling in 2017 (Section 2.4.3) found that TP concentrations upstream of the WRRF were below the PWQO (i.e. Policy 1) during the summer dry events, and that high TP (above PWQO) occurred during high flow conditions, when TSS was elevated (Figure 2). A seasonal interpretation of TP concentrations found that the receiver was Policy 1 during summer low flow conditions, for which ACS predictions are based. Additional sampling (Section 2.4.5) was completed in 2018 to confirm the policy designation of the Humber River during traditionally low flow conditions.

The upstream median and 75th percentile TP concentrations of 0.0165 and 0.0229 mg/L (Table 13) from the combined 2017 and 2018 data sets indicate that the Humber River is Policy 1 for TP[7].

Table 13. 2017 and 2018 TSS and TP data from the Humber River Upstream of the Nobleton WRRF.

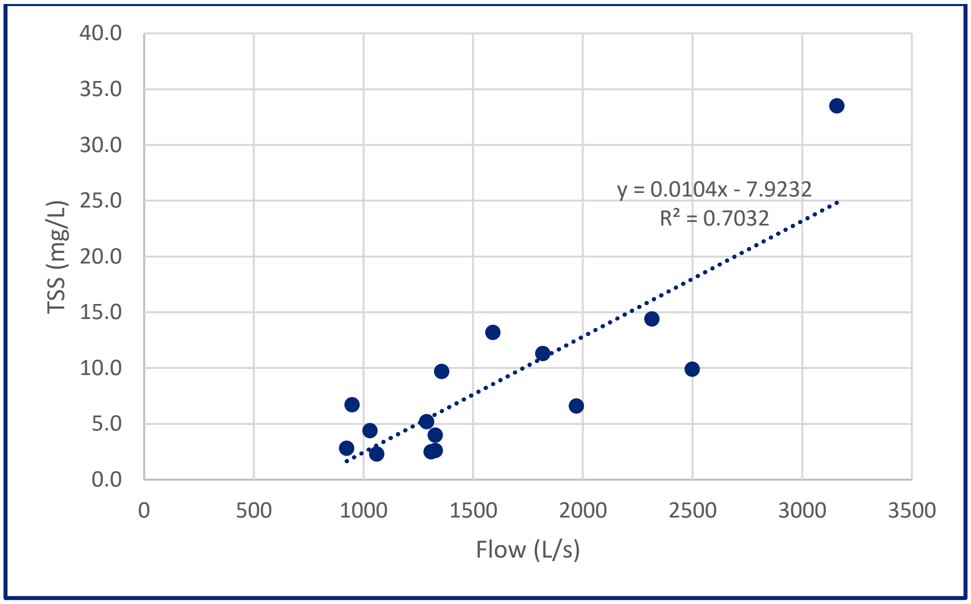
Date	TSS All	TSS Dry	TSS Wet	TP All	TP Dry	TP Wet	TP summer	Wet/Dry event
31-May-17	33.5		33.5	0.0373		0.0373		Wet
27-Jun-17[1]	409		409	0.2770		0.2770		Wet
01-Aug-17	6.6	6.6		0.0168	0.0168		0.0168	Dry
29-Aug-17	2.5	2.5		0.0129	0.0129		0.0129	Dry
20-Sep-17	2.6	2.6		0.0129	0.0129		0.0129	Dry
13-Oct-17	14.4		14.4	0.0304		0.0304		Wet
05-Feb-18				0.0186	0.0186			Dry
12-Jun-18	5.2	5.2		0.0151	0.0151		0.0151	Dry
04-Jul-18	6.7	6.7		0.0161	0.0161		0.0161	Dry
17-Jul-18	9.7		9.7	0.0222		0.0222	0.0222	Wet
31-Jul-18	2.3	2.3		0.0124	0.0124		0.0124	Dry
15-Aug-18	2.8	2.8		0.0150	0.0150		0.0150	Dry
30-Aug-18	13.2	13.2		0.0334	0.0334		0.0334	Dry
06-Sep-18	4.4	4.4		0.0129	0.0129		0.0129	Dry
12-Sep-18	4		4	0.0140		0.0140	0.0140	Wet
04-Oct-18	11.3		11.3	0.0200		0.0200		Wet
09-Oct-18	9.9		9.9	0.0251		0.0251		Wet
Median	**6.6**	**4.4**	**11.3**	**0.0165**	**0.0151**	**0.0251**	**0.0150**	
75th Percentile	**10.6**	**6.6**	**23.95**	**0.0229**	**0.0166**	**0.0339**	**0.0165**	

Notes:1 - June 27, 2017 TSS and TP values removed from analysis as determined to be an outlier (3 times the interquartile range), 2 – June to September values used to determine 75th percentile value

A strong positive relationship between field-measured flow and TSS was observed ($R^2=0.7032$, $p< 0.00000873$) with the combined 2017 and 2018 datasets (Figure 19); confirming that the elevated TSS in the Humber River is from runoff and erosion during high flow events.

[7] TSS and TP data from June 27, 2017 sampling event was not included in the analysis, as the TSS concentration (409 mg/L) was determined to be an outlier (using 3.0 times the interquartile range to assess outliers).

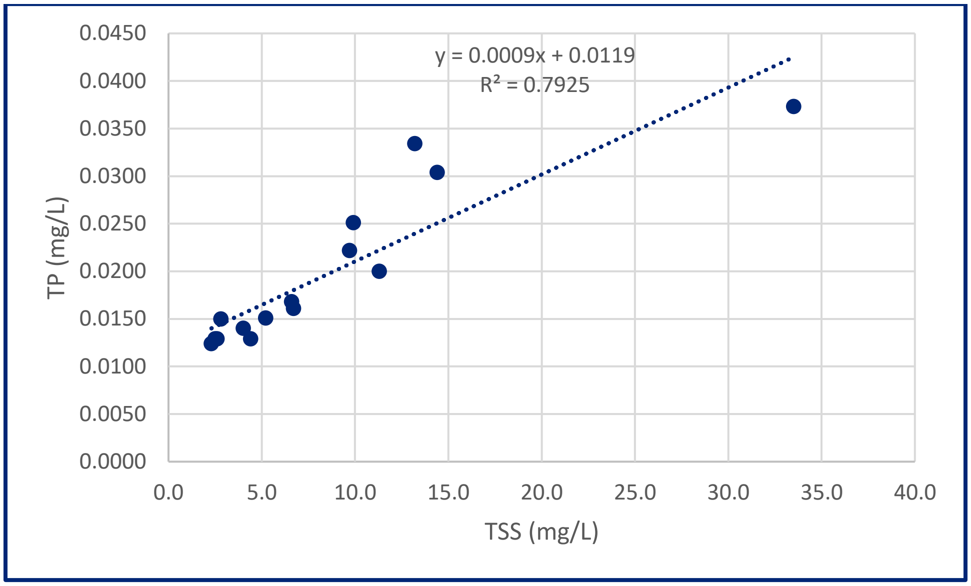
Figure 19. Relationship between Flow and Total Suspended Solids.



A strong positive relationship between TSS and total phosphorus was also observed (R^2=0.7925, $p < 0.0000939$) using the same data set (Figure 20). Solving the regression equation for the PWQO of 0.03 mg/L, provides a TSS concentration of 20.1 mg/L such that, PWQO exceedances are generally associated with TSS values over 20 mg/L.

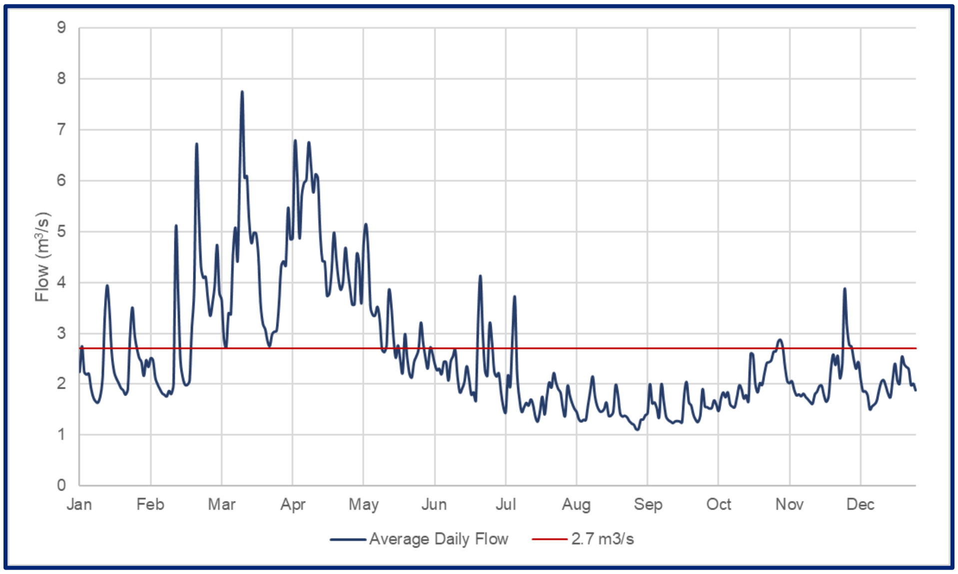
Solving the linear equation for TSS and flow using the TSS concentration of 20.1 mg/L, found that flows below 2,696 L/s (2.7 m^3/s) result in total phosphorus concentrations below the PWQO (0.03 mg/L). This represented 87.5% of flows calculated at the upstream site over the 2017 and 2018 sampling program.

Figure 20. Relationship between Total Suspended Solids and Total Phosphorus.



Average daily flows (2009-2018) from the downstream WSC station at Elder Mills (station 02HC032) were prorated to the WRRF discharge point based on area (Figure 21). Average flow was typically above 2.7 m^3/s from mid-February to mid-May (Figure 21), then decreased below 2.7 m^3/s, through the later spring, summer and fall months, except during storm events.

Figure 21. Daily Average Flow (m^3/s) in the Humber River (2009-2018).



This relationship demonstrates that erosion and runoff in other parts of the watershed are responsible for high concentrations of TP in the Humber River after summer rain events, or in the spring when flows are higher, driving TP concentrations above the PWQO.

A summer (June to September) 75th percentile TP concentration of 0.0165 mg/L (Table 13) is representative of summer (June to September) low flow conditions in the Humber River. Therefore, basing ACS predictions on summer 75th percentile TP concentrations for when the river is most sensitive to effluent inputs provides the necessary level of water quality protection.

2.5.2 Un-Ionized Ammonia

Humber River water quality sampling in 2017 found that the 75th percentile total ammonia and un-ionized concentrations were 0.085 mg-N/L and 0.0038 mg-N/L respectively (Table B2). The PWQO for un-ionized ammonia is 0.0164 mg-N/L, therefore the Humber River in the reach of interest is therefore considered a Policy 1 receiver for ammonia.

2.5.3 Nitrate

Humber River water quality sampling in 2017 found that the 75th percentile nitrate concentration of 0.51 mg-N/L (Table B2) is well below the CWQG of 3.0 mg-N/L for long-term exposure (CCME, 2012). The Humber River is therefore a Policy 1 receiver for nitrate.

2.5.4 Chloride

Humber River water quality sampling in 2017 found that the 75th percentile chloride concentration of 53 mg/L (Table B2) is well below the CWQG of 120 mg/L for long-term exposure (CCME, 2012). The Humber River is therefore a Policy 1 receiver for chloride.

2.5.5 Dissolved Oxygen

The 25th percentile DO concentration is used when determining background water quality when developing receiver-based effluent limits for DO, as the 25th percentile concentration represents a conservative estimation of low concentrations in the receiver. The 25th percentile dissolved oxygen concentration from the upstream logger data installed from June 27 to September 20, 2017, when river temperature and primary production were highest, was 8.32 mg/L (Table 8). The PWQO ranges from 4 to 8 mg/L depending on temperature and designation of biota as cold water or warm water. The 25th percentile concentration is above the PWQO therefore, the Humber River in this area is Policy 1 for dissolved oxygen.

2.6 Summary

TSS, total phosphorus, total Kjeldahl nitrogen, total ammonia and un-ionized ammonia concentrations downstream of the WRRF discharge were not statistically different ($p>0.05$) than those measured upstream. Nitrate concentrations were slightly higher downstream of the WRRF discharge; however, all measurements were well below the CWQG of 3.0 mg/L, and not statistically different ($p>0.05$) from those measured upstream. Nitrite concentrations were below detection of 0.01 mg/L at every station (except the 100 m downstream station on February 5, 2018). Un-ionized ammonia was well below the PWQO at all stations on all events, and therefore, there is no concern of acute toxicity at the point of discharge. Overall the Nobleton WRRF discharge had no significant effect on downstream water quality during the 2017 and 2018 sampling events.

PWQO exceedances of TP in the river were generally associated with TSS values over 20 mg/L which occurred when flows were greater than ~2.7 m^3/s; demonstrating that erosion and runoff in other parts of the watershed were responsible for high concentrations of TP in the Humber River and that the policy status should be determined during low flow periods.

Diurnal surveys found that DO in the Humber River was consistently above the PWQO at every site at all times of day. Dissolved oxygen concentrations were higher below the wetland outlet, indicating that there was no oxygen demand from WRRF effluent on downstream DO. Diel variations in DO were approximately 2.5 mg/L in July, 4.3 mg/L in August, and 3.3 mg/L in September. Maximum daily concentrations in DO were frequently above 100% saturation both above and below the wetland outlet, indicating naturally supersaturated conditions in the River.

The Humber River is considered a Policy 1 receiver for dissolved oxygen, nitrate and ammonia based on their 75th percentile concentrations (25^{th} for DO). The river is also considered Policy 1 for TP, based on sampling completed in 2017 and 2018, as the 75th percentile concentration was 0.0165 mg/L during the summer, low flow, months.

Overall the constructed wetland at the WRRF outfall acted as a sink for phosphorus an occasional source for TSS and had little to no effect on TAN, nitrate and $cBOD_5$ concentrations.

3. Water Quality Modelling

Water quality modeling was undertaken to predict the effects of expanding the Nobleton WRRF on the water quality of the Humber River at the point of complete mixing (mass-balance) and in the far-field (QUAL2K). Near-field or "mixing zone" modelling was deemed to be unnecessary because preliminary modelling showed that the predictions made by CORMIX (the mixing zone model) did not reflect actual receiving water conditions at, and immediately downstream of the effluent discharge – the point of interest (Appendix C). HESL therefore recommended that CORMIX modelling not be used to predict the nearfield mixing zone. This was discussed and agreed upon by the project team and MECP (Personal communication, T. Belayneh, March 7, 2019).

The modelling proceeded in two stages:

1. Modelling of the existing WRRF discharge to predict the response of the river, and
2. Modelling of the expanded discharge to predict the response of the river, compare the response to currently permitted conditions and recommend effluent limits for the expansion.

3.1 Nobleton WRRF Effluent Quality

The existing effluent quality from the Nobleton WRRF was reviewed to establish modelling inputs for assessing the effects of the Nobleton WRRF on Humber River water quality. The facility became fully operational in 2014. A summary of the 2014-2017 average effluent quality and quantity sampled at the facility (by facility staff) is provided in Table 14.

Table 14. Nobleton WRRF Effluent Quantity and Quality (2014-2017).

Effluent Parameter	Limit	2014	2015	2016	2017
Flow (L/s)	33.9	10	11	13	16
$cBOD_5$ (mg/L)	10	<2	<2	<2	<2
TSS (mg/L)	10	2.67	3.66	2.95	6.68
TP (mg/L)	0.15	0.037	0.058	0.067	0.103
Ammonia +NH4 as N (mg/L)	1.0/3.0[a]	0.068	0.084	0.119	0.145
TKN (mg/L)	N/A	1.17	0.66	0.68	0.76
DO (mg/L)	N/A	5.46	4.32	4.45	4.07
Nitrate (Calculated) (mg/L)	N/A	24.14	22.36	26.50	22.14

Note: Data provided by Black & Veatch in December 2018. It was based on the LAB data provided to B&V from York Region (not WRRF/PLANT data). a – May 1- October 31 and November 1 to April 30 limits respectively.

Effluent flows from the facility showed a steady increasing trend; from 10 L/s in 2014 to 16 L/s in 2017. As of 2017the WRRF was operating at approximately 47% of its approved capacity. The annual average concentrations of all parameters were below their ECA limits (Table 14). The annual average concentrations of $cBOD_5$, TSS, TP, and ammonia increased between 2014-2017 and concentrations of TKN, DO, and NO_3 decreased, or varied from year to year.

It is clear that use of the current effluent loadings to recommend effluent limits is not advisable because a) the plant is not yet at capacity b) plant operational efficiency has not yet stabilized and c) effluent quality is decreasing as the plant discharge increases and it is challenging to predict how the plant will operate when it reaches capacity. Therefore, modelling of the river response at the permitted (ECA) limits and not at the existing plant operational status was selected as a more appropriate comparison to evaluate effects.

3.2 Mass Balance Modelling

A mass balance loading analysis was undertaken to predict the effect of WRRF on Humber River water quality after the expansion of the WRRF and assuming complete mixing of effluent with the river water.

Parameters modeled included the ECA regulated parameters total phosphorus, total suspended solids, and total ammonia. Chloride was also modeled to assess the effects of increased loadings on downstream water quality, in recognition of increasing concern regarding cumulative loadings of Cl to surface water from road salt runoff and water softener residuals in effluent streams.

Although pH and *E. coli* are regulated by the ECA, these parameters were not modeled as mass balance analysis is not recommended for these parameters. In these two cases, pH is more influenced by alkalinity reactions than by dilution, and *E. coli* are living organisms, and their numbers may increase or decrease in the receiving environment independent of dilution. The WRRF incorporates UV disinfection of the effluent prior to discharge to the Humber River.

Mass-balance modeling assumes instantaneous and complete mixing of the effluent with the receiver. The modeling does not account for uptake that would reduce phosphorus concentrations, or the removal of ammonia from nitrification. It does, however, provide a conservative calculation of fully mixed concentrations in the receiver. The mass balance model was completed using 7Q20 flows and 75th% upstream concentrations to represent the conservative assessment of the extreme response of the river to the WRRF discharge. Flows will be higher and background concentrations will be lower 99.5%[8] and 75% of the time respectively; therefore, resultant fully mixed concentrations would be lower over 99.5% of the time.

The current effluent limits and permitted ADF were used to represent existing conditions upon which the effects of future flows and effluent quality were compared. The WRRF is newly operational (2014), its effluent flows are still increasing as new homes are connected to the WRRF, and annual results showed that effluent quality has not yet stabilized. The existing conditions cannot, therefore, be considered a true representation of what the facility will be discharging once the influent flows have stabilized, and effluent processes optimized.

3.2.1 Methods

Existing Permitted Conditions - ADF of 2,925 m^3/d

The influence of the existing permitted (ECA) loads on the Humber River were modelled using the permitted effluent flow and limits. Existing loads from the WRRF were estimated by multiplying the effluent limits of 10 mg/L for TSS and $cBOD_5$, 0.15 mg/L for TP, and 1 mg/L for TAN by the ADF of 2,925 m^3/d or 33.9 L/s. Effluent loads were also calculated for the TP objective of 0.1 mg/L. For chloride the 75th percentile concentration measured in the effluent at the wetland outlet (431 mg/L – Table B2) was used.

The upstream, background loads in the Humber River were estimated by multiplying the 75th percentile concentrations by the 7Q20 flow for the Humber River. The 7Q20 flow of 510 L/s (0.510 m^3/s) was calculated for the Humber River at the wetland outfall (Section 2.2). This value was reduced by 10%, to 459 L/s (0.459 m^3/s), to account for the uncertainty associated with climate change effects[9].

The WRRF loads were added to the background loads calculated for the Humber River to predict downstream loads and water quality under the existing rated Capacity.

Future Conditions – ADF of 3,996 m^3/d

The influence of the future loads from the WRRF on the Humber River was modelled using proposed effluent flows and limits.

The Humber River at the Nobleton WRRF is considered a Policy 1 receiver for TP, dissolved oxygen, nitrate and ammonia (Section 2.5), in the 75th percentile concentrations are below the PWQOs or CWQGs. It is

[8] Pyrce, R.S., 2004. Considering baseflow as a low flow or instream flow. WSC Report No.04-2004 Appendix, Watershed Science Centre, Peterborough, Ontario, 17 p

[9] The 10% reduction accounts for the fact that with climate change the frequency and duration of rainfall will differ from current conditions (i.e. longer hot and dry periods in the summer). Low flow statistics (i.e. 7Q20) are based on historical flow data and therefore cannot account these future changes. A 10% reduction in the 7Q20 value accounts for the uncertainty associated with changes to due climate change.

MECP's policy that in areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives. Water quality decreases downstream at Old Mill Road, and the Humber River is Policy 2 for TP (Section 1.2), in that TP concentrations are above the PWQO. All other parameters (dissolved oxygen, nitrate and ammonia) are Policy 1 at Old Mill Road (Section 1.2). It is MECP's policy that water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives. Therefore, since downstream water quality is above the PWQO, current water quality should be maintained to ensure that downstream water quality does not degrade further.

York Region would like to increase the ADF from the WRRF to 3,996 m^3/d, an increase of 1,071 m^3/d or 37%, while maintaining the existing treatment technologies (i.e. sand filters). Future loads from the WRRF were estimated by multiplying the current effluent limits for TSS TAN, and TP by the proposed ADF of 3,996 m^3/d or 46.3 L/s. The current effluent objective of 0.10 mg/L was also modelled for TP[10].

Future WRRF loads were added to upstream background loads to determine the effect on downstream concentrations (Table 15).

3.2.2 Results

The 7Q20 flow of 459 L/s (0.459 m^3/s; including 10% reduction for climate change) provides 13.5- and 9.9-times dilution of the effluent under existing and future WRRF conditions respectively. Flows, and hence effluent dilution will be higher 99.5% of the time.

Modelling results for existing permitted conditions show that under 7Q20 conditions, concentrations of TP, TSS, and TAN are predicted to increase downstream of the WRRF but remain below their respective PWQOs and CWQG (Table 15). Downstream TP will increase to 0.026 mg/L under this scenario

Table 15. Humber River Mass Balance Modelling Results – Existing Permitted Conditions.

	Humber River Upstream			Effluent			Humber River Downstream			Change from Upstream
	75th Conc	7Q20	Load	Conc	Flow	Load	Load	Flow	Conc	
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L
TP – limit	0.0165	459	8	0.15	33.9	5.1	12.7	492.9	0.026	0.009
TP – objective	0.0165	459	8	0.10	33.9	3.4	11.0	492.9	0.022	0.006
TSS	6.7	459	3075	10	33.9	339	3414	492.9	6.9	0.2
TAN	0.085	459	39	1.00	33.9	33.9	73	492.9	0.148	0.063
Chloride	53	459	24327	431	33.9	14611	38938	492.9	79	26

[10] *Example mass balance modelling at effluent concentrations of 10 mg/L TSS, 1.0 mg/L TAN and 0.10, 0.12 and 0.15 mg/L TP were used to facilitate discussion with MECP (Appendix C). These were not the final effluent limits recommended by the project time.*

The modelling results for future conditions (Table 16) were compared to the downstream existing permitted conditions scenario (Table 15) to predict changes to downstream water quality from the expanded Nobleton WRRF.

- At the current effluent TP limit of 0.15 mg/L, expansion will increase the downstream TP by 0.003 mg/L, to 0.029 mg/L (Table 16) from the concentration of 0.026 mg/L under current limits (Table 15). The river will remain just below the PWQO of 0.03 mg/L, leaving little capacity for downstream dischargers.
- At an effluent TP limit of 0.10 mg/L (the current objective), expansion will increase the downstream TP concentrations from the existing permitted downstream concentrations of 0.022 mg/L (Table 15) by 0.002 mg/L, to 0.024 mg/L (Table 16). Concentrations will remain well below the PWQO of 0.03 mg/L, and therefore provide additional capacity for downstream discharges.
- Figure 22 compares the river response to the PWQO to show the downstream assimilative capacity available after the proposed expansion for a range of effluent TP limits.

Table 16. Humber River Mass Balance Modelling Results – Future Conditions.

	Humber River Upstream			Effluent			Humber River Downstream			Change from Existing Permitted[1]
	75^{th} Conc	7Q20	Load	Conc	Flow	Load	Load	Flow	Conc	
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L
TP – current limit	0.0165	459	8	0.15	46.3	6.9	15	505.3	0.029	0.003
TP – current objective	0.0165	459	8	0.10	46.3	4.6	12	505.3	0.024	0.002
TSS	6.7	459	3075	10	46.3	463	3538	505.3	7.0	0.1
TAN	0.085	459	39	1.00	46.3	46.3	85	505.3	0.169	0.021
Chloride	53	459	24327	431	46.3	19955	44282	505.3	88	9

Note: 1 – change from downstream concentrations predicted in Table 15

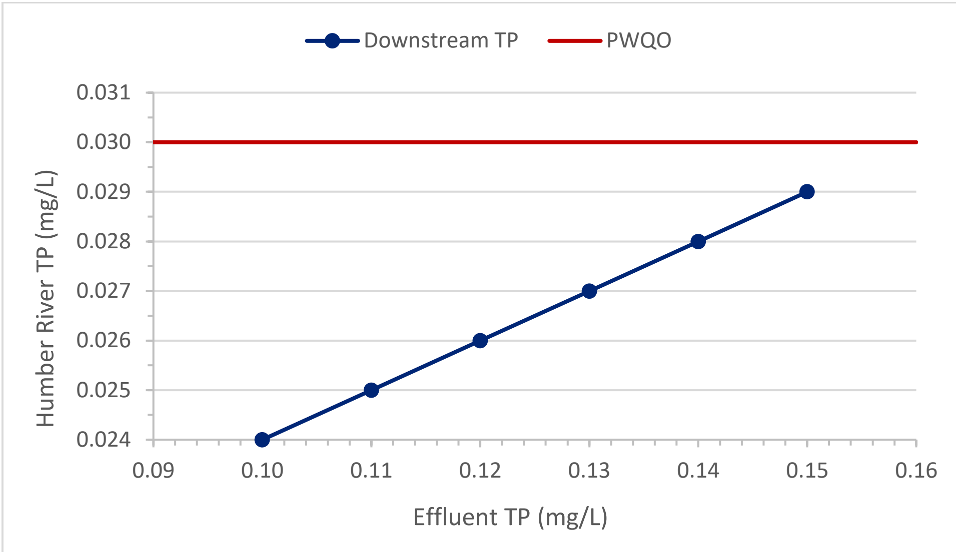


Figure 22. Downstream TP at effluent TP concentrations ranging from 0.10 to 0.15 mg/L (effluent flow = 46.3 L/s).

TSS concentrations are predicted to increase by 0.1 mg/L from existing downstream concentrations under permitted conditions (Table 15). There will be no discernable change in TSS concentration downstream of the WRRF.

Downstream TAN concentrations are predicted to increase by 0.021 mg-N/L from existing permitted conditions (Table 15) to 0.169 mg-N/L (Table 16). This TAN concentration equates to an un-ionized ammonia concentration of 0.0116 mg/L-N, below the PWQO of 0.0164 mg-N/L at a 75th percentile pH of 8.35 (Table B1) and 75th percentile summer water temperature of 20.24°C (Table 9) measured at the 10 m and 30 m downstream water quality stations respectively[11].

Chloride concentrations are predicted to increase by 9 mg/L from existing permitted conditions of 79 mg/L (Table 15) to 88 mg/L (Table 16) but will remain well below the CWQG of 120 mg/L for long-term exposure under 7Q20 flow conditions.

These results show that expanding the WRRF facility using current effluent limits will increase the concentration of TP, TAN, TSS, and chloride downstream under 7Q20 flow conditions, but concentrations will remain below their respective PWQOs or CWQG, maintaining the policy status of the river. It should be noted, however, that these predictions do not consider the influence of the wetland on effluent concentrations.

3.3 Far-Field Modelling

Modelling of far-field water quality (i.e. beyond the point at which the effluent is fully mixed in the receiver) was necessary to estimate concentrations of those parameters (i.e. dissolved oxygen, total phosphorus,

[11] *30m downstream station was used as QUAL2K modelling found that peak TAN concentration occurred within first 30 m of discharge*

nitrate and ammonia) that are influenced by uptake and transformation through the various reactions within a river system. The QUAL2K model was used to predict far-field water quality of these parameters in the Humber River under current conditions and under the expanded ADF of 3,996 m^3/d.

QUAL2K is a one-dimensional (1-D) river and stream water quality model, supported by the United States Environmental Protection Agency (US EPA), which is typically used to assess the environmental impact of pollution discharges along rivers. It accounts for assimilative as well as mixing processes. A wide range of water quality parameters and chemical and biological pollutants within the river can be modelled, including temperature, pH, DO, $CBOD_5$, nitrogen species, phosphorus species, and suspended solids.

Since QUAL2K is a 1-D model, the model assumes that all point source inputs (such as the outfall from the WRRF) are instantaneously mixed laterally and vertically at each point in the river. Variation in each water quality parameter modelled occurs only longitudinally (in the x-direction along the length of the river) and is computed as water is transported out of each reach and into the next.

The QUAL2K model requires river characterization (physical and biological) and a dye tracer study to determine time of travel in addition to the background water quality and flow information collected as part of the study. The QUAL2K model requires spatial segmentation of the river into a series of reaches, which are sections of similar hydrogeometric characteristics, (i.e., depth, cross sectional area, bank slopes, channel slopes, average velocity and average flow), channel pattern, bed materials, bank composition, and influence of riparian and in-stream vegetation on flow. As such, a stream survey and dye study were conducted as part of the ACS as input into the QUAL2K modelling.

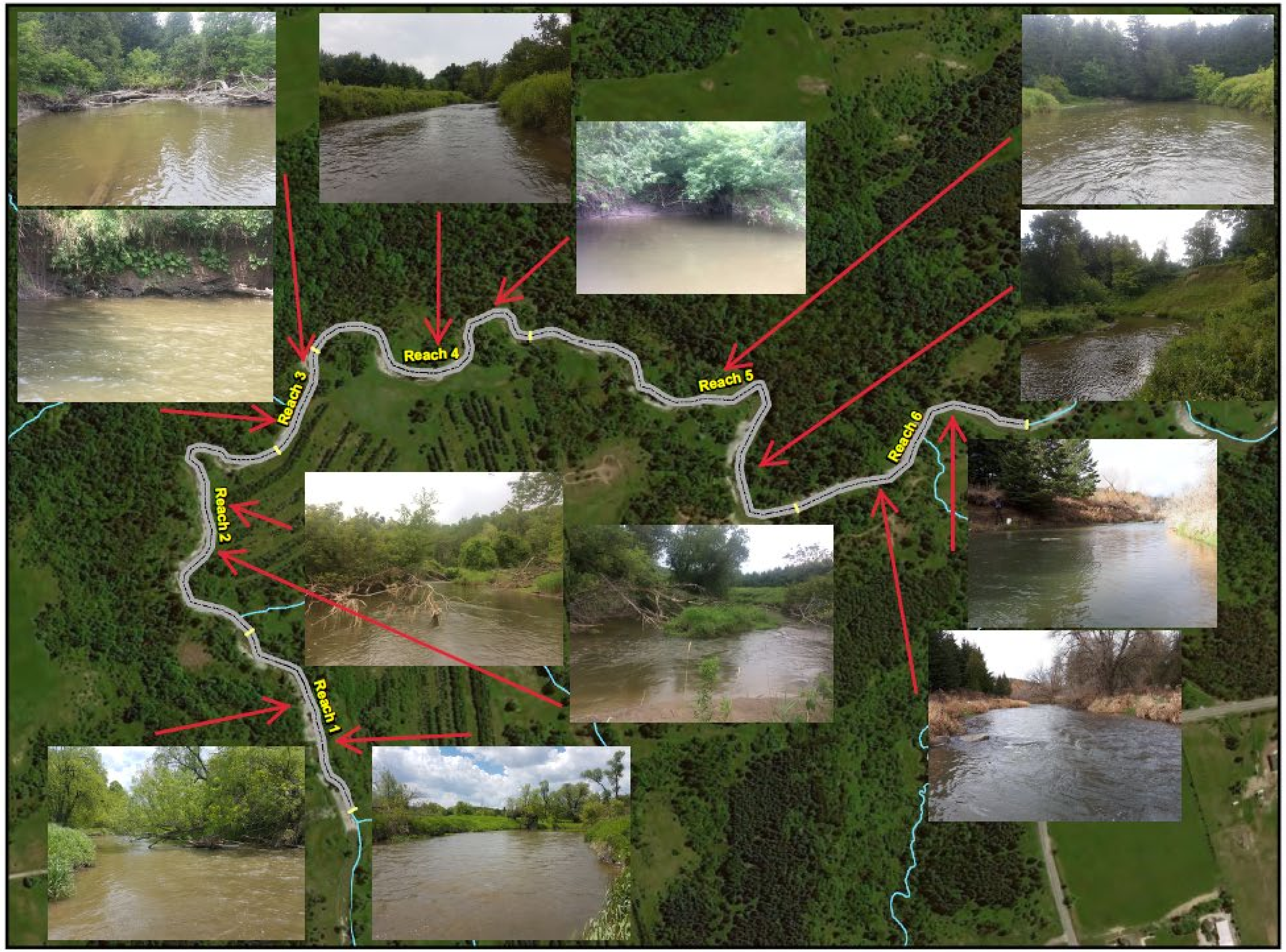
3.3.1 Stream Survey

Methods

On August 1, 2017 a detailed field reconnaissance of the Humber River extending approximately 50 m upstream to 1.7 km downstream of the WRRF outfall was carried out by HESL scientists (Figure 23). The purpose of the reconnaissance was to develop a better understanding of the proposed receiving environment, identify potential influences on water quality and the assimilation process, and to define and characterize distinct sections (also known as reaches) of the river for the purpose of informing the 1-dimensional river model, QUAL2K.

HESL scientists surveyed the longitudinal slope of the river and the left and right bank slopes at eight locations within the study area. In addition, the field reconnaissance made note of any of the following items:

- Substrate type,
- In-stream vegetation (macrophyte and periphyton growth),
- Riparian vegetation,
- Large woody debris,
- Tree canopy and percent of shading,
- inputs or modifiers that may affect assimilation such as tile drains, impoundments, and tributaries, and
- human contact points.



0 50 100 200 300
Meters

Figure 23

Project: Class Environmental Assessment for Water and Wastewater Servicing in the Community of Nobleton

Project #: J170008

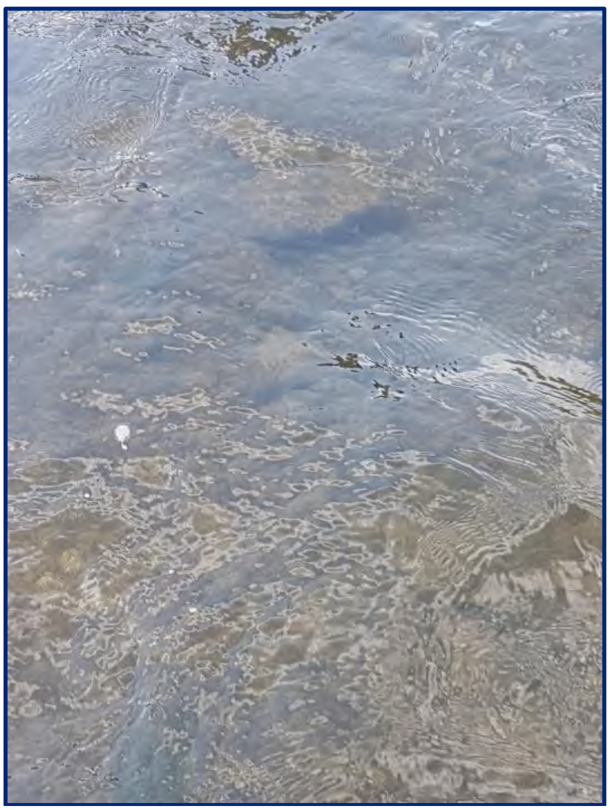
Project Lead: Deborah Sinclair
Prepared by: Kris Hadley
Data Source: HESL,ESRI Imagery
Coordinate System: NAD 1983 UTM Zone 17N

Hutchinson
Environmental Sciences Ltd.

Results

A detailed figure showing the river characteristics, distinguishing features such as woody debris, tributary inputs, man-made dams, and the locations of reach breaks (for QUAL2K modelling) was created (Figure 22). The study area of the Humber River exhibits an irregular meander pattern. The river has a relatively moderate trapezoidal cross-section with steep banks and a bankfull width between approximately 10 m and 15 m within the study area.

In shallow sections, water clarity was good, with the river bottom visible. In deeper sections, water was turbid, obscuring substrates. The substrate of the Humber River in the study area was characterized cobble, gravel, sand and rocks (Photograph 1). The substrate characteristics varied with stream morphology (e.g. riffle, run and pool), with gravel and cobble the dominant substrate within the riffles and sand the dominant substrate in the pools. Periphyton was noted on rocks and cobbles, and macrophyte growth was not present in any abundance throughout the study area.



Photograph 1. Gravel and cobble substrates in Reach 1.

The banks are comprised of silts and sands, with some gravels, and showed evidence of active erosion and slumping (Photograph 2). Riparian vegetation included grasses, shrubs and trees (Photograph 3). Uplands consist of forested areas and agricultural areas transitioning to naturalized areas (Figure 22), providing some shading of the watercourse.

Photograph 2. Sandy clay banks with evidence of erosion and slumping, Reach 3.

Photograph 3. Riparian vegetation along banks, Reach 2.

Large woody debris was present in the river and along the channel banks in many reaches (Photograph 4) and impeded flow in reaches 3 and 4 (Figure 23, Photograph 5). The woody debris is naturally occurring as the result of a dynamic system.

Photograph 4. Large woody debris deflecting flow in Reach 1.

Photograph 5. Large woody debris in Reach 4 obstructing flow.

Several small intermittent watercourses are present in study area (Figure 22), however during low flow conditions they were dry and were observed to flow only after significant precipitation (i.e. August 1, 2017). Tile drains or man-made dams were not observed in the study area.

The study area is located within the Toronto and Region Conservation (TRCA) owned Nashville Conservation Reserve (NCR). There is a public trail system located downstream of the study area off Kirby Road and Huntington Road, however un-assumed walking trails are also present throughout the NCR including the Humber River near Concession 11.

3.3.2 Dye Study

Methods

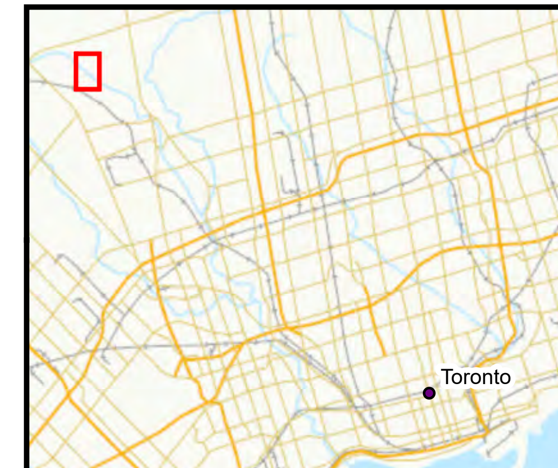
Tracer testing was conducted on August 30, 2017. Data gathered during the tracer tests were used to calculate time of travel, velocity, and longitudinal dispersion for use in the far-field 1-dimensional river model (QUAL2K) of the Humber River and to provide a one-time calibration of the model using the flow and velocity conditions on that date.

Rhodamine WT dye, a fluorescent xanthene dye that is pink in colour, was used as the tracer for the study. Rhodamine WT dye was chosen because it is a stable, non-toxic, and chemically non-reactive dye that is easily measured in the field. The substance is non-carcinogenic and is safe if it contacts skin. Rhodamine WT dye tracers are also very robust over a variety of different flow regimes.

Fluorometers (YSI 600 OMS instruments equipped with Rhodamine WT optical sensors) were placed in the Humber River at four locations downstream of the tracer injection site, as follows:

- Fluorometer 1 at 380 m downstream of the injection point;
- Fluorometer 2 at 876 m downstream of the injection point;
- Fluorometer 3 at 1,218 m downstream of the injection point; and
- Fluorometer 4 at 1,760 m downstream of the injection point (Figure 24).

The fluorometers were equipped with an optical sensor to determine the concentration of Rhodamine WT in the water, in units of µg/L (ppb), and were set up to collect one measurement every 10 seconds for the duration of the test. The fluorometers were capable of measuring concentrations of Rhodamine WT with a resolution of 0.1 ppb. The sensors were calibrated in the field on a 2-point scale that included 0 ppb and 100 ppb Rhodamine WT. The 100-ppb solution was mixed in the field from a 20% Rhodamine WT dye solution, which was obtained from a national supplier (Hoskins Environmental).



Wetland Outlet
Fluorometer Locations
Injection Point
River Reaches
Watercourse

0 25 50 100 150 Meters

Figure 24:
Fluorometer Locations

Project Lead: Deborah Sinclair
Prepared by: Kris Hadley
Data Source: HESL,ESRI Imagery
Coordinate System: NAD 1983 UTM Zone 17N

Hutchinson Environmental Sciences Ltd.

To begin the slug injection tracer test, a 136 mL of Rhodamine WT 20% dye solution was mixed into a bucket containing 10 L of water collected from the Humber River. The volume of dye was estimated by applying the following empirical equation by Kilpatrick (1989):

Equation (1)

$$V_s = 3.79 \times 10^{-5} \frac{QL}{v} C_p$$

where Vs is the volume of Rhodamine WT 20% dye, in mL;

Q is the flow rate of the Humber River, in ft^3/s;

L is the length of the measurement reach, in ft;

v is the mean-stream velocity, in ft/s; and

Cp is the peak concentration at the sampling site, in µg/L.

Equation 1 was used to determine the amount of Rhodamine WT 20% dye needed, such that the peak tracer concentration detected at the furthest fluorometer (about 1.7 km downstream) would be detectable by the fluorometer. The 10L bucket containing the Rhodamine WT 20% mixture was then quickly emptied across the width of the river to simulate an instantaneous injection. The time of the injection was recorded (13:28 hrs).

Photographs 6 and 7 show the instantaneous injection, Photograph 8 shows the Humber River looking downstream approximately 20 seconds after injection, and Photograph 9 shows the Humber River three minutes after the instantaneous injection.

Photograph 6. Instantaneous injection of Rhodamine dye in the Humber River.

Photograph 7. Humber River immediately following dye injection fully mixed across the river.

Photograph 8. Humber River approximately 20 seconds after dye injection.

Photograph 9. Humber River 80 m downstream of injection point (looking upstream), three minutes after dye injection.

The measured Rhodamine WT concentrations versus time were graphed for each of the fluorometer stations, with the time axis, (the x-axis), beginning at the recorded time of the slug injection, as illustrated in the following theoretical example (Figure 25).

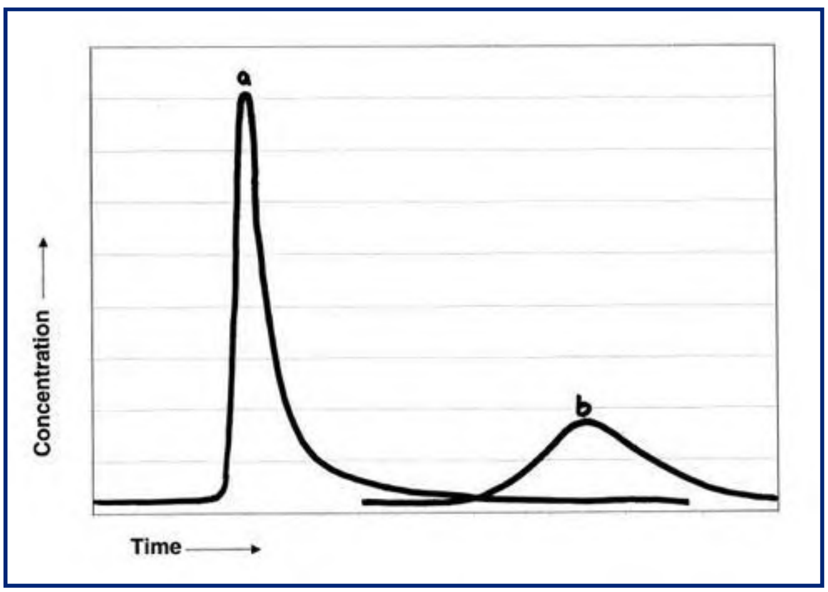


Figure 25. Example Graph of Rhodamine WT Concentration Versus Time for a Slug Injection Test.

Figure 25 shows that the fluorometer closest to the injection point (i.e., line a in the figure) would exhibit a tracer peak that was higher and seen sooner than the peak at the other fluorometer station located further downstream (i.e., line b in the figure). The time of travel and longitudinal dispersion were computed by comparing the peak Rhodamine WT concentrations and the time between the slug injection and the peak.

The travel time (¯) between the dye injection point and a given fluorometer station was calculated by the following equation:

$$\bar{t} = \frac{\sum_{i=0}^{n-1}(c_i t_i + c_{i+1} t_{i+1})(t_{i+1} - t_i)}{\sum_{i=0}^{n-1}(c_i + c_{i+1})(t_{i+1} - t_i)} \qquad \text{Equation (2)}$$

where ci is the Rhodamine WT concentration at a given time, in µg/L;

it is the corresponding time, in minutes elapsed since the time of injection; and

n is the number of data points collected by the fluorometer.

The temporal variance ( ) was calculated from the data collected at each fluorometer by the following equation:

$$s_t^2 = \frac{\sum_{i=0}^{n-1}(c_i t_i^2 + c_{i+1} t_{i+1}^2)(t_{i+1} - t_i)}{\sum_{i=0}^{n-1}(c_i + c_{i+1})(t_{i+1} - t_i)} \qquad \text{Equation (3)}$$

The mean velocity (U) between two fluorometer stations was calculated by the following equation:

$$U = \frac{x_2 - x_1}{\overline{t_2} - \overline{t_1}} \qquad \text{Equation (4)}$$

where x is the distance between the dye injection point and the fluorometer, in m.

The longitudinal dispersion coefficient (E) between two stations was calculated by:

$$E = \frac{U^2 (s_{t2}^2 - s_{t1}^2)}{2(\overline{t_2} - \overline{t_1})} \qquad \text{Equation (5)}$$

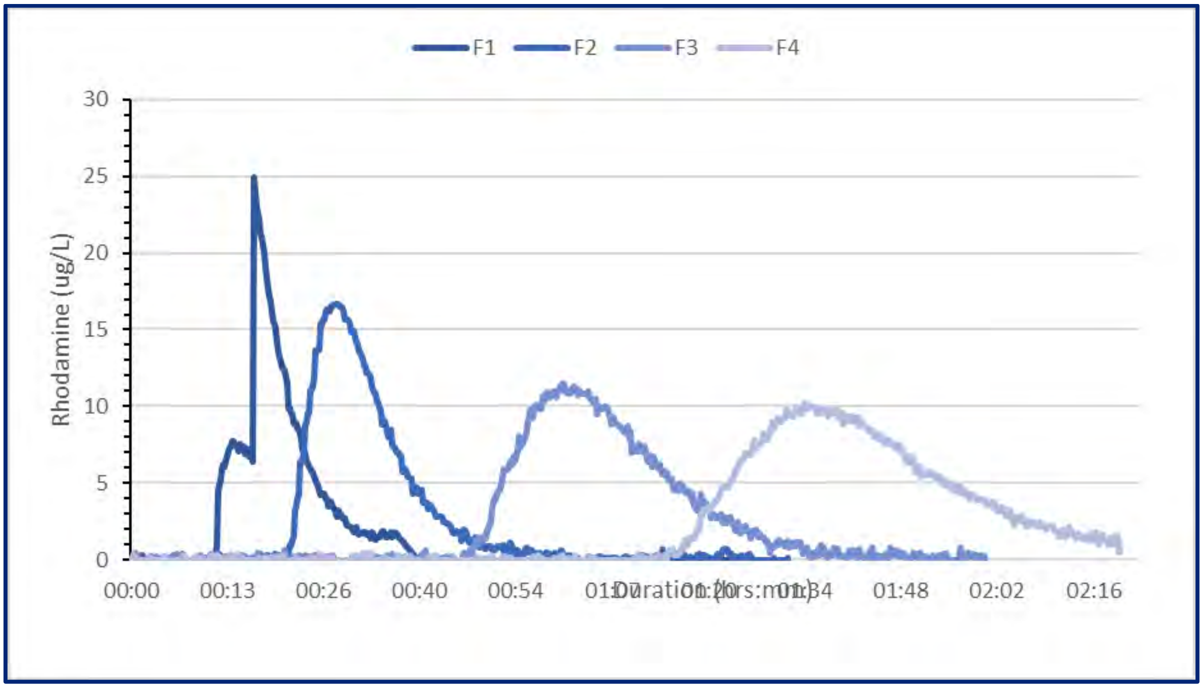
The calculated times of travel, mean velocities, and dispersion coefficient values between each of the five fluorometer locations were input into the QUAL2K model for the Humber River.

Results

Figure 26 presents the Rhodamine WT concentration over time, as recorded at each of the fluorometer stations during the slug injection tracer test.

$\bar{t}$ s_t^2

Figure 26 Humber River Slug Injection Test Results, August 30, 2018.



The data obtained from the slug injection tests showed that dye dispersion in Humber River behaved in the expected manner (as per Figure 25) and could therefore be used to determine the time of travel between the dye injection point and each fluorometer station. Data are presented as total travel time (in minutes, Table 17), average velocity (in m/s) between each fluorometer station (Table 18), and longitudinal dispersion (in m^2/min) between each fluorometer station (Table 19).

Table 17. Travel Time (min) Between Injection Point and Fluorometer Stations.

Fluorometer	Distance (m) from Injection	Time of Travel
1	380	31
2	876	46
3	1,218	77
4	1,760	102

Table 18. Humber River Velocity (m/s) between Fluorometer Stations.

Upstream Fluorometer	Downstream Fluorometer			
	Fluorometer 1	Fluorometer 2	Fluorometer 3	Fluorometer 4
Fluorometer 1	x	0.552	0.302	0.323
Fluorometer 2	x	x	0.182	0.262
Fluorometer 3	x	x	x	0.361

**Table should be read as the velocity between the upstream fluorometer (list in 1st column) and the next fluorometer of interest, by reading along the appropriate row.*

Table 19. Humber River Longitudinal Dispersion (m^2/min) between Fluorometer Stations.

Upstream Fluorometer	Downstream Fluorometer			
	Fluorometer 1	Fluorometer 2	Fluorometer 3	Fluorometer 4
Fluorometer 1	x	667	316	406
Fluorometer 2	x	x	135	298
Fluorometer 3	x	x	x	615

**Table should be read as the dispersion between the upstream fluorometer (list in 1st column) and the next fluorometer of interest, by reading along the appropriate row.*

The average Humber River velocity for the August 30, 2017 slug injection test was calculated as 0.323 m/s (velocity between fluorometer 1 and 4,Table 18). The data also show that the river moves most quickly within the first 350 m downstream of the discharge, and most slowly between 876 and 1,218 m downstream. Velocity between fluorometer 3 and 4 was similar to that between 1 and 3, and 1 and 4.

3.3.3 QUAL2K Model Calibration and Validation

Upstream Humber River water quality was combined with effluent quality from August 1 and August 29, 2017 were used to calibrate (Aug.1) and validate (Aug, 29) the QUAL2K model. These dates were chosen because flows are typically low and water temperatures typically high in August; therefore, these conditions were the most representative of 7Q20 conditions (used in ACS predictions) during our sampling program.

The parameters DO, TAN, nitrate, and TP were used to calibrate and validate the fit of the modelled values to measured values in the Humber River.

$CBOD_5$ concentrations were near or below the laboratory's method detection limit (MDL) at the upstream and far-field (1.7 km downstream) stations in the Humber River during both the August 1 and August 29 event, and so were not used in model calibration/validation. Further, TAN concentrations were below the MDL at the upstream and far-field stations during the August 29 (used for model validation) monitoring event.

The input parameters for the QUAL2K model calibration and validation are summarized in Table 20 and detailed in Appendix D.

Table 20. QUAL2K Calibration and Validation Inputs.

Variable	Units	Calibration Data – August 1, 2017	Validation Data – August 29, 2017
Headwater Characteristics – Humber River Upstream			
Flow	m^3/s	1.97	1.308
Water temperature	°C	19.91	19.11
pH	s.u.	8.33	8.41
Conductivity	µS/cm	510	519
Inorganic Suspended Solids (ISS)	mg/L	3.6	0
Dissolved oxygen	mg/L	12.84	12.35
BOD slow	mg/L	2.2	2.1
BOD fast	mg/L	<2	<2
Organic N	µg/L	324	130
TKN	µg/L	360	150
TAN	µg/L	36	<20
Nitrate-N	µg/L	160	137
Organic P	µg/L	9.5	9.9
Inorganic P	µg/L	7.3	<3
TP	µg/L	16.8	12.9
Chlorophyll a	µg/L	2.57	1.38
VSS	mg/L	<3	<3
Alkalinity	mg/L	223	227
TSS	mg/L	6.6	2.5
WRRF Effluent Characteristics (measured at wetland outlet)			
Flow	m^3/s	0.012	0.005
Water temperature	°C	18.99	18.87
pH	s.u.	7.43	7.85
Dissolved oxygen	mg/L	8.72	7.87
Conductivity	µS/cm	1644	1717
Nitrate-N	µg/L	16600	22300
Nitrite - N	µg/L	<50	<50
Nitrate + Nitrite-N	µg/L	16600	22300
TAN	µg/L	56	75
TKN	µg/L	1260	820

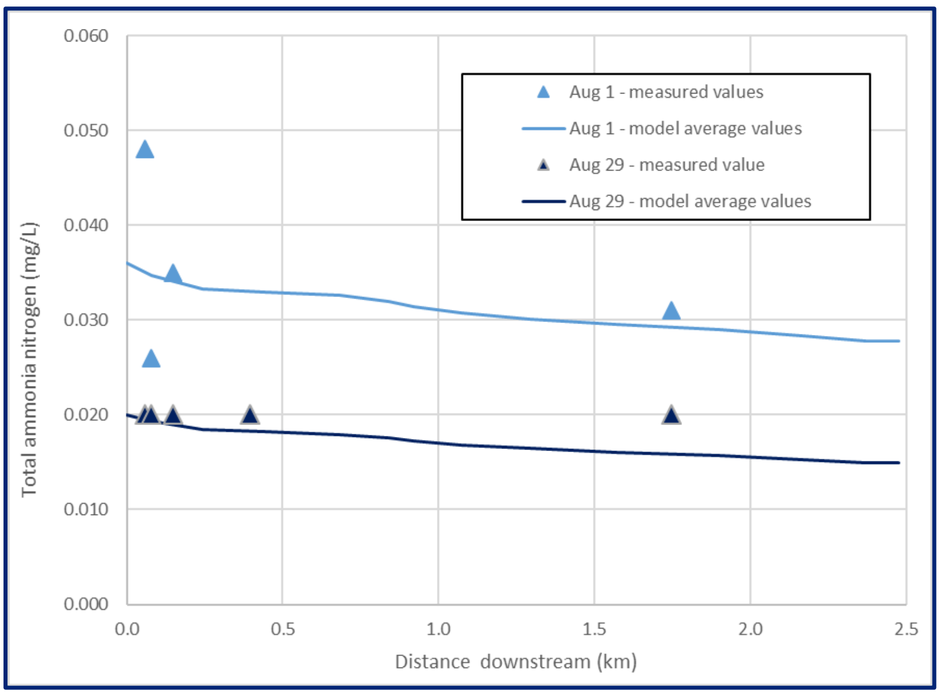
Variable	Units	Calibration Data – August 1, 2017	Validation Data – August 29, 2017
Organic N	µg/L	1204	745
TP	µg/L	59	45.6
Inorganic P	µg/L	16.2	13.1
Organic P	µg/L	42.8	32.5
TSS	mg/L	8.4	9.2
VSS	mg/L	<3	<3
ISS	mg/L	5.4	6.2
cBOD fast ($cBOD_5$)	mg/L	<2	<2
cBOD slow ($cBOD_{20}$)	mg/L	3.7	<2
Chlorophyll a	µg/L	2.61	2.61
Alkalinity	mg/L	201	185
Receiver Characteristics			
Manning's n[1]		0.035	
Bottom Algae Coverage[2]	%	40%	
Channel slope[2]		0.0005 – 0.0044	
Bank slope[2]		0.510 – 1.35	
Air and Dew Point Temperature[3]	°C		
Wind speed[3]	m/s		
Cloud cover[2]	%	20	
Shade[2]	%	50	
Model Parameters	***Value***	***Rationale***	
$cBOD_5$ oxidation rate	0.05/d	Near low end of range (0-10/d). Based on calibration and validation.	
Organic nitrogen - hydrolysis	0.1/d	Conservative estimate. Low end of range (0 to 5/d). Based on calibration and validation.	
Nitrification rate	5/d	Moderate value, midpoint of range (0-10/d). Based on calibration and validation.	
Denitrification	0.1/d	Low end of range (0 to 2/d). Based on calibration and validation.	
Organic P – settling rate	1/d	Low end of range (0 – 15/d). Based on calibration and validation.	
Inorganic P – settling rate	1/d	Mid-point of range (0-2/d). Based on calibration and validation.	
Reaeration Model	O'Connor Dobbins	Based on calibration and validation.	

Notes: 1 – obtained from Palmer Environmental Consulting Group, 2017, 2 –field measurements obtained during the August 1, 2017 stream survey, 3 - Hourly data from Environment Canada's Climate Data records for August 1 and 29, 2017.

The accuracy of the QUAL2K model calibration and validation are presented graphically in Figures 27 to 31 for TAN, nitrate, TP and DO. Concentrations measured at both the near field (10 to 350 m downstream) and far-field (1.7 km downstream) stations on August 1 and 29 are plotted against predicted concentrations. QUAL2K is used to predict water quality in the far-field after complete mixing, therefore the far-field station results are key calibration and validation values. Water quality measured at the near-field stations provides additional assurance that the model is accurately predicting receiving water concentrations.

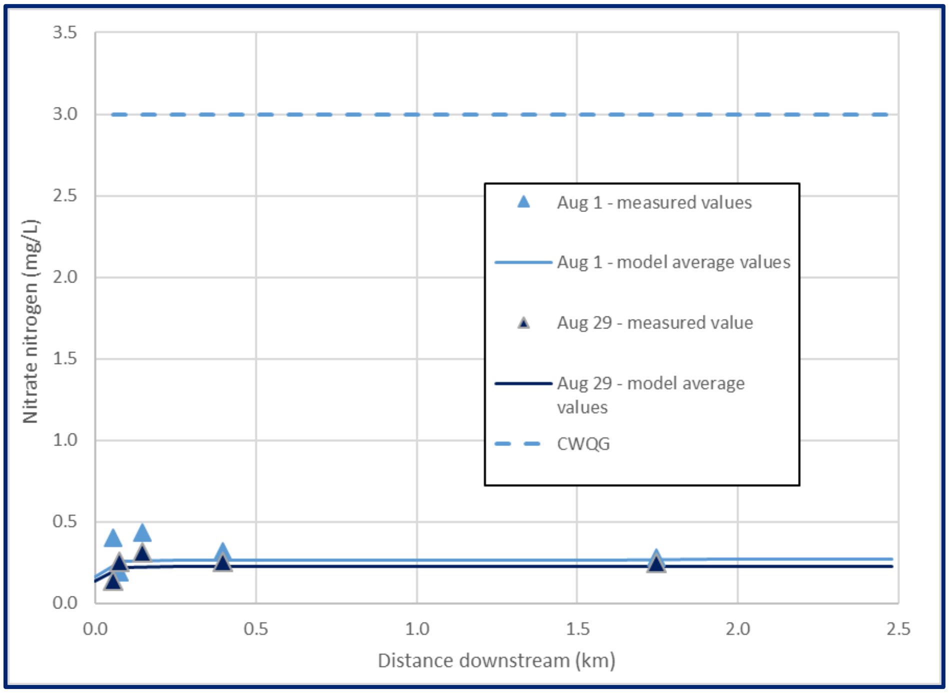
On August 1, the near-field ammonia concentrations were slightly over and underestimated at the 10 and 35 m downstream station respectively. The ammonia concentration decreased from 0.048 mg/L to 0.026 mg/L between 10 m and 30 m downstream, then increased to 0.035 mg/L 100 m downstream. The measured 1.7 km downstream concentration of 0.031 mg/L agreed well with the predicted concentration of 0.029 mg/L. The August 29 near-field measurements agreed well with predicted values. The model predicted a far-field concentration of 0.017 mg/L for the August 29 sampling event. This concentration is reasonable given that the measured far-field ammonia concentration was below the analytical detection limit (<0.02 mg/L). Overall, the measured and model-predicted far-field values for TAN were in good agreement for both the QUAL2K model calibration and validation (Figure 27).

Figure 27. QUAL2K Total Ammonia Nitrogen Calibration and Validation Results.



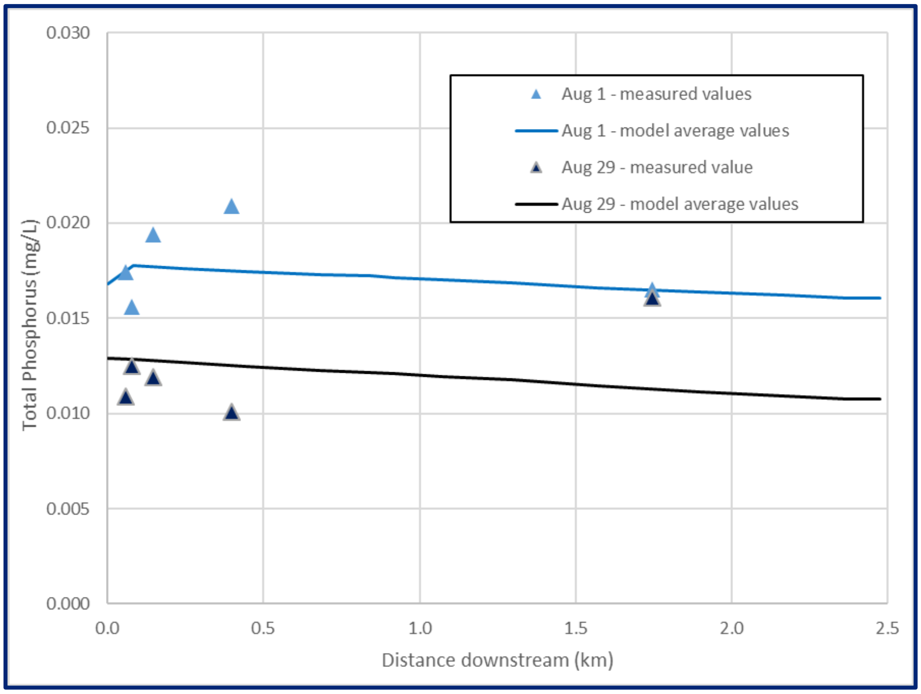
The measured and model-predicted values for nitrate were in good agreement for both the QUAL2K model calibration and validation (Figure 28).

Figure 28. QUAL2K Nitrate-N Calibration and Validation Results.



The model accurately predicted far-field concentration of 0.0165 mg/L TP for the August 1 sampling event, but under predicted the far-field concentration for August 29 (Figure 29). With an upstream flow and TP concentration of 1.3 m3/s and 0.0129 mg/L, an effluent flow and TP concentration of 0.005 m3/s and 0.0456 mg/L, the maximum TP concentration at full mixing, assuming no other inputs, is 0.0131 mg/L. The measured far-field TP concentration was 0.0161 mg/L for the August 29 sampling event. The August 29 measured concentration, therefore, slightly overestimated the maximum potential TP concentration in the River by 0.003 mg/L. The predicted value of 0.0114 mg/L is within 20% of the mass-balance predicted value and is a reasonable estimate of downstream concentrations, as it would include settling and uptake.

Figure 29. QUAL2K TP Calibration and Validation Results.

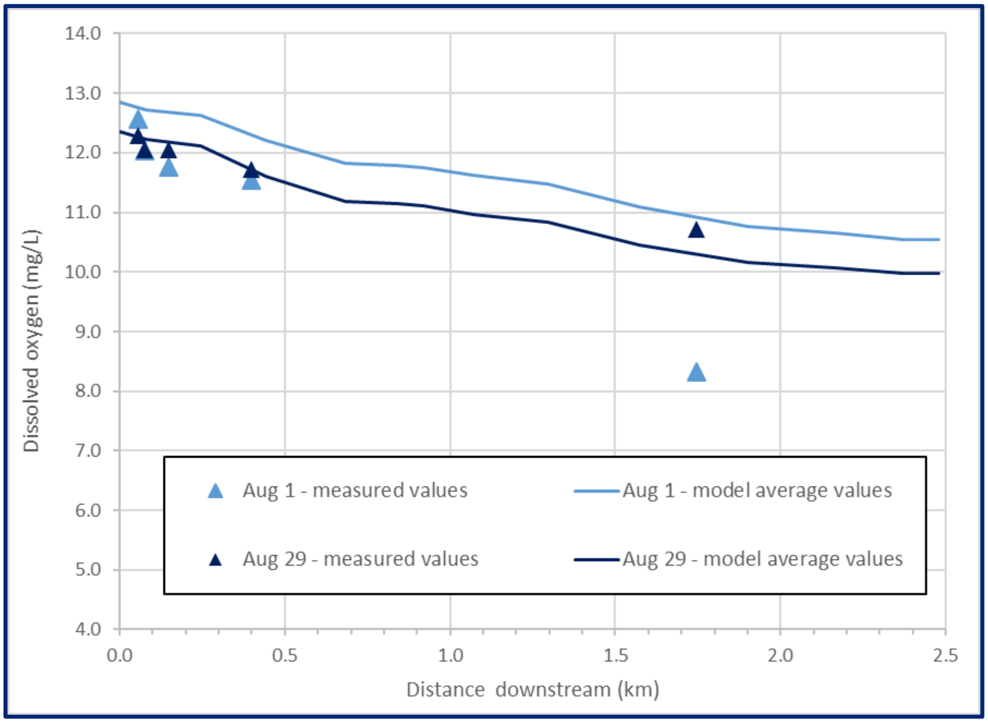


Within the first 500 m the field measurements and model-predicted DO values were in good agreement for the August 1 sampling event (Figure 30). Upstream DO concentrations were supersaturated (100% DO = 9 mg/L) and decreased with distance downstream towards saturation. The measured far-field dissolved oxygen concentration of 8.33 mg/L is approximately 2.5 mg/L less than the predicted DO concentration of 10.8 mg/L. QUAL2K contains seven different reaeration models to predict dissolved oxygen in the far-field, the O'Connor Dobbins model was found to best estimate dissolved oxygen concentrations in both the near-field and far-field. Other reaeration models were tested (e.g. Tsivoglou-Neal, Internal, Churchill) and did not improve agreement with the measured value for the August 1 sampling event.

The model-predicted DO values were in good agreement for the August 29 sampling event. The predicted far-field dissolved oxygen concentration was within 0.3 mg/L of the measured DO concentration. The measured far-field dissolved oxygen concentration on August 1 is likely erroneous. It is approximately 2.4 mg/L less than the August 29 concentration; however upstream background concentrations are similar and effluent oxygen demand was low on both events.

It should be noted that Figure 30 presents predicted daily average DO concentrations, while the measured concentrations are point-in-time measurements. DO data from the DO loggers found that DO varied by approximately 4 mg/L daily in August (Section 2.4.4). We therefore expect that the measured concentrations differ slightly from the model predicted average values.

Figure 30. QUAL2K DO Calibration and Validation Results.



The QUAL2K model calibrated and validated well for TP, nitrate, ammonia, and DO. The far-field measured DO concentration on August 1 did not agree well with the model predicted value, however, the measured DO concentration at this site, on this date is considered erroneous, as the model validated well with data for the August 29 sampling event. The model was deemed to be acceptable for use in predicting far-field water quality under a future ADF of 3,996 m3/s.

3.3.4 QUAL2K Future Scenario: ADF of 3,996 m^3/d

The QUAL2K model was used to predict far-field DO, total phosphorus, ammonia, and nitrate in the Humber River under the future ADF of 3,996 m^3/d.

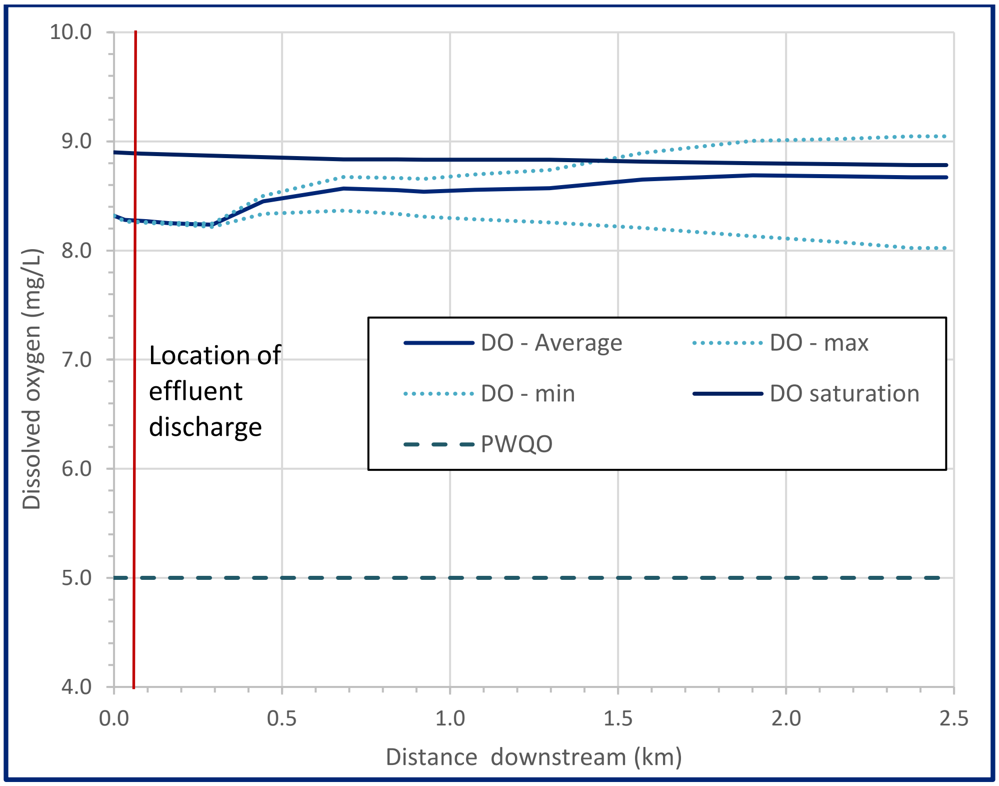
The far-field modelling was limited to the summer conditions since it is the most critical season due to low flows and increased water temperatures which result in maximum productivity, increased diurnal oxygen variation and increased speciation of ammonia to its toxic un-ionized form. Background water quality in the Humber River was characterized using 75th (25th for DO) percentile concentrations measured at the upstream station (Table 21) coupled with the 7Q20 flow of 459 L/s (Section 3.1). Proposed effluent limits of 10 mg/L for TSS and cBOD$_5$, 1 mg/L TAN, were used as inputs for effluent quality, with an effluent discharge of 0.0463 L/s (3,996 m^3/d). A limit of 0.15 mg/L TP was used as the highest effluent concentration that would maintain the river just below PWQO when fully mixed (0.029 mg/L; Table 16). The main input parameters are summarized in Table 21. Receiver characteristics and model rates were unchanged from the calibration and validation (and are presented in Table 20).

Table 21. QUAL2K Inputs for Future Scenario (ADF 3,996 m³/d).

Variable	Units	Value	Rationale
Headwater Characteristics – Humber River Upstream			
Flow	m^3/s	0.459	7Q20 value of 510 L/s reduced by 10% to account for climate change
Water temperature	°C	19.88	75th percentile of 2017 temperature logger data
pH	s.u.	8.41	75th percentile of 2017/2018 field measurements
Conductivity	µS/cm	521	75th percentile of 2017/2018 field measurements
Dissolved oxygen	mg/L	8.32	25th percentile DO logger data
BOD slow	mg/L	2.15	75th percentile of 2017 measurements
BOD fast	mg/L	2.00	75th percentile of 2017 measurements
TKN	µg/L	510	75th percentile of 2017 measurements
TAN	µg/L	85	75th percentile of 2017 measurements
Organic N	µg/L	425	TKN - TAN
Nitrate-N	µg/L	513	75th percentile of 2017 measurements
TP	µg/L	16.5	75th percentile of 2017/2018 measurements
Inorganic P (SRP)	µg/L	7.5	75th percentile of 2017 measurements
Organic P	µg/L	9.0	TP-Inorganic P
Chlorophyll a	µg/L	3.77	75th percentile of 2017 measurements
TSS	mg/L	10.6	75th percentile of 2017/2018 measurements
VSS	mg/L	4	75th percentile of 2017 measurements
ISS	mg/L	6.6	TSS-VSS
Alkalinity	mg/L	242.5	75th percentile of 2017 measurements
Phytoplankton	µg/L	3.77	75th percentile of 2017 measurements
WRRF Effluent Characteristics			
Flow	m^3/s	0.0463	Proposed ADF of 3,996 m^3/d
Water temperature	°C	19.85	75th percentile 2017 effluent logger temperature
pH	s.u.	8.28	75th percentile of 2017 measurements
Dissolved oxygen	mg/L	7.87	25th percentile of 2017 measurements
Conductivity	µS/cm	1659	75th percentile of 2017 measurements
Nitrate-N	µg/L	22,000	75th Percentile 2017 effluent concentrations (Section 3.1)
TAN	µg/L	1,000	Proposed limit
TP	µg/L	150	Maximum TP limit
TSS	mg/L	10	Proposed limit
cBOD	mg/L	10	Proposed limit

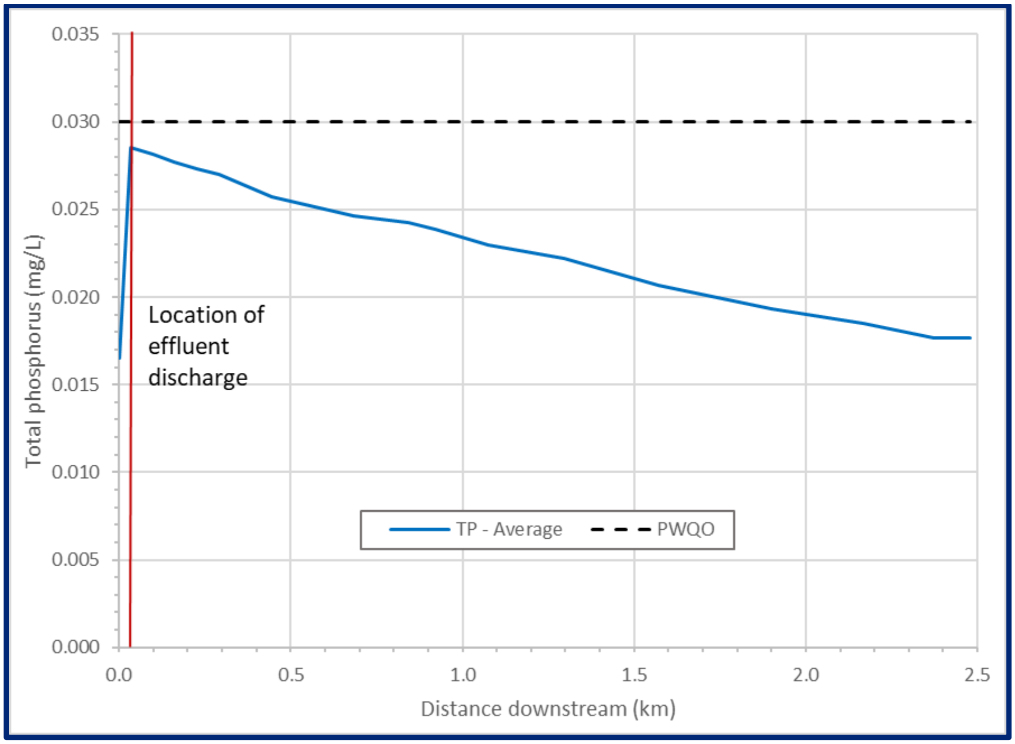
At an effluent flow of 3,996 m^3/d and 7Q20 conditions in the receiver, DO concentrations were predicted to decrease by 0.08 mg/L from the upstream concentration of 8.32 mg/L to 8.24 mg/L (Figure 31), approximately 180 m downstream of the effluent discharge. DO concentrations were predicted to increase to 8.69 mg/L at the downstream end of the study area. The increase in dissolved oxygen throughout the study area is due to the turbulence and fast-moving water of the river. DO concentrations were predicted be well above the PWQO of 5 mg/L for cold water biota at water temperatures of 20°C to 25°C.

Figure 31. QUAL2K Predicted DO concentrations in the Humber River under Future Conditions.



At an effluent concentration of 0.15 mg/L, TP was predicted to increase from 0.0165 mg/L upstream to 0.029 mg/L downstream, at the point of effluent discharge (Figure 32). Concentrations were predicted to decrease from settling and uptake to a minimum concentration of 0.0177 mg/L at the end of the study area (Figure 32). TP concentrations were predicted to remain below the PWQO of 0.03 mg/L under 7Q20 conditions.

Figure 32. QUAL2K Predicted TP concentrations in the Humber River under Future Conditions.



At an effluent TAN concentration of 1 mg-N/L, TAN concentrations were predicted to increase to 0.1631 mg-N/L at the point of effluent discharge (Figure 33). After complete mixing and nitrification, concentrations were predicted to decrease to 0.0941 mg-N/L at the end of the study area. Un-ionized ammonia concentration were predicted to increase to a maximum concentration of 0.0143 mg-N/L and were well below the PWQO of 0.0164 mg-N/L (Figure 34) under 7Q20 conditions.

Figure 33. QUAL2K Predicted TAN concentrations in the Humber River under Future Conditions.

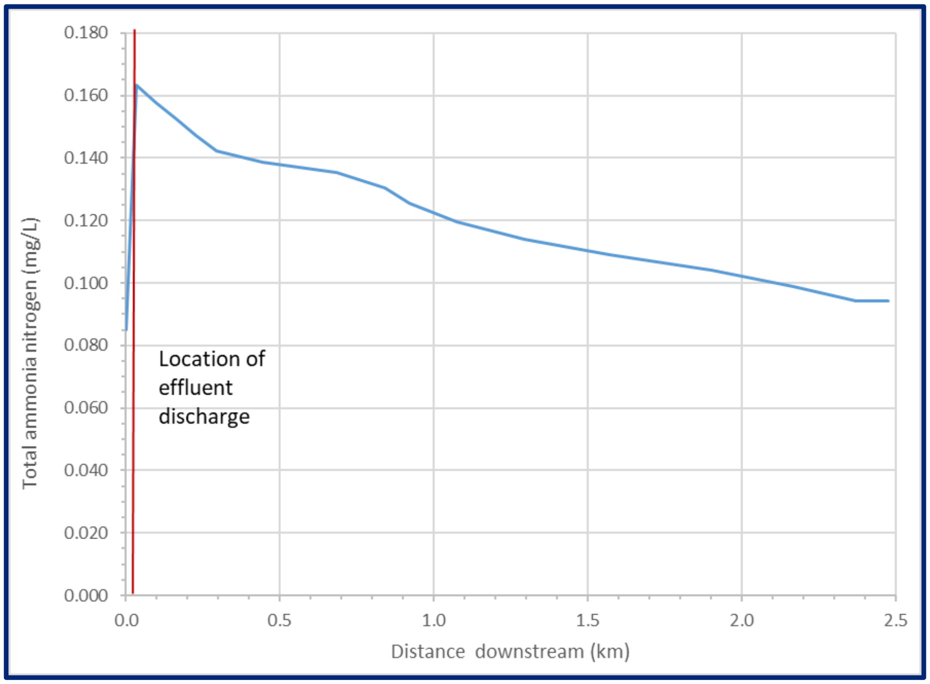
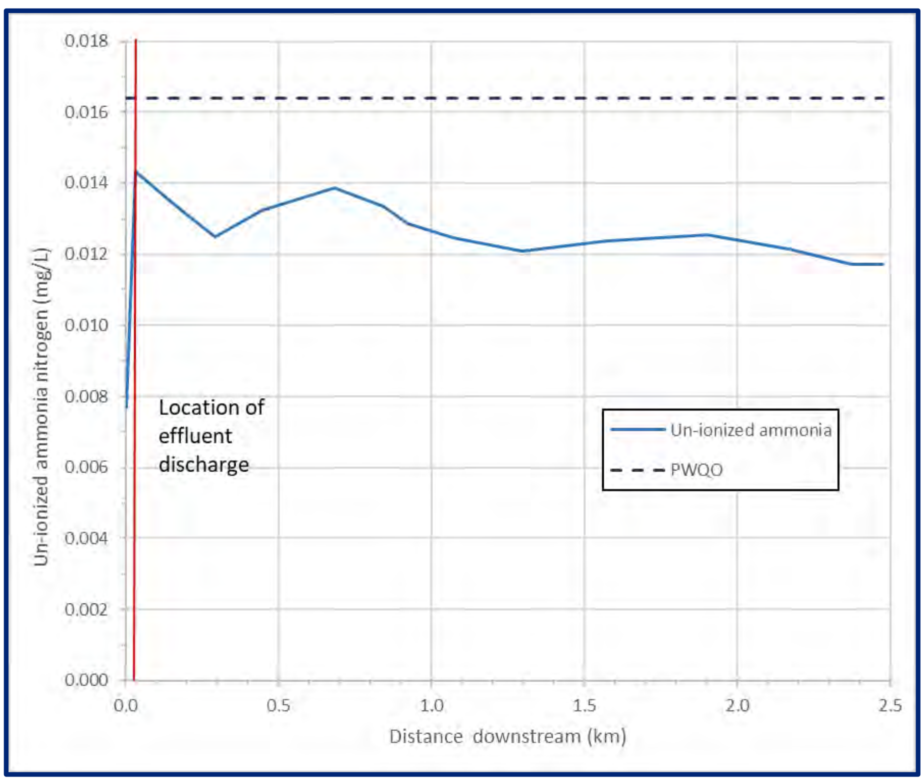
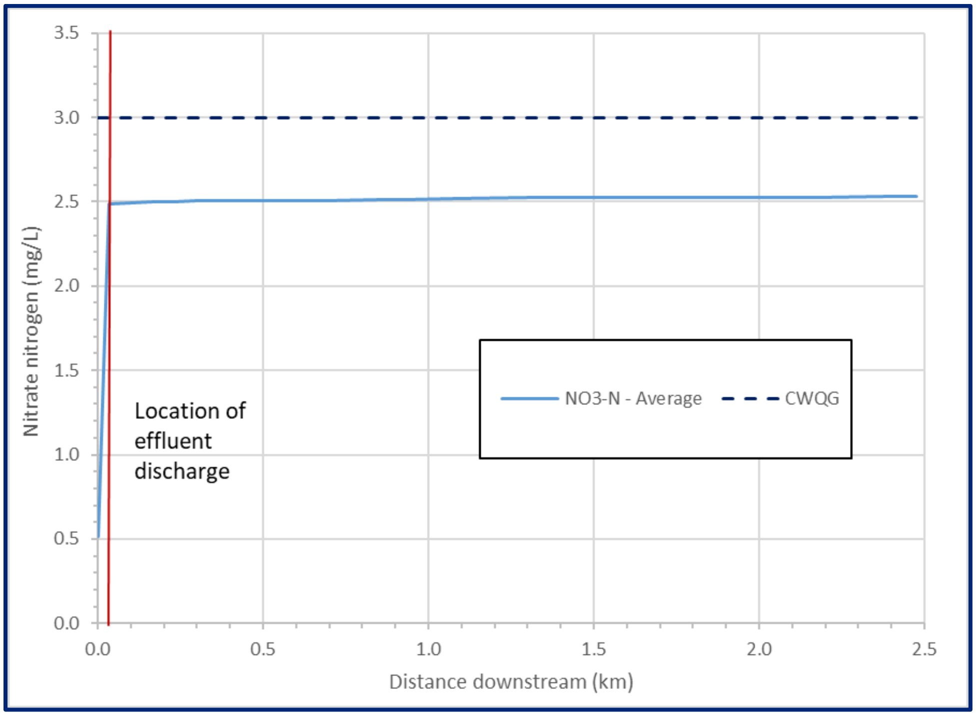


Figure 34. QUAL2K Predicted Un-ionized ammonia concentrations in the Humber River under Future Conditions.



Based on the 75th percentile effluent nitrate-nitrogen concentration of 22 mg/L, downstream nitrate concentrations are predicted to increase to 2.49 mg-N/L at the point effluent discharge; Figure 35). After complete mixing, concentrations are predicted to increase from the nitrification of ammonia to 2.53 mg-N/L at the end of the study area (Figure 35). Nitrate concentrations in the Humber River are predicted to be below the CWQG of 3 mg-N/L under 7Q20 conditions.

Figure 35. QUAL2K Predicted NO_3-N concentrations in the Humber River under Future Conditions.



3.4 Summary

Water quality modeling was undertaken to predict the effects of the WRRF expansion on Humber River water quality at the point of complete mixing (mass-balance) and in the far-field (QUAL2K). Near-field or "mixing zone" modelling was deemed to be unnecessary because the predictions made by CORMIX (the mixing zone model) did not reflect actual receiving water conditions at, and immediately downstream of the effluent discharge.

Mass-balance modelling found that expansion of the WRRF at effluent limits of 10 mg/L for $cBOD_5$ and TSS, 1 mg/L TAN (May 1 – October 31), and 0.15 mg/L TP (objective of 0.1 mg/L) will increase downstream concentrations under 7Q20 conditions, but concentrations will remain below their PWQO or CWQQ, maintaining the existing Policy 1 status of the receiver.

Far-field modelling results were effective in showing assimilation processes downstream of the effluent outfall, with fully mixed values of TP and TAN similar to those predicted by mass balance. The mass balance results were conservative and showed that even the maximum potential change in water quality maintained the Policy 1 status of the Humber River. The expansion of the WRRF facility at the proposed effluent limits will increase the concentration of TP, TAN, un-ionized ammonia, and NO_3-N in the nearfield, but concentrations will remain below their respective PWQOs or CWQG in both the near and the far-field, maintaining the policy status of the river. Dissolved oxygen concentrations will decrease slightly (0.08 mg/L) downstream of the discharge, to a minimum of 8.24 mg/L, but will increase with distance farther downstream, and will remain well above the PWQO of 5 mg/L.

These are conservative assessments, as modelled predictions are under 7Q20 flow conditions, and do not consider the influence of wetland assimilation on effluent concentrations (reduction in TP – section 2.4.6). Effluent concentrations at the wetland outlet, and hence downstream, may differ and be lower than modelled predictions.

4. Aquatic Biota

4.1 Methods

Biological data were collected in the Humber River to:

1) Assess the presence or absence of impacts associated with treated effluent from the WRRF through a spatial comparison between upstream and downstream sites. Data were also compared with historical data that was collected as part of the Municipal Class EA in 2002 where appropriate, to determine impacts through any changes in condition over time;

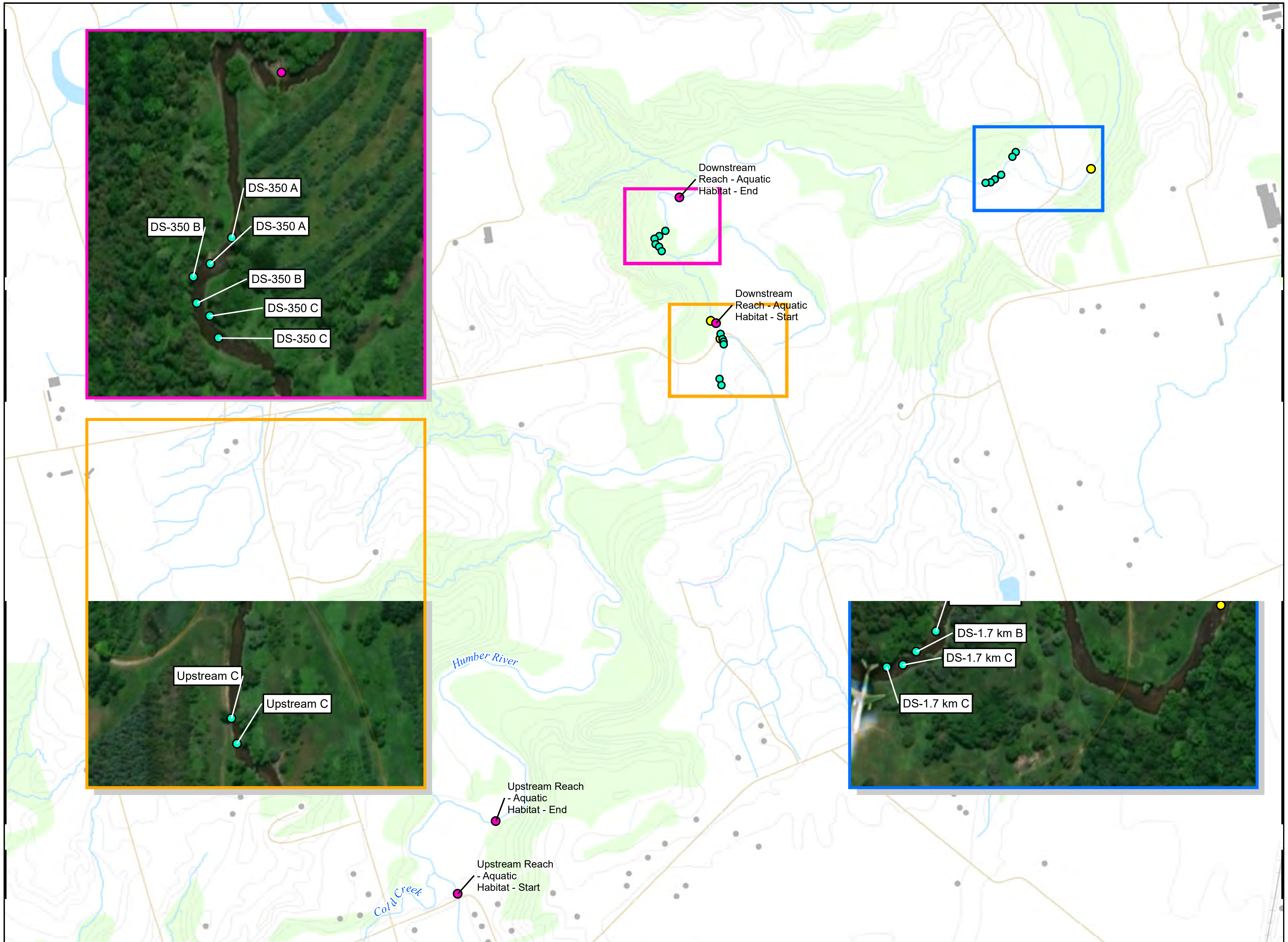
2) Characterize current biological conditions so that future monitoring can rely on this dataset to determine the presence or absence of temporal impacts associated with treated effluent from the re-rated WRRF;

3) Identify any site-specific sensitivities that are needed to inform the ACS and related effluent treatment.

4.1.1 Periphyton

Periphyton generally refers to microbial growth on substrate (rock, sand or wood on the riverbed) and can include algae, bacteria and detritus that are living or dead. Periphyton are an important food source for higher trophic organisms and an effective indicator of water quality.

Periphyton samples were collected at three sites: upstream of the WRRF and 30m and 1.7 km downstream of the WRRF on August 29th, 2017 (Figure 36). Samples were collected from the surface of cobbles of various sizes by brushing off a circular area of 2.6 cm diameter using a syringe sampler. The material was collected into a consistent water volume (50 mL) using a second syringe connected by a silicone tube to the base of the syringe sampler (Figure 37 and Figure 38).



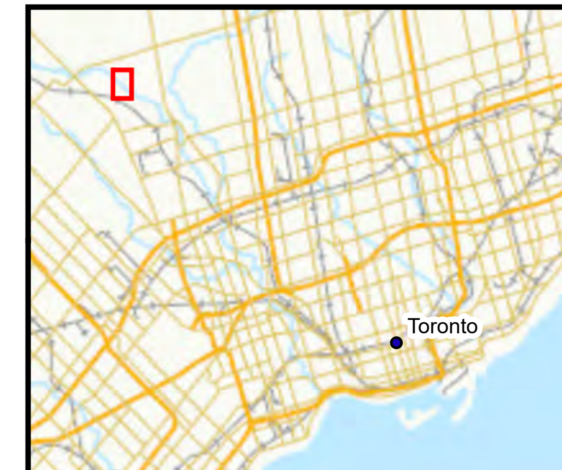


Figure 36:
Aquatic Biota Sampling Stations

Project Lead: Deborah Sinclair
Prepared by: Kris Hadley
Data Source: HESL,ESRI Imagery
Coordinate System: NAD 1983 UTM Zone 17N

Hutchinson
Environmental Sciences Ltd.

Figure 37. Syringe Sampler for Periphyton Sampling.

Figure 38. Application of Syringe Periphyton Sampler in the Field.

Five replicates were obtained at each location. All subsamples from each site were composited in a 500 mL plastic jar, preserved with Lugol's solution (1/100 mL), kept in coolers or refrigerated until analysis and shipped to ALS in Waterloo, Ontario for taxonomic analysis (species identification and enumeration).

Algal biomass, in combination with a variety of metrics were calculated from the periphyton data as indicators of nutrients effects on aquatic ecosystems. Metrics such as taxa richness, the Shannon Weaver Diversity Index and percent dominant taxon provide an effective means of assessment by encompassing multiple aspects of assemblages (Karr et al. 1986).

Excessive growth of attached algae (due to nutrient enrichment) can cause large oxygen fluctuations in the water affecting other aquatic life. Trends in biomass were assessed by measuring total biovolume at the three sites. Other metrics used cell counts (cells#/litre) as recommended by the US EPA. Taxa richness indicates the number of distinct taxa in a sample. Increasing taxa richness correlates with increased health of the community and suggests adequate habitat and food sources. The Shannon Weaver Diversity Index is a measure of ecological diversity which measures the likelihood that the next individual will be the same species as the previous sample - values range from 0 to 4 with higher values indicating greater diversity. Lastly, % dominance is simply the representation of the most dominant species in a sample and is a measure of redundancy. Generally, a high level of dominance is driven by the proliferation of a pollution tolerant organism and indicates degraded conditions.

4.1.2 Benthic Invertebrates

Benthic invertebrates are the most used organism in the bioassessment of freshwater ecosystems (Bailey et al. 2004). Reasons for their popularity include their limited mobility so they are constantly exposed to the effects of pollution, they are reasonably long-lived so the effects of stressors can be integrated over a longer time period and they are a well-documented, aquatic ecological indicator with various tolerance levels (Resh and Rosenberg 1993).

Benthic invertebrates were sampled following protocol outlined in Nobleton Sewage Servicing Follow Up Studies: 2000-2001 (GLL 2002) so that temporal comparisons between datasets could be completed. Triplicate samples were collected using a 5-minute timed, kick-and-sweep sampling method over a ~30m reach. Riffle habitat was selectively sampled per GLL (2002) approach because riffle habitats typically support benthic invertebrate species that are most sensitive to water quality impacts which improves the sensitivity of the bioassessment. The downstream near-field (DS-350) sampling locations mirrored those sampled by GLL (2002) but upstream reference (Up-Stream) and downstream far-field (DS-1.7 km) were selected independently to align with water quality sampling locations (Figure 37). The upstream sampling location used by GLL (2002) was selected as a potential discharge location but it did not constitute an ideal upstream reference site in 2017 because it is located >3km upstream of the effluent outfall and habitat was different than that located in the near field mixing zone. DS-1.7 km was selected based on QUAL2K modelling results as it represents the furthest downstream point of modelled water quality changes from the effluent discharge and therefore should be outside the range of impact in the future after the plant is re-rated.

Samples were preserved with 99% isopropyl alcohol and sent to Richard Bland Associates for sorting and taxonomic identification to the lowest practical level. Taxonomic data was later interpreted through a variety of biological metrics designed to describe community composition: abundance, richness, diversity, % *Ephemeropter, Plecoptera* and *Trichoptera* (%EPT) and the Hilsenhoff Biotic Index, which was developed to assess organic impairment (Hilsenhoff 1988). Taxa tolerance values for individual species were updated following Benthic Macroinvertebrates in Freshwaters – Taxa Tolerance Values, Metrics, and Protocols (Mandaville 2002).

Habitat is a critical driver of benthic invertebrate assemblages. The effects of habitat on benthic assemblage were partially controlled by selectively sampling riffle habitats during spatial comparisons of upstream and downstream sites. Habitat was also described at each sampling location so that results could be related to habitat variables as required.

4.1.3 Fisheries

MNRF determined that there was sufficient fisheries information from the Humber River to inform a Class EA process and denied the Application to Collect Fish for Scientific Purposes that was submitted to the Aurora District MNRF office as part of the project (Heaton, M. Personal Communication. September 18, 2017). The fisheries assessment was therefore focused on habitat and fish community information gathered through the background review and as a result, it was not possible to compare fisheries data spatially or temporally to determine biological impact associated with treated effluent.

4.1.4 Aquatic Habitat

Aquatic habitat was characterized on November 16, 2017 in 500m reaches at an upstream reference site at Peel/King Town Line and in the near field mixing zone downstream from the effluent outfall (Figure 37) to align with aquatic habitat sites described in GLL (2002). Habitat variables were recorded, mapped described and compared with the habitat assessment included in GLL (2002). The following habitat variables were assessed: morphology, substrates, macrophytes and woody debris, and interpreted in relation to habitat requirements of target, resident fish species.

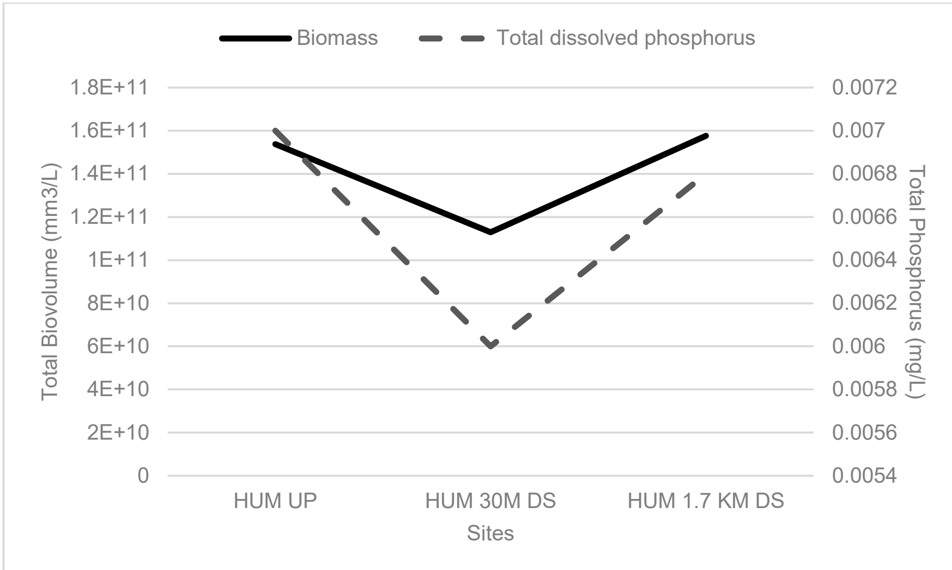
4.2 Results

4.2.1 Periphyton

Biomass

Biovolume was used as a surrogate for biomass to assess periphyton growth downstream of the Nobleton WRRF. There was a small decrease in periphyton biomass 30 m downstream of the Nobleton WRRF Figure 39) indicating that current nutrient loads from the Nobleton WRRF are not causing excess periphyton growth.

Figure 39. Periphyton Biomass and Total Dissolved Phosphorus Concentrations in the Humber River August 29th, 2017.



Community Composition

Attached diatoms, which often reflect good water quality, made up the majority (92 - 98%) of the species composition at each site. Green algae species are often associated with moderate nutrient enrichment but made up a small portion of the community (0.02%) 30 m downstream of the Nobleton WRRF. Cyanobacteria generally known as "blue-green algae", and an indicator of higher nutrient concentrations, made up a minor (2% -8%) component of the algal communities at all sites (Figure 40). These results indicate that community composition of major algal groups in this reach of the Humber River was not affected by the existing WRRF discharge.

Richness, Dominance and Diversity

Taxon richness was similar between sites; ranging from 16, 1.7 km downstream of the Nobleton WRRF to 22, 30 m downstream of WRRF. The diatom genus *Navicula* was the dominant taxon at all sites, making up 57% - 60% of the community, and indicating that water quality was similar amongst the three sites. Diversity was also relatively consistent across all sites ranging from 1.36 1.7 km downstream to 1.5 upstream (Figure 41). Values closer to 4 would indicate more diverse communities, however the consistent values between sites indicates that the Nobleton WRRF is not negatively impacting the water quality downstream of its discharge.

Figure 40. Periphyton Composition in the Humber River on August 29th, 2017.

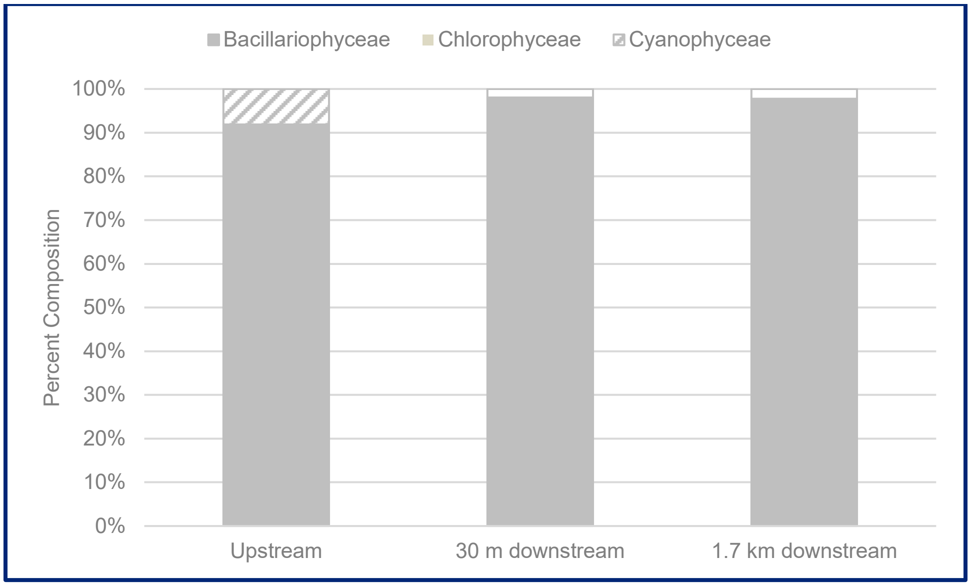
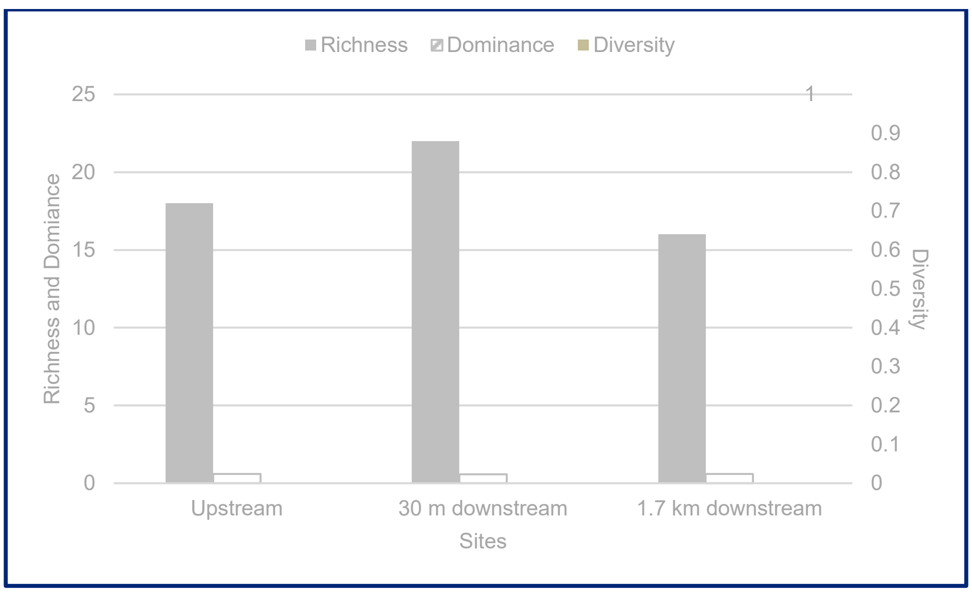


Figure 41. Periphyton Metric Results from the Humber River on August 29th, 2017.



4.2.2 Benthic Invertebrates

Benthic invertebrates were collected from riffle or shallow run habitats with predominantly rocky substrates (Table 22). Habitat characteristics are described in Table 22 and biological metric results are provided in Table 23.

All samples were extremely productive with abundance ranging from 1078 individuals (combined three subsamples) at the Up-Stream site to 1600 at the DS-1.7 km site. Richness was similar at the Up-Stream (49 taxa) and DS-350 m (47) sites but was higher at the DS-1.7 km (57) site. There were no statistically significant differences in water quality between upstream and downstream sites so the increased richness at DS-1.7 km likely reflects the predominantly rocky and more diverse habitat at that site compared to more sands and silts at the upstream sites. Diversity increased from upstream to downstream: Up-Stream (2.43), DS-350 m (2.58) and DS-1.7 km (2.77) but the small differences likely reflected habitat variability. Hilsenhoff Biotic Index values decreased from upstream to downstream: Up-Stream (4.48), DS-350 m (4.34) and DS-1.7 km (3.74) indicating “good’ to “excellent” water quality and habitat and improving quality downstream of the effluent outfall. The percentage of EPT taxa was relatively high and similar at all sites, ranging from 56.1% (DS-350) to 61.7% (Up-Stream), indicating good water quality.

There was some variance in metric results between replicate samples at each of the sample sites as expected but triplicate samples, assessment of combined site data, and focused sampling of riffle habitat minimized the influence of habitat variability on results. The 2017 benthic bioassessment indicated that the current WRRF is not having a negative impact on the benthic community through this reach of the Humber River.

GLL (2002) collected triplicate samples from DS-350 m in 2002. Raw data couldn’t be accessed so the only common results available for comparison were abundance, richness and % EPT (Table 24). Abundance ranged from 96 at DS-350-B to 114 at DS-350-A, which is considerably lower than abundance observed in 2017. The difference in abundance limits the interpretative ability of richness because a greater number of species should be expected if more organisms are collected but percent EPT is proportional and affords temporal comparison. Percent EPT was higher at DS-350-A (66%) and DS-350-B (58%) in 2017 than 2002 (DS-350-A = 57%, and DS-350-B = 41%), but lower at DS-350-C in 2017 (56%) than 2002 (68%). The temporal comparison is very limited but the %EPT results indicate that benthic habitat has not been impacted by WWTP effluent in the near field mixing zone.

.

Table 22. Habitat Characteristics at Sampling Locations.

	Up-Stream SREF-A	Up-Stream SREF-B	Up-Stream SREF-C	DS-350 m NF-A	DS-350 m NF-B	DS-350 m NF-C	DS-1.7 km FF-A	DS-1.7 km FF-B	DS-1.7 km FF-C
Morphology	Riffle	Run	Riffle	Riffle	Riffle	Run	Riffle	Run	Riffle
Water depth	20-50	5-20	5-50	5-40	5-70	5-70	5-40	10-100	10-30
Substrates	Rocky substrates, primarily cobble and gravel with some silty sand	Mixed substrates: gravel>cobbles>sand>silt	Rocky substrates with silty sand	Rocky substrates with silty sand deposits	Gravel with coarse sand and some gravel	Cobble with silty sand	Rocky with sand at river margins	Rocky, some underlying silt and sand	Rocky substrates with underlying coarse sand and gravel
Woody debris and macrophytes	Sparse but lots of periphyton growth	Sparse but lots of periphyton growth	Sparse	No macrophytes and sparse woody debris	No macrophytes and sparse woody debris	None	Sparse	Sparse	Sparse but lots of periphyton growth

Table 23. Benthic Invertebrate Biological Metric Results.

	Up-Stream-AU SREF-A	Up-Stream-BU SREF-B	Up-Stream-CU SREF-C	DS-350-AUS-REF-Combined	DS-350-BDSNF-A	DS-350-CDSNF-B	DS-1.7 km-ADSNF-C	DS-1.7 km-BDSNF-Combined	DS-1.7 km-CDSFF-A	Up-Stream-ADSFF-B	Up-Stream-BDSFF-C	Up-Stream-CDSFF-Combined
Abundance	484	359	235	1078	450	349	317	1116	569	544	487	1600
Richness	32	35	27	49	27	31	35	47	37	40	36	57
Diversity (Shannon-Wiener)	2.14	2.63	2.30	2.43	2.21	2.42	2.77	2.58	2.51	2.79	2.56	2.77
Hilsenhoff Index	4.61	4.44	4.28	4.48	3.74	4.13	5.43	4.34	3.54	4.24	3.43	3.74
Water Quality	Good	Good	Good	Good	Excellent	Very Good	Fair	Good	Excellent	Very Good	Excellent	Excellent
Percent EPT	67.77	55.15	59.15	61.69	66.22	58.17	39.43	56.09	69.60	51.65	58.73	60.19

Table 24. Benthic Invertebrate Biological Metric Results 2002 vs. 2018.

	DS-350NF-A		DSNF-350-B		DSNF-350-C	
Sampling Year	2002	2017	2002	2017	2002	2017
Abundance	114	450	96	349	111	487
Richness	15	27	16	31	17	35
Percent EPT	57	66	41	58	68	56

4.2.3 Fisheries

Current and site-specific fisheries information could not be obtained for the assessment as the MNRF determined that existing information was adequate and denied the Application to Collect Fish for Scientific Purposes permit. Our assessment was therefore based on information available from MNRF and the TRCA.

The Humber River has supported 74 fish species over the last 150 years, 64 of which are native (MNR and TRCA 2005).

- The study area is located in the Upper Main Humber River Subwatershed and it has supported 45 different fish species such as American Brook Lamprey (*Lampetra appendix*), Brook Trout (*Salveliunus fontinalis*), Atlantic Salmon (*Salmo salar*), Redside Dace (*Clinostomus elongatus*), White Sucker (*Catostomus commersonii*), Creek Chub (*Semotilus atromaculatus*), Brook Stickleback (*Culea inconstans*), Rainbow Darter (*Etheostoma caeruleum*), Mottled Sculpin (*Cottus bairdii*), Rainbow Trout (*Oncorhynchus mykiss*) and Brown Trout (*Salmo trutta*), the latter two of which are introduced.
- The following species have been captured at the closest sampling station (HUO26WMN) to the study area located at Highway 50 and King Road: Brown Trout, White Sucker, Northern Hog Sucker (*Hypentelium nigricans*), Creek Chub, Rainbow Darter, Fantail Darter (*Etheostoma flabellare*), Johnny Darter (*Etheostoma nigrum*), Mottled Sculpin, American Brook Lamprey, Chinook Salmon (*Oncorhynchus tshawytscha*) and Rainbow Trout.
- GLL (2002) electrofished at Up-Stream and DS-350 and captured similar species plus additional *Centrarchidae*: Central Mudminnow (*Umbra limi*), Common Shiner (*Luxilus cornutus*) and Bluntnose Minnow (*Pimephales notatus*).

Index of Biotic Integrity (IBI) scores are often used to summarize fish community health and to inform water quality assessments as an indicator of biological conditions. TRCA (2008) calculated IBI scores based on fisheries data collected in 2001 and 2004 from the closest aquatic sampling station (HUO26WMN) to the study area and assigned “good” IBI score based on 2001 data and a “fair” score based on 2004 data.

The study area is found within Management Zone 3 which has Brown Trout and Redside Dace as target species. Redside Dace reside in small streams with gravelly bottoms, and the study area contains stream widths greater than the regulated bankfull width of 7.5 m or less, so the study area does not constitute regulated Redside Dace habitat. Atlantic Salmon are also stocked in the Management Zone and it is a Provincial fish sanctuary between January 1 and the fourth Saturday of April, and October 1 – December 31 to protect both spring and fall spawning species.

It is clear that the study area supports a wide range of fish species indicative of warm, cool and coldwater thermal regimes, including a management target species (Brown Trout). All species are protected from impacts associated with the conveyance of treated effluent through adherence to Provincial and federal Water Quality Objectives and the Class EA and ECA process. Although a site-specific assessment of fish response to the current WRRF outfall was not possible, our assessment of water quality and the benthic invertebrate communities showed no evidence of impairment from the existing effluent discharge and we conclude that the same would apply to the fish community.

4.2.4 Aquatic Habitat

TRCA (2008) provided a summary of aquatic habitat conditions in the study area. The closest habitat assessment to the Nobleton WRRF study area was made for the Humber River at Hwy. 50 and King Road which was characterized as moderately stable thermal stability and intermediate, riverine coldwater habitat (TRCA 2008). These reaches typically receive a proportionately high percentage of groundwater, have relatively high base-flow ratios, stable flows and water temperatures (TRCA et al. 1998).

The Humber River is a fourth order stream in the study area and the closest instream barriers are upstream at Highway 50 in Bolton and downstream near Woodbridge (MNR and TRCA 2005).

HESL staff conducted a habitat assessment on November 16, 2017. A sinuous river pattern with riffle/run stream morphology was evident at the upstream reach. Water depths in the riffles varied between 0.1 and 0.3 m, runs were 0.5-0.7 m deep, and pools were >1 m. Stream width varied between 11 and 16 m. Substrate was sorted somewhat per morphology and consisted of cobble (80%), gravel (10%) and boulders (10%) in riffles and cobble (20-70%), sand (20-60%) and gravel (10-20%) in runs, and sand (30%). Deflector logs, smaller woody debris and boulders provided cover habitat but in general, fish habitat cover was limited and lacked complexity.

A sinuous river pattern and riffle/run stream morphology was also evident in the downstream reach through a gradual stream gradient. Water depths in the riffles varied between 0.1 and 0.3 m, runs were 0.4-0.7 m deep, and pools were >1 m. Stream width varied between 9 and 15 m. Substrate was sorted somewhat per morphology and consisted of cobble (40-70%), gravel (30-60%) in riffles and cobble (20-50%), silty sand (5-40%), and organics (5-10%). Deflector logs were abundant, while smaller woody debris and some undercut banks also provided cover habitat.

Aquatic habitat was similar to results characterized in the Nobleton Sewage Servicing Follow Up Studies: 2000-2001 (GLL 2002) but substrate ratios had changed, and cover habitat locations altered as a result of the dynamic nature of the Humber River and associated erosive and depository forces.

The study area has some potential for Brown Trout spawning as they prefer rocky substrates with a diameter of 1 – 7 cm, water depths of 20 – 45 cm and flows between 40 – 70 cm/sec. Although these features are found in the study area, Brown Trout generally seek out gravelly headwaters or groundwater upwellings (Hickman et al. 1984; Raleigh et al. 1986). Field investigations did not include a specific spawning assessment but were completed during the general spawning period (October 15 – early November (Scott and Crossman 1973) and during appropriate spawning water temperatures (2-13°C) and no spawning fish were observed. Visual assessment was limited by turbid water, but the TSS-driven turbidity is also an indication of poor habitat as TSS can infill rocky crevice habitat and limit oxygen concentrations in developing eggs and parr. Also, cover habitat is limited and there are few calm areas for rearing and nursery habitat.

Habitat is of moderate quality in the study area and does not appear to support any critical life stages for target fish species. Habitat will nonetheless be protected from any impacts associated with effluent discharge through adherence to Provincial and Federal Water Quality Objectives.

4.3 Summary

Periphyton and benthic invertebrate communities indicated that water quality in the study area ranged from good to excellent from upstream to downstream of the WRRF, with no observable changes related to the existing WRRF discharge. Decreases in periphyton biomass, minor contributions of blue-green algae in community composition, and consistent diversity values suggest the WRRF is not causing nutrient induced changes in the periphyton community. This is supported by the diurnal dissolved oxygen concentrations discussed in Section 2.4.4 which remained within PWQO values during day and night. Although changes in the diversity of the benthic invertebrate community and the Hilsenhoff Biotic Index suggested water quality improvements from upstream to downstream of the WRRF outfall, the changes were small, water quality measurements did not indicate an improvement (Section 4.2.2) and the observed differences were as likely to be related to changes in habitat characteristics. The percent of EPT taxa also remained relatively consistent across all stations indicating that the WRRF is not having a negative impact on the benthic invertebrate community in this reach of the Humber River. Fish habitat in the area was considered moderate and did not appear to support any critical life stages for target fish species. Therefore, the current WRRF is not negatively impacting aquatic biota in the area.

5. Summary and Recommendations

5.1 Water Quality Characterization

TSS, total phosphorus, total Kjeldahl nitrogen, total ammonia, nitrate, and un-ionized ammonia concentrations downstream of the WRRF discharge were not statistically different ($p>0.05$) than those measured upstream. Un-ionized ammonia was well below the PWQO at all stations on all events with no threat to aquatic life. Overall the Nobleton WRRF discharge had no significant effect on downstream water quality during the 2017 and 2018 sampling events.

The Humber River is a Policy 1 receiver for all parameters of concern. TP concentrations generally exceeded the PWQO only when TSS values exceeded 20 mg/L when flows were greater than ~2.7 m^3/s. Erosion and runoff in the watershed are responsible for high concentrations of TP in the Humber River and the 75th percentile concentration of 0.0165 mg/L during summer conditions was well below the PWQO.

Diurnal surveys showed that DO conditions in the Humber River were consistently above the PWQO at every site. Dissolved oxygen concentrations were higher below the wetland outlet of the WRRF, indicating that there was no oxygen demand from WRRF effluent on downstream DO. Diel variations in DO were approximately 2.5 mg/L in July, 4.3 mg/L in August, and 3.3 mg/L in September. Maximum daily concentrations in DO were frequently above 100% saturation both above and below the wetland outlet, indicating naturally supersaturated conditions in the River and nighttime low values remained within the PWQO.

The constructed wetland at the WRRF outfall appeared to provide some effluent polishing, although results were compromised because the effluent was sampled on different days at the WRRF and the wetland outlet and different labs analysed the samples. Nevertheless, TP concentrations were significantly reduced within the wetland. The wetland had little to no effect on TAN, nitrate and $cBOD_5$ concentrations and TSS were occasionally elevated at the wetland outlet.

5.2 Water Quality Modelling

Water quality modeling was undertaken to predict the effects of the WRRF expansion on Humber River water quality at the point of complete mixing (mass-balance) and in the far-field (QUAL2K). Mass-balance modelling found that expanding the WRRF at the current effluent limits of 10 mg/L for TSS, 1 mg/L TAN (May 1 – October 31), and 0.15 mg/L TP (objective of 0.1 mg/L) would increase downstream concentrations under 7Q20 flow conditions, but concentrations would remain below their respective PWQO or CWQQ, maintaining the Policy 1 status of the receiver. A TP limit between 0.10 and 0.15 mg/L is however recommended to protect the river and maintain assimilative capacity.

Far-field modelling results showed that the proposed effluent limits will increase the concentration of TP, TAN, un-ionized ammonia, and NO_3-N in the nearfield, but concentrations will remain below their respective PWQOs or CWQG in both the near and the far-field, maintaining the Policy 1 status of the river. Dissolved oxygen concentrations will decrease slightly (0.08 mg/L) downstream of the discharge, to a minimum of 8.24 mg/L, but will increase with distance farther downstream, and will remain well above the PWQO of 5 mg/L.

Modelled predictions were made for 7Q20 flow conditions and 75th percentile background concentrations and are therefore conservative assessments. Effluent concentrations at the wetland outlet, and hence downstream, may differ and be lower than modelled predictions.

5.3 Aquatic Biota

Periphyton and benthic invertebrate communities generally suggest water quality in the area ranges from good to excellent from upstream to downstream of the WRRF. Decreases in periphyton biomass, minor contributions of blue-green algae in community composition and consistent diversity values suggest the WRRF is not causing nutrient induced changes in the periphyton community. This is supported by the diurnal dissolved oxygen concentrations discussed in Section 2.4.4. Although changes in the diversity of the benthic invertebrate community and the Hilsenhoff Biotix Index suggested water quality improvements from upstream to downstream of the WRRF outfall, the changes were small, water quality measurements did not indicate an improvement (Section 4.2.2) and the observed differences were as likely to be related to changes in habitat characteristics. The percent of EPT taxa remained consistent across all stations indicating that the WRRF is not having a negative impact on the benthic invertebrate community in this reach of the Humber River. The study area supports a wide range of fish species indicative of warm, cool and coldwater thermal regimes, including a management target species (Brown Trout). All species are protected from impacts associated with the conveyance of treated effluent through adherence to PWQOs and the Class EA and ECA process. Our assessment of water quality and the benthic invertebrate communities showed no evidence of impairment from the existing effluent discharge and we conclude that the current WRRF is not negatively impacting aquatic biota in the area.

5.4 Conclusions

The existing Nobleton WRRF is not having a negative effect on downstream water quality and aquatic biology. Water quality downstream of the WRRF discharge was not different from upstream water quality. Un-ionized ammonia was well below the PWQO at all stations on all events. DO concentrations were above the PWQO in the river, and higher downstream of the effluent outlet, indicating that the WRRF is not negatively impacting downstream DO. These results are supported by the aquatic biota in the study area, which are characterized by good water quality, and improvement in the benthic community with distance downstream.

Water quality modelling (both mass-balance and QUAL2K) found that the proposed effluent limits of 10 mg/L for $cBOD_5$ and TSS, 1 mg/L TAN (May 1 – October 31), will increase downstream concentrations under 7Q20 conditions, but concentrations will remain low and below their PWQO or CWQG, maintaining policy status of the receiver. At the current TP limit of 0.15 mg/L, the downstream concentrations (0.029 mg/L) will be just below the PWQO of 0.03 mg/L. An effluent TP limit between 0.10 and 0.15 mg/L is recommended to protect water quality of the Humber River and maintain assimilative capacity. DO concentrations will be maintained well above the PWQO.

5.5 Effluent Limits

The effluent limits presented in Table 25 will maintain water quality in the Humber River within PWQO/CWQGs. A total phosphorus effluent limit less than 0.15 mg/L will also maintain additional capacity in the river.

Table 25. Effluent Limits for Nobleton WRRF at effluent flow of 3,996 m^3/d.

Effluent Parameter		Units	Monthly Average Concentration (mg/L)
5-day Carbonaceous biochemical oxygen demand ($cBOD_5$)		mg/L	10
Total Suspended Solids		mg/L	10
Total Phosphorus - limit		mg/L	0.15
Total Phosphorus - objective		mg/L	0.10
Total Ammonia Nitrogen	May 1 – Oct 31	mg/L	1.0
	Nov 1 – Apr 30	mg/L	3.0
E. coli		CFU/100 mL	200
pH		n/a	6.0 – 9.5

6. References

Bailey, R.C., Norris, R.H., and T.B. Reynoldson. 2004. Bioassessment of freshwater ecosystems using the reference condition approach. Kluwer Academic Publishers, Norwell, MS.

Gartner Lee Ltd. 1999. Community of Nobleton Class Environmental Assessment Humber River Assimilative Capacity Assessment, Prepared for Regional Municipality of York by Gartner Lee Ltd. and R.V. Anderson Associates Ltd. January 1999. 70pp.

Gartner Lee Ltd. 2002. Nobleton Sewage Servicing Follow Up Studies: 2000-2001. Prepared for Totten Sims Hubicki Associates and the Regional Municipality of York. June, 2002. 182pp.

Gartner Lee Ltd. 2006. Nobleton Sewage Servicing Phosphorus Offsetting Strategy. Prepared for Slokker Canada Corporation, June 2006. 55pp.

Harmel, R. D., R. J. Cooper, R. M. Slade, R. L. Haney, J. G. Arnold. 2006. Cumulative uncertainty in measured streamflow and water quality data for small watersheds. American Society of Agricultural and Biological Engineers Vol. 49(3): 689-701 ISSN 0001-2351

HIlsenhoff, W.L. 1988. Rapid Field Assessment of Organic Pollution with a Family-Level Biotic Index. Journal of the North American Benthological Society. 7(1) 65-68.

Mandaville, S.M. 2002. Benthic Macroinvertebrates in Freshwaters – Taxa Tolerance Values, Metrics, and Protocols. Soil and Water Conservation Society of Metro Halifax.

Ministry of Natural Recourses and Toronto Region Conservation Authority. 2005. Humber River Fisheries Management Plan. Queens Printer of Ontario.

Ontario Ministry of Environment and Energy. 1994a. Water management policies guidelines and water quality objectives of the Ministry of Environment and Energy, July 1994. ISBN 0-7778-8473-9 rev.

Ontario Ministry of the Environment (MOE). 1994b. Deriving receiving water based point source effluent requirements for Ontario waters. PIBS#3302 Procedure B-1-5.

Raleigh, R.F., Zuckerman, L.D., and P.C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Brown Trout, revised. U.S. Fish and Wildlife Service. 82(10.124)

Resh, V.H. and D.M. Rosenberg. 1993. Introduction to Freshwater Biomonitoring and Benthic Invertebrates. Chapman and Hall, New York.

Toronto and Region Conservation Authority (TRCA). 1998. Ontario Ministry of Natural Resources, Great Lakes 2000 Cleanup Fund, Action to Restore a Clean Humber, 1998.

Toronto and Region Conservation (TRCA). 2008. Humber River Watershed Plan. Pathways to a Healthy Humber. P. 2013.

Toronto and Region Conservation Authority. 2008. Humber River State of the Watershed Report – Aquatic System.

.

Appendix A. 7Q20 Flow Results and ACS Workplan

Hutchinson
Environmental Sciences Ltd.

1-5 Chancery Lane, Bracebridge, ON P1L 2E3 | 705-645-0021
202-501 Krug Street, Kitchener, ON N2B 1L3 | 519-576-1711
www.environmentalsciences.ca

Memorandum

Date: **August 10, 2017**

To: **Susan Liver, Black and Veatch**

From: **Deborah Sinclair, Brent Parsons, Neil Hutchinson**

Re: **J170005 – 196238 Nobleton Class EA – Assimilative Capacity Study Work Plan**

1. Introduction

York Region is currently undertaking a Class EA to service population growth in Nobleton. The objective of the project is to identify a preferred water and wastewater solution to accommodate Nobleton's planned growth. The preferred solution needs to optimize the existing infrastructure (i.e. "infrastretching") to minimize the financial, community and environmental impacts. The existing Nobleton Water Resource Recovery Facility (WRRF) was commissioned following a Class EA that was completed between 1998 and 2003. It was built to service a population of 6,590 with an average daily flow of 2,925 m^3/day with effluent limits of 10 mg/L for $CBOD_5$ and TSS, 0.15 mg/L for TP, 1.0 mg/L for TAN and 200 counts/100 ml for *E. coli.* The ECA also specifies monthly loading limits of 0.45 kg/day for TP. The plant was approved subject to implementation of a phosphorus offsetting program in recognition of the need to prevent further degradation of phosphorus concentrations in the Humber River, which was considered a Policy 2 receiver for Total Phosphorus.

An Assimilative Capacity Study (ACS) is being undertaken to form the basis of wastewater treatment performance objectives. It will include the collection of water quality data to a) assess the response of the river to the existing effluent discharge, b) review the policy status of the river with respect key indicator parameters (e.g. phosphorus, ammonia, dissolved oxygen), and c) determine the ability of the river to assimilate the existing effluent. The ability of the River to assimilate additional effluent will be evaluated using recent flow data to derive a 7Q20 statistic for the area of the existing discharge to the Humber River, the CORMIX model of near field assimilation and mixing zone characteristics and a QUAL2K model of far field assimilation to determine any effects after complete mixing. These will be used to develop effluent objectives for CBOD, TSS, TP and TAN. Water Survey of Canada flow gauging data will be used to calculate the 7Q20 flow statistic.

This memorandum provides an outline of the ACS work plan to be completed as part of Phases 1 and 2 of the Nobleton Class EA. It replaces a memo provided on July 27 and includes a map of sampling sites that was not included in the original.

2. Task 1 – Background Review

The ACS completed by Gartner Lee Limited (1999) and used to inform the 2003 EA will be reviewed to confirm the approach, water quality conditions prior to discharge from the WWTP, water quality parameters modeled, 7Q20 derivation, model assumptions, modeling results, and proposed effluent limits; information which will be used to help scope the ACS.

Aquatic biological data was previously collected in the study area to describe aquatic habitat, fisheries and benthic invertebrate communities at three potential effluent outfall locations (Gartner Lee Limited, 1999). Data will be gathered from Gartner Lee Limited (1999), Steedman (1987), TRCA (2000), and other relevant sources, and reviewed to help characterize previous ecological conditions in the Humber River to determine if the discharge has altered any aspect of habitat or the aquatic community.

The background review will also include a review of Species at Risk occurrences through the Natural Heritage Information Centre (Ministry of Natural Resources and Forestry, 2016). If the mixing zone provides suitable habitat for a Species at Risk as proven through the background review and a review of habitat requirements, an Information Gathering Form will be submitted to the Ministry of Natural Resources and Forestry (MNRF) to determine if the proposed activities could affect species or habitat protected under the Endangered Species Act. The present workplan does not cover tasks that would be required if MNRF deems that the proposed works would contravene the Endangered Species Act.

3. Task 2 – Field Investigations

There is no recent water quality data available in the vicinity of the existing outfall and only limited historical data from the 2003 EA. We will complete a characterization of water quality, aquatic biology and fish habitat to identify sensitivities, determine existing policy status for key parameters and how the river has responded to the existing discharge. Palmer Environmental Consulting Group will complete the Erosion and Fluvial Geomorphology Assessment by interpreting existing river conditions against the proposed increase in flows to the river.

3.1 Water Quality Assessment

HESL will complete a water quality sampling program to establish a) if existing wastewater effluent input from the Nobleton Water Resource Recovery Facility is impacting water quality in the Humber River, b) the policy status of the Humber River in relation to phosphorus, ammonia, water temperature, dissolved oxygen and chloride, c) a detailed understanding of resident aquatic biota and aquatic habitat, d) a "baseline" with which future monitoring results can be compared, and e) key parameters for input into the water quality modeling.

Water quality samples will be collected from six locations (Figure 1):

- Humber River upstream of effluent discharge location;
- Final discharge point of Nobleton effluent to Humber River (outlet from wetland);
- Humber River 10 m downstream of effluent discharge;
- Humber River 30 m downstream of effluent discharge;

- Humber River 100 m downstream of effluent discharge; and
- Humber River 350 m downstream of effluent discharge (July to September).
- Humber River ~2 km (far-field) downstream of effluent discharge (two summer events)

Samples will be collected monthly from May to October 2017 and once in January/February 2018. Water samples will only be collected in July, August and September from 350 m downstream to characterize downstream water quality under low-flow conditions, and two events during summer conditions approximately 2 km downstream (farfield) to characterize water quality in the far-field. Water samples will be analyzed for ammonia, biological oxygen demand (carbonaceous and 20 day), orthophosphate, dissolved phosphorus, total phosphorus, nitrate, nitrite, total Kjeldahl nitrogen, alkalinity, chloride, and total suspended solids at a commercially accredited laboratory. Chlorophyll *a* and volatile suspended solids will only be monitored during the two summer low flow events as calibration and validation for the water quality modeling. Water temperature, dissolved oxygen, conductivity and pH will be measured in the field at the time of each sampling with a multi-parameter meter.

The intent of the sampling is to collect water quality samples representative of spring, summer, fall and winter conditions. Every effort will be made to collect samples during flows representative of these seasons, however, the water quality modeling (as described in Task 3) will predict downstream effects to water quality under low flow conditions with enriched water quality (i.e. worst-case scenario). We also note that high precipitation in the summer of 2017 to date means that we may not observe typical lower flow summer conditions – the flows will inform our interpretation.

Streamflow will be measured at each of the water sampling stations using an electromagnetic flow meter. Stream velocity will measured at a minimum of 10 points across the stream cross-section. At points where the water depth is less than 0.7 m the velocity will be measured at 0.6 of the depth below the water surface. Where water depths are greater the 0.7 m the velocity will be measured at 0.2 and 0.8 of the depth below the surface and the mean of these values computed. The area-velocity method will be used to calculate stream discharge. Manual streamflow measurements are generally accurate to within 6-19% (Harmel et al. 2006) of the actual flow in the watercourse, with lower flows being less accurate.

A plume dispersion study for the current discharge will be completed during one of the summer low-flow sampling events. The purpose of the plume study will be to assess the behaviour of the current discharge plume in the river and compare the observed plume behaviour to the original modelling predictions. We will measure conductivity in-situ to provide fine scale mapping of the plume in real time.

Diurnal oxygen (DO) surveys will be conducted during summer low-flow conditions (June through September) to determine current oxygen conditions in the river, and determine if oxygen is a limiting factor at night when photosynthesis is low and respiration is high. Optical dissolved oxygen probes (HOBO brand) will be deployed at three locations: upstream, nearfield (30 m downstream), and far 350 m downstream. The probes will measure dissolved oxygen and temperature, which will be used as input into the QUAL2K model, to estimate the dissolved oxygen sag point, and potential for formation of un-ionized ammonia and to assess aquatic habitat conditions in the Humber River.

3.2 Physical Attributes

The QUAL2K model requires a spatial segmentation of the receiving stream into a series of constant hydrogeometric characteristics, (i.e. depth, cross sectional area, average velocity and average flow). A good understanding of the physical environment is therefore necessary prior to undertaking the modeling exercise. A comprehensive stream assessment of Humber River will be undertaken by HESL aquatic scientists and fluvial geomorphologists (Palmer Environmental Consulting Group). The primary objective of the investigation is to define and characterize distinct reaches in the Humber River (within the study area) for input into the hydrodynamic model.

Specific reaches will be defined by channel pattern, gradient, dimensions, bed material, and bank composition, riparian and aquatic vegetation and in-stream obstructions (e.g., large woody debris). Developing a detailed image of the study area, both within the mixing zone (near-field) and beyond the point of complete mixing of the effluent and the River (far-field), is important to provide a better understanding of the receiving environment, other potential influences on water quality and the assimilation process. The habitat and characteristics of each reach will be documented and mapped for inclusion in the ACS.

3.3 Dye Study

A dye study under low flow summer conditions will be conducted in the Humber River to calculate time of travel and longitudinal dispersion, inputs required for QUAL2K modeling. A slug injection test, where a known amount of tracer is instantaneously injected into the river just upstream of the preferred discharge location, will be completed. Fluorometers (YSI 600 OMS instruments equipped with Rhodamine WT optical sensors) will be placed in the river at three locations downstream of the proposed discharge location to measure changes in concentration over time and thus velocity and dispersion. Rhodamine WT dye, a fluorescent pink xanthene dye, will be used as the tracer for the study. Rhodamine WT dye is a stable, non-toxic, and chemically unreactive dye that is easily measured in the field. The substance is non-carcinogenic, and is safe if it comes into contact with skin.

3.4 Aquatic Biology

An aquatic biological assessment will be completed to a) assess impacts, if any, of wastewater effluent inputs from the existing NWRF on aquatic biota, b) inform the ACS and selection of required treatment through determination of the sensitivity and/or rarity of resident aquatic species, and c) establish a "baseline" with which future monitoring results can be compared. Objective a) will be completed through a spatial comparison of data between sites collected in 2017 and a temporal comparison of data collected during the original Nobleton EA (Gartner Lee Limited, 1999) and data collected in 2017. It should be noted that fish are mobile and there are no obvious migratory obstacles in the study area, making a spatial comparison of sites challenging. The spatial comparison of fish assemblages will be qualified and include consideration of habitat.

Sampling will largely mirror field efforts undertaken previously by Gartner Lee Limited (GLL) so that a temporal comparison of results is possible. Fish and benthic invertebrates will be sampled in October 2017 (as the GLL sampling was also conducted in October).

Sampling of benthic invertebrates and the fish community, as well as aquatic habitat characterization will be completed at three locations located in the Humber River:

1. Upstream of the existing discharge location;
2. In the nearfield mixing zone (co-located with historical GLL sampling sites); and
3. In the far field (outside of the influence of the existing effluent discharge).

The general location of the sites is depicted on Figure 1. Site selection will be refined based on a field reconnaissance survey, to ensure that habitat characteristics between the sites are similar, and that the sites can be used as suitable monitoring stations for future effects monitoring.

3.4.1 Benthic Invertebrates

Benthic invertebrates are a well-documented, aquatic ecological indicator that provide an indication of water and sediment quality which integrates environmental conditions and extremes over the long term that may not be captured by water quality sampling at discrete times. Benthic invertebrate sampling will follow the GLL (2002) sampling methodology so that results can be compared with historical data. Invertebrates will be collected by the “traveling kick” method using a D-frame dip net with a 500 µm mesh size. Sampling will cover approximate 30 m reach of stream for a 5-minute period. The sampling effort in each microhabitat will be proportional to the area it covers within the site. Samples will be preserved and shipped to a qualified taxonomist and identified to the lowest practical taxonomic level. Data will be evaluated through calculation of a variety of biological metrics such as richness, *Ephemeroptera*, *Plecoptera*, *Trichoptera* richness, diversity, and Hilsenhoff’s Biotic Index.

3.4.2 Fisheries

A fish species list compiled through the background review will be supplemented with field sampling. Sampling will be completed via backpack electrofishing following the protocol outlined in GLL (2002). Fish collection will require completion of an Application to Collect Fish for Scientific Purposes and approval from the Aurora District MNRF Office. Fish will be captured, identified to species, measured for length and live released. Catch-Per-Unit-Effort, rarity and sensitivity of captured species will be assessed and used to inform the ACS.

3.4.3 Aquatic Habitat

Aquatic habitat will be characterized at benthic invertebrate and fish sampling locations. The Humber River is a dynamic river, and habitat is influenced by a wide variety of anthropogenic and natural stressors. It will be very difficult to determine if changes in aquatic habitat are a result of effluent from the NWRF so a temporal comparison of habitat changes since 2002 will not be completed. Aquatic habitat will however be characterized at benthic invertebrate and fish sampling locations because habitat is an important driver of both assemblages and should be considered during interpretation. Characterization of aquatic habitat will also allow for determination and mapping of any critical habitat by assessing habitat requirements of resident species (e.g. spawning substrates).

4. Task 3 – Modeling

4.1 7Q20 Flow Statistic

Effluent discharge to any receiver requires the determination that the receiver can effectively assimilate or dilute the effluent. In Ontario streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity of a stream or river. The 7Q20 flow represents the minimum 7-day average flow with a recurrence period of 20 years. This value determines the 5% chance of there not being adequate streamflow to properly dilute the point discharge and therefore represents a conservative (protective) assessment for the ACS.

The Water Survey of Canada maintains flow gauging stations on the Humber River upstream (near Palgrave Stn. 02HC047) and downstream (Elder Mills 02HC025), these stations were used to calculate the 7Q20 flow statistic for the assimilation study in 1998. We will use these two sites to a) determine if there are any trends in flow over the past 10 years and b) to calculate a revised 7Q20 flow statistic (pro-rated to the discharge location) to inform the ACS for the plant expansion. We will subtract 10% of the 7Q20 flow to account for the potential for reduced flows as a result of changing climate.

4.2 CORMIX

CORMIX is a mixing zone model developed by Cornell University for the analysis, prediction, and design of aqueous pollutant discharges into diverse water bodies. The model simulates the hydrodynamic behaviour of the effluent discharge and calculates the plume trajectory, dilution and maximum centerline concentration in the river. CORMIX will be used to predict near field water quality up to and including the point of complete mixing between the WWTP effluent and the Humber River.

The CORMIX model will use measurements made during the field investigations and will be run for 7Q20 flows for the river to assess the extreme low flow condition. The CORMIX model will examine total ammonia nitrogen (with un-ionized ammonia concentrations calculated from field pH and temperature), BOD, and TP in order to determine concentrations of these parameters between the outfall and the point of complete mixing. The MOECC will be consulted to determine if any additional parameters should be modelled within the mixing zone. The existing outfall is a simple bank overflow discharge. We will model various outfall configurations (i.e., co-flowing, protruding, etc.) to determine the configuration which results in optimal mixing if initial modelling or the field program suggests mixing problems with the existing discharge configuration.

4.3 QUAL2K

QUAL2K is a one-dimensional (1-D, longitudinal assuming complete vertical and horizontal mixing) river and stream water quality model, supported by the United States Environmental Protection Agency (US EPA), which is typically used to assess the far-field impact of discharges in rivers. A wide range of water quality parameters and chemical and biological pollutants can be modeled, including temperature, DO (including the sag point location), CBOD, nitrogen species, phosphorus species, and suspended solids. QUAL2K assumes instantaneous complete mixing and as such, will be used to predict water quality in the Humber River beyond the point of complete mixing (i.e., far-field water quality).

The QUAL2K model will be created with the measurements and water quality data collected from the field investigations outlined above. Similar to the CORMIX modelling, the QUAL2K model will be built and run for the 7Q20 flow to assess far field assimilation of nitrogen and phosphorus, and oxygen demand. The MOECC will be consulted to determine if any additional parameters should be modelled in the far-field.

5. Task 4 – Derivation of WWTP Effluent Limits

The Ontario Ministry of the Environment and Climate Change (MOECC) have three documents that direct the discharge requirements for waste water treatment plants (WWTP). In *Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy* (MOE 1994a) the MOE provides direction on the management of surface water and groundwater quality and quantity for the Province of Ontario. In *Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters* (MOE 1994b), the MOE provides guidance with regard to the requirements for point-source discharges and the procedures for determining effluent requirements for an Environmental Compliance Approval (ECA). In the Guideline F-5 Series *Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters* (MOE 1994c), the levels of treatment required are described, along with guidance on deriving effluent limits (concentrations and loading).

For the Nobleton WRRF, effluent limits will be derived from the results of the ACS, and the loading limits will be based on these effluent limits and the design average daily flow for the plant. Provided the Humber River is still Policy 2 for total phosphorus, the existing phosphorus loads will need to be maintained, and effluent limits will need to be reduced to meet Policy 2 requirements.

6. Task 5 – Reporting

A draft and final Assimilative Capacity Study (ACS) summarizing the results of the field investigations, water quality modeling, aquatic biology assessment, and recommended effluent limits will be prepared. The assessment of erosion and fluvial geomorphology by PECG will be summarized in the text of the ACS and the complete report from PECG included as an appendix.

7. References

Gartner Lee Limited. 1999. Community of Nobleton, Class Environmental Assessment – Humber River Assimilative Capacity Assessment. Prepared for Regional Municipality of York. January 1999. GLL 98-279.

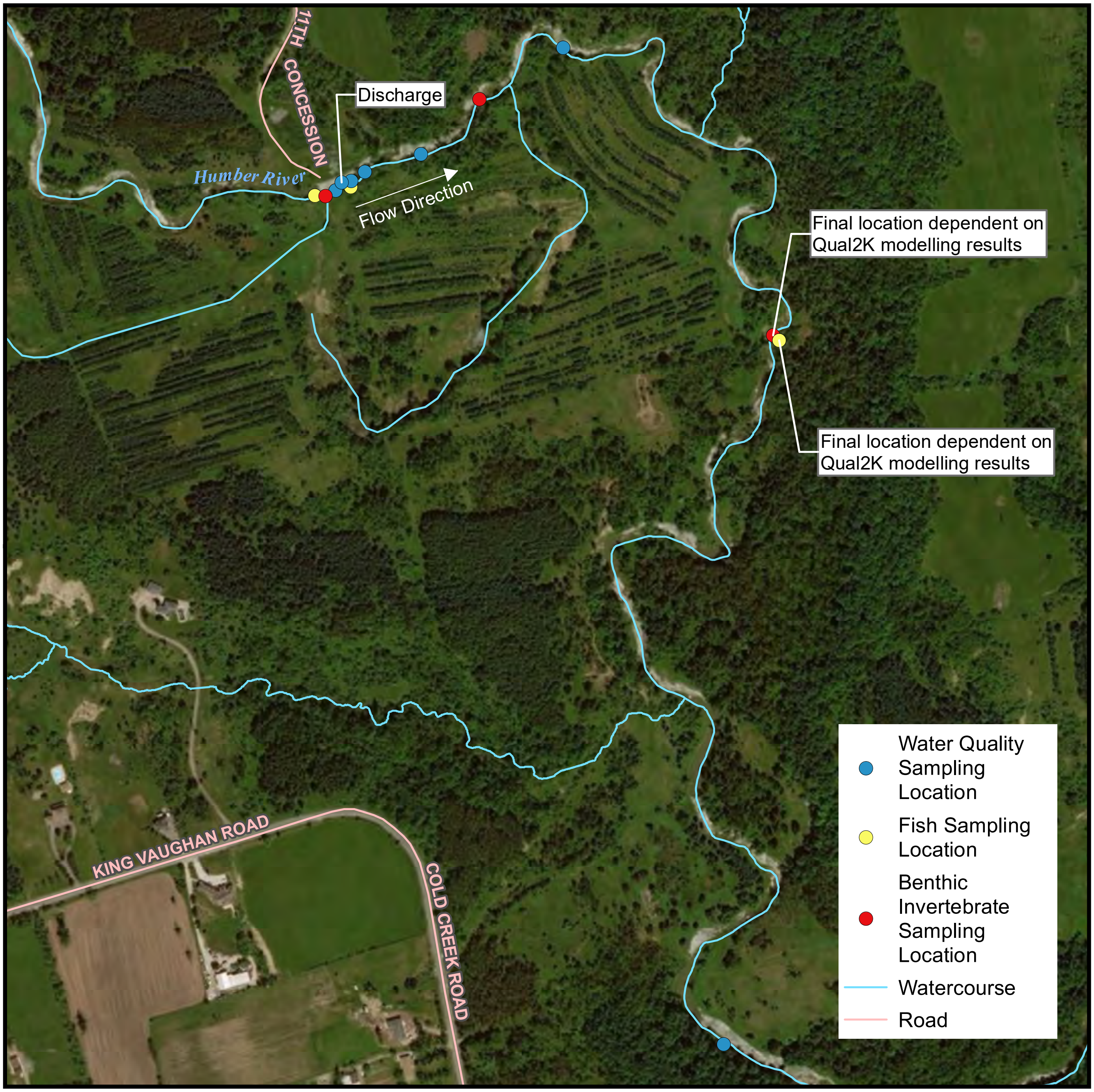
Harmel, R. D., R. J. Cooper, R. M. Slade, R. L. Haney, J. G. Arnold. 2006. Cumulative uncertainty in measured streamflow and water quality data for small watersheds. American Society of Agricultural and Biological Engineers Vol. 49(3): 689-701 ISSN 0001-2351

Ontario Ministry of Environment and Energy. 1994a. Water management policies guidelines and water quality objectives of the Ministry of Environment and Energy, July 1994. ISBN 0-7778-8473-9 rev.

Ontario Ministry of the Environment (MOE). 1994b. Deriving receiving water based point source effluent requirements for Ontario waters. PIBS#3302 Procedure B-1-5.

Steedman, R.J. 1987. Comparative Analysis of Stream Degradation and Rehabilitation in the Toronto Area. Ph.D Thesis. University of Toronto.

Toronto and Region Conservation Authority *et al*. 1998. Humber River Watershed Fisheries Management Plan. Toronto, Ontario. Draft.



N

0 50 100 200 m

Project Lead: Deborah Sinclair
Prepared by: Eric Dilligeard
Data Source: HESL, ESRI Imagery
Coordinate System: NAD 1983 UTM Zone 17N

Figure 1:
Sampling Locations

Project: Class Environmental Assessment for Water and Wastewater Servicing in the Community of Nobleton
Project #: 170008

August 9, 2017

Hutchinson Environmental Sciences Ltd.

Deborah Sinclair

From: Amanda McKay <amckay@matrix-solutions.com>
Sent: January 18, 2018 8:25 AM
To: Deborah Sinclair
Cc: Sam Bellamy
Subject: RE: HUmber River Flows

Hi Deborah,
Thanks for the chat on Tuesday.
I have calculated estimates of return period low flows for the Humber River at the WWTF outlet. They are in the table below with assumptions listed.
Note that I have not corrected for any water takings or WWTP discharges.

Estimated Humber River Low Flows at the WWTF Outlet

Return Period Low Flow	Flow (m3/s)
7Q2	0.74
7Q10	0.56
7Q20	0.51

Notes
*Prorated from WSC Station (02HC025) assuming a drainage area of 270 km2 at the WWTF outlet
**Includes data from 1963 to 2002 and 2008 to 2016 inclusive
***Log Pearson Type 3 Distribution

Let me know if you want to chat at all,

Amanda McKay, P.Eng.
Water Resources Engineer
Matrix Solutions Inc.
Direct 289.323.3780 **Cell** 519.803.3208

From: Neil Hutchinson [mailto:Neil.Hutchinson@environmentalsciences.ca]
Sent: Friday, November 17, 2017 8:41 AM
To: Deborah Sinclair; Amanda McKay
Subject: HUmber River Flows

Hi Folks – I said that I would connect the two of you to coordinate on flow statistics for the Nobleton project to make sure we are consistent.

Neil

Appendix B. Water Quality Results

Table B1 Field Measurements

Date	Station	Water Temp °C	Specific Conductivity	Conductivity	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH
			μS/cm[c]	μS/cm			
PWQO					**a**	**a**	**6.5-8.5**
ECA Limit							**6.0-9.0**
31-May-17	Up-Stream	16.07	606	504	152.5	14.99	8.42
	Effluent	17.28	1947	1659	158.6	15.16	7.57
	DS-10m	16.37	602	506	154.9	15.24	8.45
	DS-30m	18.21	611	532	164.2	15.45	8.49
	DS-100	17.83	606	523	164.0	15.56	8.49
	DS-350	17.21	575	488	152.0	14.65	8.49
27-Jun-17	Up-Stream	17.43	556	476	96.7	9.25	8.25
	Effluent	16.90	1622	1378	87.1	8.4	7.66
	DS-10m	17.55	548	470	98.8	9.43	8.28
	DS-30m	17.52	552	472	98.7	9.43	8.29
	DS-100	17.33	522	446	98.6	9.46	8.19
01-Aug-17	Up-Stream	19.91	565	510	140.1	12.84	8.33
	Effluent	18.99	1863	1644	94.2	8.72	7.43
	DS-10m	19.40	574	515	136.8	12.57	8.30
	DS-30m	18.98	580	512	129.6	12.03	8.25
	DS-100	18.62	586	515	126.0	11.76	8.23
	DS-350	18.30	580	506	122.9	11.54	8.17
	DS-1.7 km	22.01	576	543	117.8	8.33	8.33
29-Aug-17	Up-Stream	19.11	589	519	133.6	12.35	8.41
	Effluent	18.87	1945	1717	85.1	7.87	7.85
	DS-10m	18.77	589	520	132.0	12.29	8.39
	DS-30m	18.20	600	523	128.0	12.06	8.39
	DS-100	17.79	608	524	127.0	12.06	8.37
	DS-350	17.41	605	617	121.4	11.72	8.28
	DS-1.7 km	15.73	501	609	108.2	10.72	8.21
20-Sep-17	Up-Stream	19.67	624	561	122.6	11.12	8.31
	Effluent	19.57	2078	1860	84.4	7.64	7.58
	DS-10m	19.11	640	569	118.6	10.95	8.31
	DS-30m	18.89	646	574	116.7	10.83	8.29
	DS-100	18.47	641	561	112.2	10.54	8.26
	DS-350	18.00	646	560	112.5	10.63	8.21
13-Oct-17	Up-Stream	11.83	576	431	107.9	11.6	8.33
	Effluent	16.77	1646	1387	87.1	8.35	7.51
	DS-10m	11.74	593	442	112.4	12.07	8.32
	DS-30m	11.65	584	436	109.4	11.88	8.31
	DS-100	11.59	581	432	112.1	12.14	8.30
	DS-350	11.58	586	436	113.2	12.28	8.26
05-Feb-18	Up-Stream	0.09	742	386	107.9	15.74	8.02
	Effluent	6.51	2149	1390	107.6	13.13	7.44
	DS-10m	0.06	750	392	109.4	15.95	8.01
	DS-30m	0.14	800	416	108.0	15.75	7.98
	DS-100	0.05	770	403	109.0	15.82	7.86

Table B2 - Water Quality Characterization Results

Sites	Sample Date	[1]Total Suspended Solids (mg/L)	Volatile Suspended Solids (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Orthophosphate (mg/L)	Chlorophyll a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Total Ammonia (as N) (mg/L)	Un-ionized Ammonia (as N) (mg/L)	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Nitrate and Nitrite as N (mg/L)	Chloride (Cl) (mg/L)	BOD Carb, 5 day (mg/L)	BOD Carb, 20 Day (mg/L)	[2]Total Alkalinity, (as CaCO3) (mg/L)
PWQO/CWQG				0.03						0.0164	3	0.06		120			
Upstream	31-May	33.5	4.9	0.0373	0.0092	0.0048	4.97	0.65	0.106	0.0076	0.331	< 0.01	0.331	54.9	< 2	< 2	237
	27-Jun	409		0.2770	0.0138	0.0124		2.02	0.064	0.0035	0.812	< 0.01	0.812	45.8	< 2	3	214
	1-Aug	6.6	< 3	0.0168	0.0089	0.0073	2.57	0.36	0.036	0.0028	0.160	< 0.01	0.16	46.2	< 2	2.2	223
	29-Aug	2.5	< 3	0.0129	0.007	< 0.003	1.38	< 0.15	< 0.020	0.0017	0.137	< 0.01	0.137	50.4	< 2	2.1	227
	20-Sep	2.6		0.0129	0.0065	0.0031		< 0.15	0.056	0.0041	0.180	< 0.01	0.18	48.9	< 2	< 2	241
	13-Oct	14.4		0.0304	0.0168	0.0077		0.37	0.024	0.0010	0.297	< 0.01	0.297	50.4	< 2	< 2	244
	5-Feb			0.0186	0.0082	0.0072		0.29	0.178	0.0015	0.695	< 0.01	0.695	85.8	< 2	2.1	262
	Median	10.5	3.0	0.019	0.009	0.007	2.57	0.36	0.056	0.0028	0.30	0.01	0.30	50.4	2.0	2.1	237
	75th percentile	28.7	4.0	0.034	0.012	0.008	3.77	0.51	0.085	0.0038	0.513	0.01	0.51	52.7	2.0	2.2	243
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
Wetland Outle	31-May	7.6	< 3	0.0628	0.0321	0.0079	3.65	0.37	0.129	0.0015	19.8	< 0.01	19.8	414	< 2	3.6	185
	27-Jun	25		0.0577	0.026	0.0097		1.04	0.033	0.0005	13.9	< 0.01	13.9	320	< 2	3.3	197
	1-Aug	8.4	< 3	0.0590	0.0352	0.0162	2.61	1.26	0.056	0.0005	16.6	< 0.05	16.6	425	< 2	3.7	201
	29-Aug	9.2	< 3	0.0456	0.0217	0.0131		0.82	0.075	0.0019	22.3	< 0.05	22.3	432	< 2	< 2	185
	20-Sep	8.2		0.0448	0.032	0.0138		0.88	0.075	0.0011	18.0	< 0.1	18	430	< 2	< 2	190
	13-Oct	7.3		0.0565	0.0374	0.0176		1.02	0.046	0.0005	18.2	< 0.05	18.2	372	< 2	2.7	188
	5-Feb			0.0342	0.0211	0.005		1.77	0.597	0.0023	26.0	< 0.01	26.145	503	< 2	4.5	132
	Median	8.3	3.0	0.057	0.032	0.013		1.02	0.075	0.0011	18.20	0.05	18.20	425	2.0	3.3	188
	75th percentile	9.0	3.0	0.058	0.034	0.015	3.39	1.15	0.102	0.0017	21.05	0.05	21.05	431	2.0	3.7	194
	N	6	3	7	7	7	2	7	7	7	7	7	7	7	7	7	7
10 m d/s	31-May	28.8	3.4	0.0363	0.0111	0.0059	5.12	0.46	0.082	0.0064	0.307	< 0.01	0.307	53.2	< 2	2.1	231
	27-Jun	84.8		0.0847	0.0167	0.0138		1.01	0.045	0.0007	0.359	< 0.01	0.359	45.9	< 2	2.2	213
	1-Aug	7.2	< 3	0.0174	0.0087	0.0052	1.14	0.37	0.048	0.0033	0.405	< 0.01	0.405	58.9	< 2	< 2	226
	29-Aug	2.4	< 3	0.0109	0.006	0.0033	1.4	< 0.15	< 0.02	0.0016	0.140	< 0.01	0.14	46.9	< 2	< 2	227
	20-Sep	3.1		0.0110	0.006	0.0033		0.22	0.103	0.0072	0.221	< 0.01	0.221	50.1	< 2	< 2	238
	13-Oct	12.9		0.0310	0.0132	0.0078		0.41	0.046	0.0019	0.328	< 0.01	0.328	50.5	< 2	2.1	241
	5-Feb			0.0167	0.0074	0.008		0.3	0.157	0.0013	1.4	< 0.01	1.4	97.9	< 2	< 2	252
	Median	10.1	3.0	0.017	0.009	0.006	1.40	0.37	0.048	0.0019	0.33	0.01	0.33	50.5	2.0	2.0	231
	75th percentile	24.8	3.2	0.034	0.012	0.008	3.26	0.44	0.093	0.0049	0.38	0.01	0.38	56.1	2.0	2.1	240
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
30 m d/s	31-May	27.2	< 3	0.0373	0.0108	0.0062	3.3	0.36	0.053	0.0051	0.488	< 0.01	0.488	58.4	< 2	< 2	228
	27-Jun	88.1		0.0885	0.0177	0.0128		0.81	0.042	0.0025	0.417	< 0.01	0.417	46.7	< 2	2.1	205
	1-Aug	7.4	3.2	0.0156	0.0072	0.0041	1.6	0.31	0.026	0.0016	0.194	< 0.01	0.194	53.7	< 2	< 2	231
	29-Aug	2.9	< 3	0.0125	0.006	< 0.003	1.6	< 0.15	< 0.02	0.0016	0.254	< 0.01	0.254	53.0	< 2	< 2	236
	20-Sep	2.5		0.0102	0.011	0.0038		0.17	0.038	0.0025	0.365	< 0.01	0.365	53.4	< 2	< 2	236
	13-Oct	15.3		0.0287	0.0156	0.009		0.41	0.228	0.0095	0.400	< 0.01	0.4	52.5	< 2	2.2	242
	5-Feb			0.0163	0.0094	0.0076		0.53	0.157	0.0012	1.63	< 0.01	1.63	101	< 2	2.2	251
	Median	11.4	3.0	0.016	0.011	0.006	1.60	0.36	0.042	0.0025	0.40	0.01	0.40	53.4	2.0	2.0	236
	75th percentile	24.2	3.1	0.033	0.013	0.008	2.45	0.47	0.105	0.0038	0.45	0.01	0.45	56.1	2.0	2.2	239
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
100 m d/s	31-May	29.3	3.7	0.0326	0.0122	0.0057	3.44	0.33	0.024	0.0022	0.394	< 0.01	0.394	56.5	< 2	2.4	247
	27-Jun	86.6		0.0724	0.0197	0.0138		0.79	0.047	0.0022	0.420	< 0.01	0.42	43.0	< 2	2.9	195
	1-Aug	9.2	< 3	0.0194	0.0074	0.0047	2.34	0.31	0.035	0.0020	0.436	< 0.01	0.436	59.3	< 2	< 2	230
	29-Aug	3.2	< 3	0.0119	0.0058	< 0.003	1.54	< 0.15	< 0.02	0.0012	0.312	< 0.01	0.312	54.0	< 2	2.1	234
	20-Sep	3.6		0.0128	0.0083	0.0052		0.16	0.07	0.0042	0.316	< 0.01	0.316	52.1	< 2	< 2	238
	13-Oct	17.1		0.0321	0.0149	0.0087		0.42	0.035	0.0014	0.352	< 0.01	0.352	51.2	< 2	2.1	251
	5-Feb			0.0166	0.0086	0.0072		0.4	0.151	0.0009	1.1	0.145	1.1	92.7	< 2	2.1	256
	Median	13.2	3.0	0.019	0.009	0.006	2.34	0.33	0.035	0.0020	0.39	0.01	0.39	54.0	2.0	2.1	238
	75th percentile	26.3	3.4	0.032	0.014	0.008	2.89	0.41	0.059	0.0022	0.43	0.01	0.43	57.9	2.0	2.3	249
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
350 m d/s	31-May	31.7	10.4	0.0381	0.0089	0.0053	4.35	0.47	0.093	0.0083	0.395	< 0.01	0.395	56.2	< 2	< 2	232
	1-Aug	9.2	< 3	0.0209	0.0064	0.005	1.98	0.29	< 0.02	0.0010	0.317	< 0.01	0.317	56.4	< 2	< 2	233
	29-Aug	3.1	< 3	0.0101	0.0069	< 0.003	1.71	< 0.15	< 0.02	0.0012	0.257	< 0.01	0.257	53.0	< 2	< 2	232
	20-Sep	3.9		0.0119	0.006	0.0036		0.19	0.073	0.0038	0.352	< 0.01	0.352	52.8	< 2	< 2	241
	13-Oct	19.2		0.0317	0.0145	0.0076		0.49	0.056	0.0020	0.454	< 0.01	0.454	53.3	< 2	2.4	249
	Median	9.2	3.0	0.021	0.007	0.005	1.98	0.29	0.056	0.0020	0.35	0.01	0.35	53.3	2.0	2.0	233
	75th percentile	19.2	6.7	0.032	0.009	0.005	3.17	0.47	0.073	0.0038	0.40	0.01	0.40	56.2	2.0	2.0	241
	N	5	3	5	5	5	3	5	5	5	5	5	5	5	5	5	5
1.7 km d/s	1-Aug	< 2	< 3	0.0165	0.0064	0.0036	2.32	0.26	0.031	0.0027	0.276	< 0.01	0.276	56.2	< 2	< 2	232
	29-Aug	4.6	< 3	0.0161	0.0068	0.0032	2.25	< 0.15	< 0.02	0.0009	0.247	< 0.01	0.247	53.0	< 2	< 2	228

Note: [1] Accoring to CWQGs TSS is allowed an average increase of 5 mg/L during clear flow conditions and a maximum increase of 25 mg/L from background levels when background levels are between 25 and 250 mg/L.

[2] According to PWQOs alkalinity should not decrease by more than 25% of the natural concentration.

Table B3 - Wetlnd Performance Evaluation

Parameter	WRRF Date	HESL Date		WRRF (lab)		HESL data	Reduction
Total Phosphorus (mg/L)	31-May-17	31-May-17		0.167		0.0628	0.1042
	28-Jun-17	27-Jun-17		0.09		0.0577	0.0323
	02-Aug-17	1-Aug-17		0.06		0.059	0.001
	30-Aug-17	29-Aug-17		0.044		0.0456	-0.0016
	20-Sep-17	20-Sep-17		0.086		0.0448	0.0412
	10-Oct-17	13-Oct-17		0.238		0.0565	0.1815
	07-Feb-18	5-Feb-18		0.06		0.0342	0.0258
	Average			0.106		0.052	0.055
	Median			0.086		0.057	0.032
Orthophosphate (mg/L)	31-May-17	31-May-17		0.049		0.0079	0.0411
	28-Jun-17	27-Jun-17		0.019		0.0131	0.0028
	02-Aug-17	1-Aug-17		0.019		0.0162	0.0028
	30-Aug-17	29-Aug-17		0.013		0.0131	-0.0001
	20-Sep-17	20-Sep-17		0.019		0.0138	0.0052
	10-Oct-17	13-Oct-17		0.06		0.0176	0.0424
	07-Feb-18	5-Feb-18	<	0.004		0.005	-0.001
	Average			0.025		0.012	0.013
	Median			0.019		0.013	0.003
Total Ammonia Nitrogen (mg/L)	31-May-17	31-May-17		0.09		0.129	-0.039
	28-Jun-17	27-Jun-17		0.08		0.033	0.047
	02-Aug-17	1-Aug-17		0.08		0.056	0.024
	30-Aug-17	29-Aug-17	<	0.07		0.075	-0.005
	20-Sep-17	20-Sep-17		0.08		0.075	0.005
	10-Oct-17	13-Oct-17		1.3		0.046	1.254
	07-Feb-18	5-Feb-18		0.07		0.597	-0.527
	Average			0.25		0.144	0.108
	Median			0.08		0.075	0.005
Total Suspended Solids (mg/L)	31-May-17	31-May-17		13.2		7.6	5.6
	28-Jun-17	27-Jun-17		6.6		25	-18.4
	02-Aug-17	1-Aug-17		3		8.4	-5.4
	30-Aug-17	29-Aug-17		4.8		9.2	-4.4
	20-Sep-17	20-Sep-17		3.7		8.2	-4.5
	10-Oct-17	13-Oct-17		9.1		7.3	1.8
	Average			6.7		11.0	-3.6
	Median			5.7		8.3	-4.4
BOD Carbonaceous (mg/L)	31-May-17	31-May-17	<	2	<	2	0
	28-Jun-17	27-Jun-17	<	2	<	2	0
	02-Aug-17	1-Aug-17	<	2	<	2	0
	30-Aug-17	29-Aug-17	<	2	<	2	0
	20-Sep-17	20-Sep-17	<	2	<	2	0
	10-Oct-17	13-Oct-17	<	3	<	2	n/a
	07-Feb-18	5-Feb-18	<	2	<	2	0
	Average			2		2	0
	Median			2		2	0

Parameter	WRRF Date	HESL Date		WRRF (lab)		HESL data	Reduction
Nitrate (as N) (mg/L)	31-May-17	31-May-17		21.7		19.8	1.9
	28-Jun-17	27-Jun-17		16.1		13.9	2.2
	02-Aug-17	1-Aug-17		18.5		16.6	1.9
	30-Aug-17	29-Aug-17		25		22.3	2.7
	20-Sep-17	20-Sep-17		16.6		18	-1.4
	10-Oct-17	13-Oct-17		14.2		18.2	-4
	07-Feb-18	5-Feb-18		27.1		26	1.1
	Average			19.9		19.3	0.6
	Median			18.5		18.2	1.9
Total Kjeldahl Nitrogen (mg/L)	31-May-17	31-May-17		0.76		0.37	0.39
	28-Jun-17	27-Jun-17		0.69		1.04	-0.35
	02-Aug-17	1-Aug-17		0.6		1.26	-0.66
	30-Aug-17	29-Aug-17		0.57		0.82	-0.25
	20-Sep-17	20-Sep-17		0.64		0.88	-0.24
	10-Oct-17	13-Oct-17		2.11		1.02	1.09
	07-Feb-18	5-Feb-18		0.78		1.77	-0.99
	Average			0.88		1.023	-0.144
	Median			0.69		1.020	-0.250

Appendix C. CORMIX Modelling Memo

Hutchinson
Environmental Sciences Ltd.

202-501 Krug St., Kitchener ON, N2B 1L3 │519-576-1711
www.environmentalsciences.ca

Memorandum

Date: **February 25, 2019**

To: **Ted Beleyneh, MECP**

CC: **Zhifei Hu, Black and Veatch**

From: **Deborah Sinclair, Neil Hutchinson**

Re: **Preliminary ACS Results**

This memorandum provides selected water quality sampling results and preliminary modelling results for the assimilative capacity study (ACS) completed in support of the Class Environmental Assessment for Water and Wastewater Servicing in the Community of Nobleton. The purpose of this memorandum is to provide the foundation for a meeting with HESL and MECP regarding the policy status of the Humber River, modelling requirements, proposed effluent limits and contents of the ACS report.

The effluent limits for the plant will be derived on the basis of the 7Q20 flows and these occur during the summer dry period when water quality in the river is not influenced by runoff. Although water quality is important in all seasons, the river is most sensitive to effluent discharges during the low flow period. The ACS should therefore be informed by the water quality of the river during summer low flow conditions. The initial sampling program showed that water quality varied substantially with river flow and so additional sampling was carried out to confirm water quality for input to the ACS. This memo describes the approach, results and interpretation and makes recommendations for next steps.

1. 2017 Humber River Water Quality Characterization

1.1 Methods

Water quality samples were collected from the Humber River upstream of the Nobleton Water Resource Recovery Facility (WRRF), at the point of discharge from the wetland to the Humber River, 10 m, 30 m, 100 m, and 350 m downstream of the WRRF from May 2017 to February 2018.

Water samples were also collected 1.7 Km downstream of the WRRF during the August 1st and August 29th, 2017 sampling events.

Table 1 Amount of Precipitation (mm) prior to sampling events

Sampling Date	Precipitation (mm) 72 Hours Prior to Sampling	Event Type
31-May-17	13.6	Wet
27-Jun-17	7.0	Wet
1-Aug-17	0.0	Dry
29-Aug-17	0.0	Dry
20-Sep-17	0.0	Dry
13-Oct-17	4.4	Wet
5-Feb-18	6.0*	Dry

Notes: *as cm snow

During each sampling event, grab samples were collected for analysis of:

- total phosphorus (TP)
- orthophosphate (PO_4)
- total dissolved phosphorus (TDP)
- total Kjeldahl nitrogen (TKN)
- nitrate (NO_3) and nitrite (NO_2)
- total ammonia nitrogen (TAN)
- total suspended solids (TSS)
- chloride
- total alkalinity
- 5 and 20-day and carbonaceous biochemical oxygen demand ($cBOD_5$ and cBODu)
- chlorophyll a (May and August only)
- volatile suspended solids (VSS) (May and August only)

Field measurements of pH, dissolved oxygen (DO; mg/L and % saturation), temperature (°C) and specific conductivity (µS/cm) were collected with a water quality multi-parameter meter (YSI 600 QS). Stream flow was measured during each sampling event.

1.2 Results

- These results focus on the determination of the policy status of the Humber River upstream of the WRRF, and inputs into the assimilation modelling. A more detailed analysis of parameter concentrations and trends will be presented in the ACS report.
- Upstream flow in the Humber River ranged from 1,308 L/s to 3,158 L/s providing approximately 150 to 2,000 times dilution of the effluent.

Table 2 Humber River (upstream of Nobleton WRRF) and Effluent Flows

Date	Flow (L/s)		Effluent Dilution
	Humber River	Effluent*	
31-May-17	3,158	2	1,784
27-Jun-17	4,963	20	244

Date	Flow (L/s)		Effluent Dilution
	Humber River	Effluent*	
1-Aug-17	1,970	12	164
29-Aug-17	1,308	5	285
20-Sept-17	1,327	4	337
13-Oct-17	2,314	16	148
5-Feb-18	1,918	n/a	n/a

Notes: *Measured by HESL at the wetland outlet channel

- TSS, total phosphorus, total Kjeldahl nitrogen, total ammonia and un-ionized ammonia concentrations downstream of the WRRF discharge were not statistically different ($p>0.05$) than those measured upstream (Tables 3 and 4 appended). Nitrate concentrations were slightly higher downstream of the WRRF discharge; however, all measurements were well below the CWQG of 3.0 mg/L, and not statically different ($p>0.05$) from those measured upstream. Nitrite concentrations were below detection of 0.01 mg/L at every station (except the 100 m downstream station on February 5, 2018).
- TSS concentrations upstream of the WRRF discharge showed a positive exponential relationship with flow (Figure 1), indicating that elevated TSS concentrations in the river are related to runoff and erosion from high flow events. This relationship is based on five data points, and further sampling is needed to confirm the relationship.

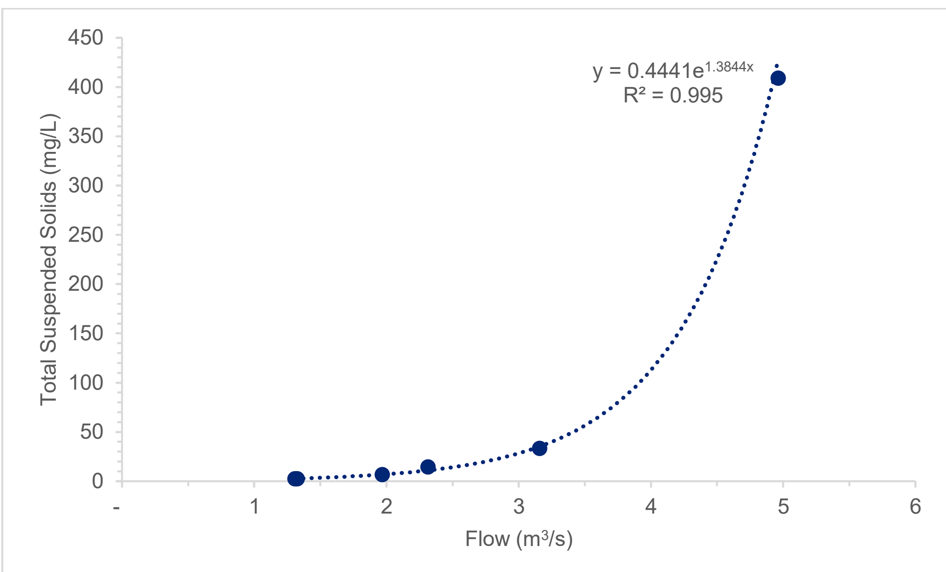


Figure 1 TSS and Flow in the Humber River Upstream of the Nobleton WRRF

- TP concentrations also showed a strong positive relationship with TSS; with high TP concentrations measured during the high flow and high TSS events,

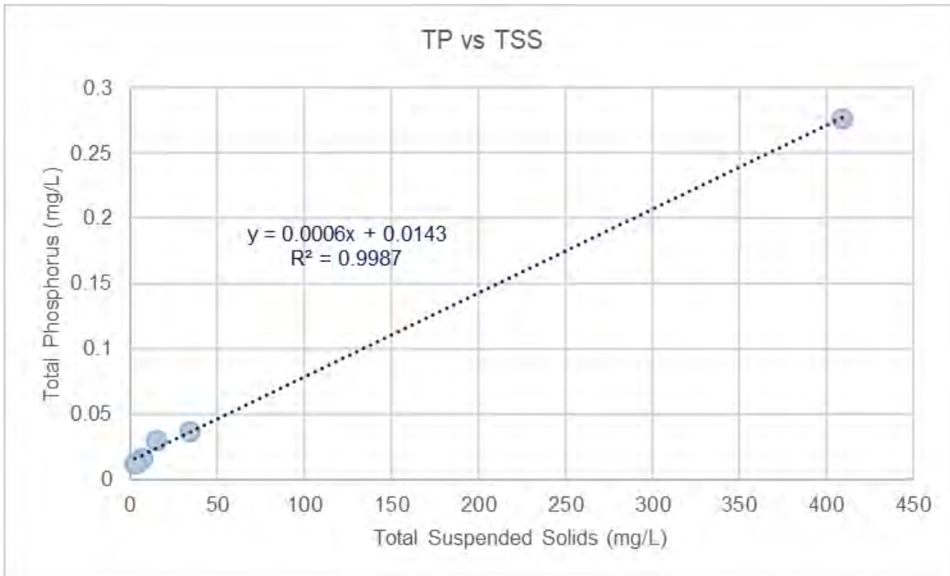


Figure 2. Relationship between TSS and TP in the Humber River Upstream of the Nobleton WRRF

- The upstream 75th percentile TP concentration was 0.034 mg/L, suggesting Policy 2 status (Table 4). This value was largely influenced by the three high flow/wet events (May, June and October), in which TSS and TP concentrations were elevated. The median TP concentration was 0.019 mg/L, for the four TP measurements taken during dry conditions (Table 1) when flow was less than 2,000 L/sec (Table 2). Additional water quality sampling was undertaken in summer/fall 2018 to further understand the TP/TSS relationship and confirm the Policy status of the Humber River for TP (Section 2.0).
- Un-ionized ammonia was well below the PWQO at all stations on all events.
- The Main Humber River upstream of the Nobleton WRRF is considered a "Policy 1" receiver for dissolved oxygen and un-ammonia based on 25th and 75th percentiles of 8.32 mg/L and 0.0028 mg/L respectively.
- Overall the Nobleton WRRF discharge had no significant effect on downstream water quality during the sampling events.

1.3 Wetland Assimilation

- Effluent from the WRRF discharges to a constructed wetland before discharging to the Humber River. The assimilation of nutrients by the wetland was evaluated by comparing the concentrations of nutrients measured in the effluent at the WRRF (by facility staff) to those measured at the outfall of the wetland (by HESL as part of the water quality sampling)[1].
- Detailed results will be provided in the ACS report, however on average, concentrations of TP, orthophosphate, total ammonia decreased (by 38%, 21%, and 23% respectively) and concentrations of TSS and TKN increased (by 102% and 38%) through the wetland.

---

[1] *WRRF and wetland effluent sampling dates were not coordinated during the study; therefore WRRF samples taken within 3 days of wetland effluent sampling were used for the analysis.*

Table 3 Field Measurements

Date	Station	Water Temp °C	Specific Conductivity µS/cm[c]	Conductivity µS/cm	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH
PWQO					**a**	**a**	**6.5-8.5**
ECA Limit							
31-May-17	Up-Stream	16.07	606	504	152.5	14.99	8.42
	Effluent	17.28	1947	1659	158.6	15.16	7.57
	DS-10m	16.37	602	506	154.9	15.24	8.45
	DS-30m	18.21	611	532	164.2	15.45	8.49
	DS-100	17.83	606	523	164	15.56	8.49
	DS-350	17.21	575	488	152	14.65	8.49
27-Jun-17	Up-Stream	17.43	556	476	96.7	9.25	8.25
	Effluent	16.9	1622	1378	87.1	8.4	7.66
	DS-10m	17.55	548	470	98.8	9.43	8.28
	DS-30m	17.52	552	472	98.7	9.43	8.29
	DS-100	17.33	522	446	98.6	9.46	8.19
	DS-350						
01-Aug-17	Up-Stream	19.91	565	510	140.1	12.84	8.33
	Effluent	18.99	1863	1644	94.2	8.72	7.43
	DS-10m	19.4	574	515	136.8	12.57	8.3
	DS-30m	18.98	580	512	129.6	12.03	8.25
	DS-100	18.62	586	515	126	11.76	8.23
	DS-350	18.3	580	506	122.9	11.54	8.17
	DS-1.7 km	22.01	576	543	117.8	8.33	8.33
29-Aug-17	Up-Stream	19.11	589	519	133.6	12.35	8.41
	Effluent	18.87	1945	1717	85.1	7.87	7.85
	DS-10m	18.77	589	520	132	12.29	8.39
	DS-30m	18.2	600	523	128	12.06	8.39
	DS-100	17.79	608	524	127	12.06	8.37
	DS-350	17.41	605	617	121.4	11.72	8.28
	DS-1.7 km	15.73	501	609	108.2	10.72	8.21
20-Sep-17	Up-Stream	19.67	624	561	122.55	11.12	8.31
	Effluent	19.57	2078	1860	84.4	7.64	7.58
	DS-10m	19.11	640	569	118.6	10.95	8.31
	DS-30m	18.89	646	574	116.7	10.83	8.29
	DS-100	18.47	641	561	112.2	10.54	8.26
	DS-350	18	646	560	112.5	10.63	8.21
	DS-1.7 km						
13-Oct-17	Up-Stream	11.83	576	431	107.9	11.6	8.33
	Effluent	16.77	1646	1387	87.1	8.35	7.51
	DS-10m	11.74	593	442	112.4	12.07	8.32
	DS-30m	11.65	584	436	109.4	11.88	8.31
	DS-100	11.59	581	432	112.1	12.14	8.3
	DS-350	11.58	586	436	113.2	12.28	8.26
	DS-1.7 km						
	Up-Stream	0.09	742	386	107.9	15.74	8.02

Date	Station	Water Temp °C	Specific Conductivity µS/cm[c]	Conductivity µS/cm	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH
05-Feb-18	Effluent	6.51	2149	1390	107.6	13.13	7.44
	DS-10m	0.06	750	392	109.4	15.95	8.01
	DS-30m	0.14	800	416	108	15.75	7.98
	DS-100	0.05	770	403	109	15.82	7.86
	DS-350						
	DS-1.7 km						

2017 Laboratory Data

Sites	Sample Date	[1]Total Suspended Solids (mg/L)	Volatile Suspended Solids (mg/L)	Phosphorus, Total (mg/L)	Phosphorus (P)-Total Dissolved (mg/L)	Orthophosphate-Dissolved (as P) (mg/L)	Chlorophyll a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Ammonia, Total (as N) (mg/L)	Un-ionized Ammonia (as N) (mg/L)	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Nitrate and Nitrite as N (mg/L)	Chloride (Cl) (mg/L)	BOD Carb, 20 Day (mg/L)	BOD Carbonaceous (mg/L)	[2]Alkalinity, Total (as CaCO3) (mg/L)
PWQO										0.0164							
CWQO		Narrative			0.03				Variable	0.016	3	0.06		120			
Upstream	31-May	33.5	4.9	0.0373	0.0092	0.0048	4.97	0.65	0.106	0.0076	0.331	< 0.01	0.331	54.9	< 2	< 2	237
	27-Jun	409		0.277	0.0138	0.0124		2.02	0.064	0.0035	0.812	< 0.01	0.812	45.8	3	< 2	214
	1-Aug	6.6	< 3	0.0168	0.0089	0.0073	2.57	0.36	0.036	0.0028	0.16	< 0.01	0.16	46.2	2.2	< 2	223
	29-Aug	2.5	< 3	0.0129	0.007	< 0.003	1.38	< 0.15	< 0.020	0.0017	0.137	< 0.01	0.137	50.4	2.1	< 2	227
	20-Sep	2.6		0.0129	0.0065	0.0031		< 0.15	0.056	0.0041	0.18	< 0.01	0.18	48.9	< 2	< 2	241
	13-Oct	14.4		0.0304	0.0168	0.0077		0.37	0.024	0.0010	0.297	< 0.01	0.297	50.4	< 2	< 2	244
	5-Feb			0.0186	0.0082	0.0072		0.29	0.178	0.0015	0.695	< 0.01	0.695	85.8	2.1	< 2	262
	Median	10.5	3.0	0.019	0.009	0.007	2.57	0.36	0.056	0.0028	0.30	0.01	0.30	50	2.1	2.0	237
	75th percentile	28.7	4.0	0.034	0.012	0.008	3.77	0.51	0.085	0.0038	0.51	0.01	0.51	53	2.2	2.0	243
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
Effluent	31-May	7.6	< 3	0.0628	0.0321	0.0079	3.65	0.37	0.129	0.0015	19.8	< 0.01	19.8	414	3.6	< 2	185
	27-Jun	25		0.0577	0.026	0.0097		1.04	0.033	0.0005	13.9	< 0.01	13.9	320	3.3	< 2	197
	1-Aug	8.4	< 3	0.059	0.0352	0.0162	2.61	1.26	0.056	0.0005	16.6	< 0.05	16.6	425	3.7	< 2	201
	29-Aug	9.2	< 3	0.0456	0.0217	0.0131		0.82	0.075	0.0019	22.3	< 0.05	22.3	432	< 2	< 2	185
	20-Sep	8.2		0.0448	0.032	0.0138		0.88	0.075	0.0011	18	< 0.1	18	430	< 2	< 2	190
	13-Oct	7.3		0.0565	0.0374	0.0176		1.02	0.046	0.0005	18.2	< 0.05	18.2	372	2.7	< 2	188
	5-Feb			0.0342	0.0211	0.005		1.77	0.597	0.0023	26	< 0.01	26.145	503	4.5	< 2	132
	Median	8.3	3.0	0.057	0.032	0.013	3.13	1.02	0.075	0.0011	18.20	0.05	18.20	425	3.3	2.0	188
	75th percentile	9.0	3.0	0.058	0.034	0.015	3.39	1.15	0.102	0.0017	21.05	0.05	21.05	431	3.7	2.0	194
	N	6	3	7	7	7	2	7	7	7	7	7	7	7	7	7	7
10 m d/s	31-May	28.8	3.4	0.0363	0.0111	0.0059	5.12	0.46	0.082	0.0064	0.307	< 0.01	0.307	53.2	2.1	< 2	231
	27-Jun	84.8		0.0847	0.0167	0.0138		1.01	0.045	0.0007	0.359	< 0.01	0.359	45.9	2.2	< 2	213
	1-Aug	7.2	< 3	0.0174	0.0087	0.0052	1.14	0.37	0.048	0.0033	0.405	< 0.01	0.405	58.9	< 2	< 2	226
	29-Aug	2.4	< 3	0.0109	0.006	0.0033	1.4	< 0.15	< 0.02	0.0016	0.14	< 0.01	0.14	46.9	< 2	< 2	227
	20-Sep	3.1		0.011	0.006	0.0033		0.22	0.103	0.0072	0.221	< 0.01	0.221	50.1	< 2	< 2	238
	13-Oct	12.9		0.031	0.0132	0.0078		0.41	0.046	0.0019	0.328	< 0.01	0.328	50.5	2.1	< 2	241
	5-Feb			0.0167	0.0074	0.008		0.3	0.157	0.0013	1.4	< 0.01	1.4	97.9	< 2	< 2	252
	Median	10.1	3.0	0.017	0.009	0.006	1.40	0.37	0.048	0.0019	0.33	0.01	0.33	51	2.0	2.0	231
	75th percentile	24.8	3.2	0.034	0.012	0.008	3.26	0.44	0.093	0.0049	0.38	0.01	0.38	56	2.1	2.0	240
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
30 m d/s	31-May	27.2	< 3	0.0373	0.0108	0.0062	3.3	0.36	0.053	0.0051	0.488	< 0.01	0.488	58.4	< 2	< 2	228
	27-Jun	88.1		0.0885	0.0177	0.0128		0.81	0.042	0.0025	0.417	< 0.01	0.417	46.7	2.1	< 2	205
	1-Aug	7.4	3.2	0.0156	0.0072	0.0041	1.6	0.31	0.026	0.0016	0.194	< 0.01	0.194	53.7	< 2	< 2	231
	29-Aug	2.9	< 3	0.0125	0.006	< 0.003	1.6	< 0.15	< 0.02	0.0016	0.254	< 0.01	0.254	53	< 2	< 2	236
	20-Sep	2.5		0.0102	0.011	0.0038		0.17	0.038	0.0025	0.365	< 0.01	0.365	53.4	< 2	< 2	236
	13-Oct	15.3		0.0287	0.0156	0.009		0.41	0.228	0.0095	0.4	< 0.01	0.4	52.5	2.2	< 2	242
	5-Feb			0.0163	0.0094	0.0076		0.53	0.157	0.0012	1.63	< 0.01	1.63	101	2.2	< 2	251
	Median	11.4	3.0	0.016	0.011	0.006	1.60	0.36	0.042	0.0025	0.40	0.01	0.40	53	2.0	2.0	236
	75th percentile	24.2	3.1	0.033	0.013	0.008	2.45	0.47	0.105	0.0038	0.45	0.01	0.45	56	2.2	2.0	239
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
100 m d/s	31-May	29.3	3.7	0.0326	0.0122	0.0057	3.44	0.33	0.024	0.0022	0.394	< 0.01	0.394	56.5	2.4	< 2	247
	27-Jun	86.6		0.0724	0.0197	0.0138		0.79	0.047	0.0022	0.42	< 0.01	0.42	43	2.9	< 2	195
	1-Aug	9.2	< 3	0.0194	0.0074	0.0047	2.34	0.31	0.035	0.0020	0.436	< 0.01	0.436	59.3	< 2	< 2	230
	29-Aug	3.2	< 3	0.0119	0.0058	< 0.003	1.54	< 0.15	< 0.02	0.0012	0.312	< 0.01	0.312	54	2.1	< 2	234
	20-Sep	3.6		0.0128	0.0083	0.0052		0.16	0.07	0.0042	0.316	< 0.01	0.316	52.1	< 2	< 2	238
	13-Oct	17.1		0.0321	0.0149	0.0087		0.42	0.035	0.0014	0.352	< 0.01	0.352	51.2	2.1	< 2	251
	5-Feb			0.0166	0.0086	0.0072		0.4	0.151	0.0009	1.1	0.145	1.1	92.7	2.1	< 2	256
	Median	13.2	3.0	0.019	0.009	0.006	2.34	0.33	0.035	0.0020	0.39	0.01	0.39	54	2.1	2.0	238
	75th percentile	26.3	3.4	0.032	0.014	0.008	2.89	0.41	0.059	0.0022	0.43	0.01	0.43	58	2.3	2.0	249
	N	6	3	7	7	7	3	7	7	7	7	7	7	7	7	7	7
350 m d/s	31-May	31.7	10.4	0.0381	0.0089	0.0053	4.35	0.47	0.093	0.0083	0.395	< 0.01	0.395	56.2	< 2	< 2	232
	1-Aug	9.2	< 3	0.0209	0.0064	0.005	1.98	0.29	< 0.02	0.0010	0.317	< 0.01	0.317	56.4	< 2	< 2	233
	29-Aug	3.1	< 3	0.0101	0.0069	< 0.003	1.71	< 0.15	< 0.02	0.0012	0.257	< 0.01	0.257	53	< 2	< 2	232
	20-Sep	3.9		0.0119	0.006	0.0036		0.19	0.073	0.0038	0.352	< 0.01	0.352	52.8	< 2	< 2	241
	13-Oct	19.2		0.0317	0.0145	0.0076		0.49	0.056	0.0020	0.454	< 0.01	0.454	53.3	2.4	< 2	249
	5-Feb															< 2	
	Median	9.2	3.0	0.021	0.007	0.005	1.98	0.29	0.056	0.0020	0.35	0.01	0.35	53	2.0	2.0	233
	75th percentile	19.2	6.7	0.032	0.009	0.005	3.17	0.47	0.073	0.0038	0.40	0.01	0.40	56	2.0	2.0	241
	N	5	3	5	5	5	3	5	5	5	5	5	5	5	5	6	5
1.7 km d/s	1-Aug	< 2	< 3	0.0165	0.0064	0.0036	2.32	0.26	0.031	0.0027	0.276	< 0.01	0.276	56.2	< 2	< 2	232
	29-Aug	4.6	< 3	0.0161	0.0068	0.0032	2.25	< 0.15	< 0.02	0.0009	0.247	< 0.01	0.247	53	< 2	< 2	228

Note: [1] Acording to CWQGs TSS is allowed an average increase of 5 mg/L during clear flow conditions and a maximum increase of 25 mg/L from background levels when background levels are between 25 and 250 mg/L.

[2] According to PWQOs alkalinity should not decrease by more than 25% of the natural concentration.

- Wetland performance varied between events, and TP was the only parameter that was significantly different ($p < 0.05$) between the plant and wetland outlet.
- This shows that the wetland has acted as a sink for phosphorus, and inconsistently ammonia, but a source of organic nitrogen (as TKN) and suspended sediments over the period monitored, although we cannot state, from the available data, if this is true year round.

Table 5 Influence of Wetland on Effluent Concentrations

Parameter	Average	Median
Total Phosphorus	-38%	-43%
Orthophosphate	-21%	-15%
Total Ammonia Nitrogen	-23%	-18%
Total Kjeldahl Nitrogen	38%	44%
Total Suspended Solids	102%	107%
Nitrate (as N)	-2%	-9%
BOD Carbonaceous	-5%	0%

1.4 Summary

The initial program showed that the Humber River Policy designation was influenced by the flow of the river and that the resultant responses of TSS and TP to high flow events changed the Policy status from Policy 1 to Policy 2, but only during higher flows. The river was Policy 1 for TP during the summer low flow period of greatest sensitivity.

2. Additional P and TSS Sampling – Summer 2018

Additional TP and TSS sampling were completed in 2018 to confirm the policy designation of the Humber River during summer low flow conditions for which the ACS predictions are based, and the response of the river immediately downstream of the existing effluent discharge.

Water quality samples were collected from the Humber River upstream and 10 m downstream of the Nobleton WRRF outfall on:

- June 12th, 2018
- July 5th, 2018
- July 17th, 2018
- July 31st, 2018
- August 15th, 2018
- August 30th, 2018
- September 6th, 2018
- September 12th, 2018
- October 4th, 2018
- October 9th, 2018

During each sampling event, grab samples were collected for analysis of:

- total phosphorus
- total dissolved phosphorus
- total suspended solids

Field measurements of pH, dissolved oxygen (DO; mg/L and % saturation), temperature (°C) and specific conductivity (µS/cm) were collected with a water quality multi-parameter meter (YSI 600 QS). Stream flow was measured during each sampling event.

2.1 Results

- These results focus on determining the TP policy status of the Humber River as input into the assimilation modelling. A comparison of upstream versus downstream concentrations will be presented in the ACS report.
- Combining the TP data sets from May 2017-February 2018 and the summer of 2018 provided upstream median and 75th percentile concentrations of 0.0165 and 0.0229 mg/L[2], indicating that the Humber River is Policy 1 for TP – and water quality must be maintained at or above the PWQO.
- The June 2017 values were not included in the analysis as the TSS value (409 mg/L) was determined to be an outlier (3.0 times the interquartile range). In the four days prior to sampling 46 mm of precipitation was recorded at Toronto North York climate station (Climate ID: 615S001), causing high flow conditions.
- The upstream median and 75th percentile TSS concentrations were 6.6 and 10.6 mg/L.

Table 6 2017 and 2018 TSS and TP data from the Humber River Upstream of the Nobleton WRRF.

Date	TSS	TP	Wet/Dry event[1]
31-May-17	33.5	0.0373	Wet
27-Jun-17	409.0	0.2770	Wet
01-Aug-17	6.6	0.0168	Dry
29-Aug-17	2.5	0.0129	Dry
20-Sep-17	2.6	0.0129	Dry
13-Oct-17	14.4	0.0304	Wet
05-Feb-18		0.0186	Dry
12-Jun-18	5.2	0.0151	Dry
04-Jul-18	6.7	0.0161	Dry
17-Jul-18	9.7	0.0222	Wet
31-Jul-18	2.3	0.0124	Dry
15-Aug-18	2.8	0.0150	Dry

[2] *June 2017 values were removed from the analysis as the TSS value (409 mg/L) was determined to be an outlier (3.0 times the interquartile range)*

Date	TSS	TP	Wet/Dry event[1]
30-Aug-18	13.2	0.0334	Dry
06-Sep-18	4.4	0.0129	Dry
12-Sep-18	4	0.0140	Wet
04-Oct-18	11.3	0.0200	Wet
09-Oct-18	9.9	0.0251	Wet
Median[2]	**6.6**	**0.0165**	
75th Percentile[1]	**10.6**	**0.0229**	

Notes:1 – Wet event determined as greater than 5 mm of precipitation recorded 72 hours prior to sampling. 2- June 2017 values removed from analysis as determined to be an outlier

- A positive relationship between flow and TSS (R^2=0.7032)[3] was observed, confirming that elevated TSS in the Humber River is from runoff and erosion from high flow events.

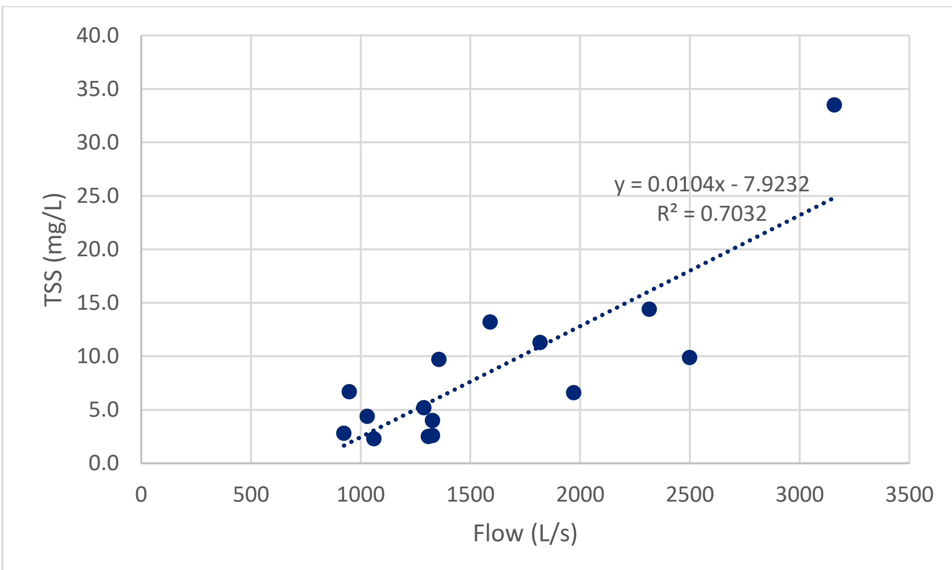


Figure 3 TSS and Flow relationship in Humber River Upstream of Nobleton WRRF (2017 and 2018 data)

- A positive relationship between TSS and total phosphorus was also observed (R^2=0.7925).

[3] *June 2017 values were removed from the analysis as the TSS value (409 mg/L) was determined to be an outlier (3.0 times the interquartile range)*

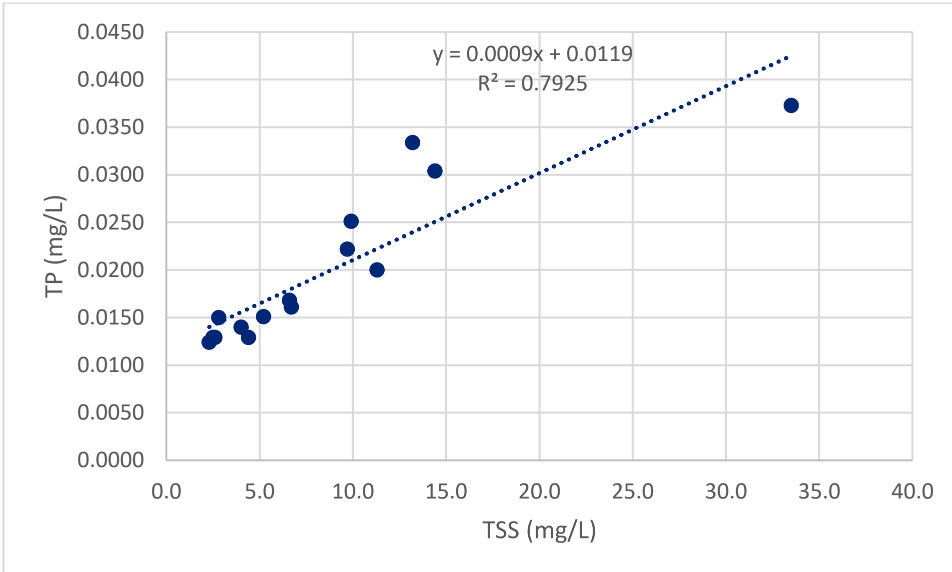


Figure 4 TSS and TP relationship in Humber River Upstream of Nobleton WRRF (2017 and 2018 data)

- Solving the regression equation for the PWQO of 0.03 mg/L, provides a TSS concentration of 20 mg/L such that, PWQO exceedances are generally associated with TSS values over 20 mg/L.
- TSS concentrations above 20 mg/L, typically occur during high-flow events, when flows are greater than ~2,700 L/s.
- This relationship demonstrates that erosion and runoff in other parts of the watershed are responsible for high concentrations of TP in the Humber River after summer rain events, or in the spring and fall when flows are higher driving TP concentrations above the PWQO.
- A 75th percentile TP concentration of 0.0165 mg/L that represents summer conditions (June to September[4]) is more representative of actual conditions in the Humber River during low flow conditions and will be used in the ACS for water quality predictions.

3. Nobleton WRRF Effluent Quality

- Existing effluent quality from the Nobleton WRRF was reviewed to establish modelling inputs for assessing the effects of the Nobleton WRRF re-rating on Humber River water quality.
- The current ECA limits for the Nobleton WRRF are presented in Table 7.

[4] *June 2017 values were removed from the analysis as the TSS value (409 mg/L) was determined to be an outlier (3.0 times the interquartile range)*

Table 7. Current Effluent Objectives and Limits (ECA 8678-B38R26)

Effluent Parameter	Units	Effluent Objectives (mg/L)	Effluent Limits	
			Monthly Average Concentration (mg/L)	Monthly Average Loading (kg/d)
5-day Carbonaceous biochemical oxygen demand ($CBOD_5$)	mg/L	5	10	
Total Suspended Solids	mg/L	7	10	
Total Phosphorus	mg/L	0.1	0.15	160
Total Ammonia Nitrogen (Ammonia Nitrogen + Ammonium Nitrogen)	mg/L	0.5 (May 1 – Oct 31) 2.0 (Nov 1 – Apr 30)	1.0 (May 1 – Oct 31) 3.0 (Nov 1 – Apr 30)	
E. coli	Counts/ 100 mL	100	200	-
pH	n/a	6.5 – 8.5	6.0 – 9.5	

- The facility became fully operational in 2014.
- A summary of the 2014-2017 average effluent quality and quantity sampled at the facility (by facility staff) is provided in Table 8.

Table 8. Nobleton WRRF Effluent Quantity and Quality (2014-2017)

Effluent Parameter	Limit	2014	2015	2016	2017
Flow	33.9	10	11	13	16
$cBOD_5$	10	<2	<2	<2	<2
TSS	10	2.673	3.660	2.954	6.682
TP	0.15	0.037	0.058	0.067	0.103
Ammonia +NH4 as N	1.0/3.0[a]	0.068	0.084	0.119	0.145
TKN		1.174	0.664	0.675	0.758
DO		5.455	4.324	4.451	4.069
Nitrate (Calculated)		24.135	22.358	26.502	22.142

Note: all concentrations in mg/L, except flow in L/s. Data provided by Black & Veatch. a – May 1- October 31 and November 1 to April 30 limits respectively.

- Effluent flows from the facility show a steady increasing trend from 10 L/s in 2014 to 16 L/s in 2017. As of 2017 it was operating at approximately 47% of its approved capacity.
- The annual average concentrations of all parameters are below their ECA limits (Table 8).

- The annual average concentrations of cBOD, TSS, TP, and ammonia increased between 2014-2017, and concentrations of TKN, DO, and NO_3 decreased, or varied from year to year.
- It is clear that use of the current effluent loadings to recommend effluent limits is not advisable because a) the plant is not yet at capacity b) plant operational efficiency has not yet stabilized and c) effluent quality is decreasing as the plant discharge increases and it is challenging to predict how the plant will operate when it reaches capacity. Therefore, modelling of the river response at the permitted (ECA) limits and not at the existing plant operational status is a more appropriate comparison to evaluate effects.

4. Mass-Balance Modelling

- Mass balance modelling was used to predict the effect of WRRF re-rating on Humber River water quality.
- Parameters modeled include TP, TSS, TAN (and un-ionized ammonia), DO and nitrate.
- Mass-balance modelling assumes instantaneous and complete mixing of the effluent with the receiver. It does not consider the reduction of TP and TAN through the wetland or the increase in TSS, nor does it account for processes in the Humber River that would reduce phosphorus and ammonia concentrations. It therefore provides a conservative calculation of fully mixed concentrations of TP and TAN in the receiver.
- The mass balance model was completed using the 7Q20 flow and 75th percentile background concentrations of the Humber River to represent a conservative assessment. Flows will be higher and background concentrations will be lower 99.5%[5] and 75% of the time respectively; therefore, resultant fully mixed concentrations lower over 99.5% of the time.
- The current effluent limits and permitted ADF were used to represent existing conditions upon which the effects of future flows and effluent quality is compared. This is because the facility is newly operational, the facility's capacity is still increasing, and therefore effluent quality has not stabilized, and therefore cannot be considered a true representation of what the facility will be discharging once the influent flows have stabilized, and effluent processes have been optimized.

4.1 Methods

Existing Conditions– ADF of 2,925 m^3/d

- The influence of the existing permitted (ECA) loads on the Humber River were modelled using the permitted effluent flow and limits.
- Permitted loads from the WRRF were estimated by multiplying the current effluent limits (10 mg/L for TSS and cBOD, 0.15 mg/L for TP and 1 mg/L for TAN[6]) by the ADF of 2,925 m^3/d or 33.9 L/s. There are currently no limits for nitrate and so, the average 2017 effluent concentration (Table 8) was used.

[5] *Pyrce, R.S., 2004. Considering baseflow as a low flow or instream flow. WSC Report No.04-2004 Appendix, Watershed Science Centre, Peterborough, Ontario, 17 p*

[6] *The May 1-October 31 TAN limit of 1.0 mg/L was used for the modelling to simulate summer conditions when 7Q20 flows occur.*

- The total oxygen demand (TOD) of the effluent was estimated as four (4) times the TAN ECA limit of 1 mg/L (NOD load) plus the cBOD ECA limit (10 mg/L), for a TOD of 14 mg/L. The reduction in oxygen downstream of the effluent discharge was estimated by subtracting the effluent TOD load from the DO load in the Humber River and calculating the resultant oxygen concentration at 7Q20 flow.
- Humber River upstream loads were estimated by multiplying 75th percentile background concentrations by the 7Q20 flow.
- 75th percentile background concentrations are those presented in Table 4 except for TP and TSS which are presented in Table 6.
- A 7Q20 flow of 510 L/s for the Humber River at the wetland outfall was provided by Matrix Solutions. This value was calculated using Log Pearson Type III regression analysis and was reduced by 10%, to 459 L/s to account for climate change effects.
- The WRRF loads were added to the Humber River loads to predict downstream loads and concentrations (Table 9).

Future – ADF of 3,996 m^3/d

- The influence of the future loads from the WRRF on the Humber River was modelled using proposed effluent flows and limits.
- York Region would like to increase the ADF from the WRRF to 3,996 m^3/d, an increase of 1,071 m^3/d or 37%, while maintaining the existing treatment technologies (i.e. sand filters). They propose to keep the existing effluent limits for TSS, cBOD, and TAN, and reduce the effluent limit for TP by 25% to 0.12 mg/L (with a reduced effluent objective of 0.10 mg/L) to maintain similar TP loads to the receiver. The Humber River is Policy 1 for TP, un-ionized ammonia, dissolved oxygen and nitrate, and therefore, water quality must be maintained at or above the PWQOs, however some degradation of existing water quality is permissible.
- Future loads from the WRRF were therefore estimated by multiplying the current effluent limits for TSS, cBOD, TAN, and a reduced effluent limit of 0.12 mg/L (and objective of 0.10 mg/L) for TP by the proposed ADF of 3,996 m^3/d or 46.3 L/s. The current effluent limit of 0.15 mg/L was also modelled for TP, as a comparison for of the reduced effluent limit results.
- Future WRRF loads were added to upstream background loads to determine the effect on downstream concentrations (Table 10).

4.2 Results

- The 7Q20 flow of 459 L/s (including 10% reduction for climate change) provides 13.5 and 9.9 times dilution of the effluent under existing and future WRRF conditions respectively. Flows, and hence effluent dilution will be higher 99.5% of the time.
- Modeling results for existing permitted conditions show that under 7Q20 conditions, concentrations of TP, TSS, TAN, and NO_3 are predicted to increase downstream of the WRRF but remain below their respective PWQOs and CWQG (Table 9).
- The modelling results for future conditions (Table 10) were compared to current conditions to predict changes to water quality of the Humber River from re-rating the Nobleton WRRF.

- At the current effluent TP limit of 0.15 mg/L, TP concentrations will increase by 0.003 mg/L from existing conditions, but will remain just below the PWQO at 0.029 mg/L.
- At the proposed reduced effluent limit of 0.12 mg/L TP concentrations in the river are predicted to stay the same (0.026 mg/L). This is because the future and existing loadings are sufficiently similar, therefore downstream water quality is maintained. At the effluent objective of 0.10 mg/L concentrations will increase by 0.002 mg/L to 0.024 mg/L compared to current conditions. Concentrations will remain well below the PWQO of 0.03 mg/L, and therefore provide additional capacity for downstream discharges.
- TSS concentrations are predicted to increase by 0.1 mg/L. At the prosed effluent flows there will be no discernable change in TSS concentration downstream of the WRRF.
- TAN concentrations are predicted to increase by 0.021 mg/L from existing permitted conditions to 0.169 mg/L – this equates to an un-ionized ammonia concentration of 0.0131 mg/L-N, below the PWQO of 0.0164 mg/L.
- These results show that the re-rating of the WRRF facility at current effluent limits will increase the concentration of TP, TAN, TSS, and NO_3 downstream under 7Q20 flow conditions, but concentrations will remain low and below their respective PWQOs or CWQG, maintaining the policy status of the river.
- By reducing the TP effluent limit to 0.012 mg/L, existing downstream concentrations in the Humber River will be maintained and additional capacity is still available for downstream discharges.
- These predictions do not consider the reduction in TP through the wetland.

Table 9 Humber River Mass Balance Modelling Results –Existing Rated Capacity

	Humber River Upstream			Effluent			Humber River Downstream			
	75th Conc	7Q20	Load	Conc	Flow	Load	Load	Flow	Conc	Change
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L
TP – limit	0.0165	459	8	0.15	33.9	5.1	12.7	492.9	0.026	0.009
TP – objective	0.0165	459	8	0.1	33.9	3.4	11.0	492.9	0.022	0.006
TSS	6.7	459	3075	10	33.9	339	3414	492.9	6.9	0.2
TAN	0.085	459	39	1.00	33.9	33.9	73	492.9	0.148	0.063
NO3	0.51	459	234	22[a]	33.9	746	980	492.9	1.99	1.48
cBOD	2	459	918	10	33.9	339	1257	492.9	2.6	0.6
DO	8.32	459	3819	14	33.9	475	3344	492.9	6.78	-1.54

Note: a – average effluent concentration (2017), b- for DO the 25% used for Humber River concentrations and 4*NH3 + BOD used for plant effluent for TOD

Table 10 Humber River Mass Balance Modelling Results – Future Conditions

	Humber River Upstream			Effluent			Humber River Downstream				Change from Existing
	75th Conc	7Q20	Load	Conc	Flow	Load	Load	Flow	Conc	Change	
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L	mg/L
TP – current limit	0.0165	459	8	0.15	46.3	6.9	15	505.3	0.029	0.012	0.003
TP – proposed limit	0.0165	459	8	0.12	46.3	5.6	13	505.3	0.026	0.009	0.000
TP – proposed objective	0.0165	459	8	0.1	46.3	4.6	12	505.3	0.024	0.008	0.002
TSS	6.7	459	3075	10	46.3	463	3538	505.3	7.0	0.3	0.1
TAN	0.085	459	39	1.00	46.3	46.3	85	505.3	0.169	0.084	0.021
NO3	0.51	459	234	22 [a]	46.3	1019	1253	505.3	2.48	1.97	0.49
cBOD	2	459	918	10	46.3	463	1381	505.3	2.7	0.7	0.2
DO	8.32	459	3819	14	46.3	648	3171	505.3	6.27	-2.05	-0.51

Note: a – average effluent concentration (2017), b- for DO the 25% used for Humber River concentrations and 4*NH3 + BOD used for plant effluent for TOD

5. CORMIX Modelling

- The purpose of the CORMIX modelling was to predict future near field water quality of TAN, BOD and TP, and the size and shape of the mixing zone (area above PWQOs) for the WRRF re-rating.
- CORMIX simulates the hydrodynamic behaviour of an effluent discharge and calculates the plume trajectory, dilution and maximum centreline considering the physical and chemical characteristics of both the receiver, the effluent, and the discharge structure (e.g. channel, pipe).

- CORMIX3 for surface/shoreline discharges was selected for the modelling program, as the discharge enters the Humber River as a channel.
- Input parameters are provided in Table 11.
- CORMIX requires a depth at discharge that is +/- 30% of average channel depth. The depth at the discharge location was therefore entered as 0.17 m, instead of the 0.10 m it actually is.
- After many trials, and optimizations, the program would not execute CORMIX3. CORMIX3 requires that the discharge be positively buoyant, and the 75th percentile effluent temperature (measured in the discharge channel) is lower than that of the upstream temperature. A warmer effluent temperature was considered; however, this would not accurately reflect actual discharge conditions –2017 and 2018 temperature logger data has shown that the 75th percentile temperature of the Humber River is greater in than the outlet channel. It was recommended by CORMIX technical support that the system be modelled using CORMIX1 - for single port discharges.
- Modelling of the system as CORMIX1, single port required changing the outfall channel that enters the Humber River into a pipe structure. The program requires the port diameter or area. The area of the channel is approximately 0.036 m^2 (0.4 m wide x 0.09 m deep) – however this had to be reduced to 0.0025 m^2 (1 cm diameter pipe) for the program to execute, as the program limits the size of the pipe area based on the local water depth. We recognize that a 1 cm diameter outfall pipe would result in unrealistic flow velocities at the required effluent discharge rates.
- For CORMIX 1 - the height of the port above the bottom must be less than 1/3 or greater than two thirds of the local water depth, and therefore this required changing the port height to 0.0566 m or 0.016 m from the actual depth of 0.01 m. A port height of 0.0566 m was selected as it is slightly closer to 0.01 m.
- The program was executed and the effluent was described as discharging horizontally, or near horizontally from the discharge port, cross-flowing or counter flowing (i.e. perpendicular) and jet-like to the ambient current (Figure 5) and does not mix with the nearshore until a distance of approximately 2.5 m, at which point it becomes laterally mixed across the channel width (but not uniformly).

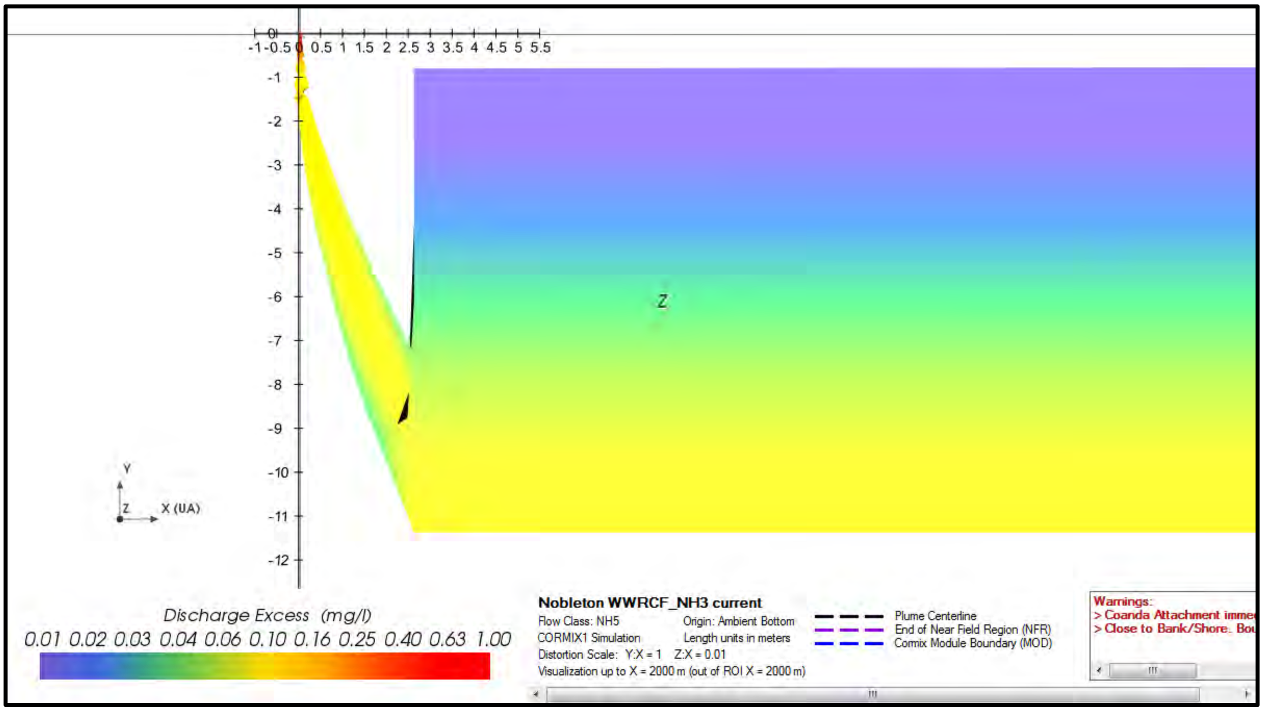


Figure 5 Plan view of model prediction for Nobleton WRRF Effluent Discharge

- Conductivity profiles completed in September 2018 (Figure 6) and field observations during water quality sampling events did not support the model results; the plume did not issue horizontally across the stream in a jet-like fashion. It attached to the left bank (discharge bank) immediately after discharge, and slowly mixed with the ambient flow with distance downstream. The highest conductivity was measured 0.5m from the left bank 10m downstream, the plume was mixed to background levels within 3m of the left bank at all distances downstream and was fully mixed by 275 m downstream of the outfall. These measurements were taken when the receiver flow was 1,317 L/s. Under low flows of 459 L/s (i.e. the 7Q20 corrected for climate change) the plume would not be as constrained to the left bank by the ambient flow allowing greater mixing into the river channel closer to the outfall.

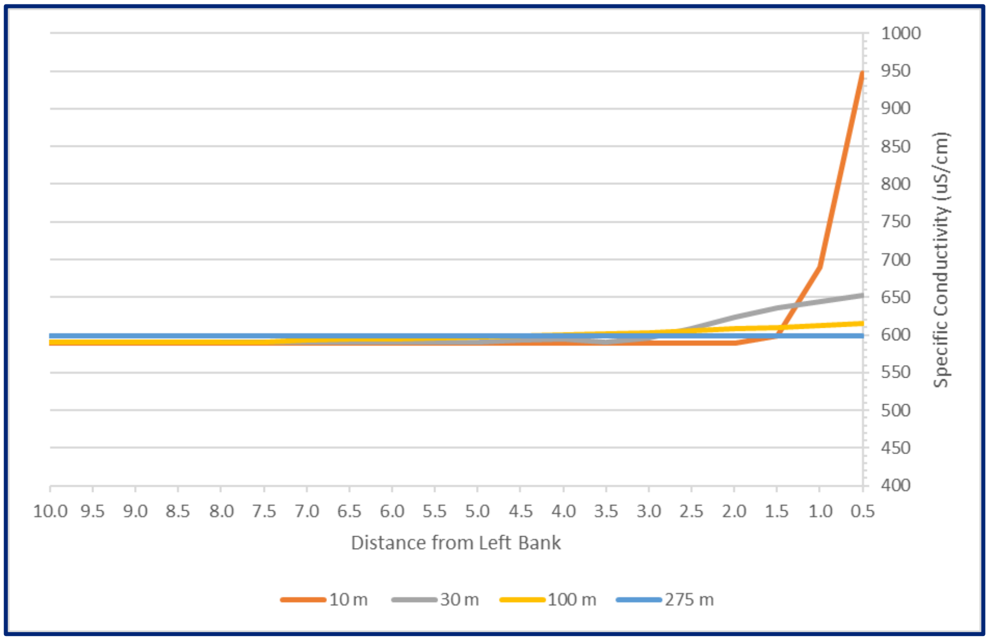


Figure 6 Conductivity Profiles – September 2018

- Nearfield mixing is strongly influenced by the discharge characteristics, and hence changes to the outfall structure can significantly change the predictions made by the program. In this case a 40-90 cm wide outfall channel was changed to a 1 cm diameter pipe. The pipe would constrict the flow of the effluent considerably changing the discharge momentum and flux conditions and we recognize that this scenario, although required for model function, is unrealistic.
- Based on our understanding of the effluent behaviour and the changes to the model inputs required to execute the program, the predictions made by CORMIX do not reflect actual receiving water conditions at and immediately downstream of the effluent discharge. We therefore do not recommend that CORMIX modelling be used to predict the nearfield mixing zone.
- Field measurements of actual plume behaviour confirm that the effluent mixes rapidly and completely with the receiver.

6. Summary

- Overall, the Nobleton WRRF had little influence on downstream water quality during the 2017 sampling events.
- Water quality sampling in 2017 showed that un-ionized ammonia is well below the PWQO in the receiver and discharge channel, and therefore, there is no concern of acute toxicity at point of discharge.
- The Main Humber River upstream of the Nobleton WRRF is considered a “Policy 1” receiver for dissolved oxygen and ammonia based on 25th and 75th percentiles, respectively.

- Based on TP sampling completed in 2017 and 2018, the Main Humber River upstream of the Nobleton WRRF is also considered Policy 1 for TP, as the 75th percentile concentration is 0.0165 mg/L.
- T he wetland is acted as a sink for TP, and inconsistently total ammonia (decreased by 38%, and 23% respectively) and source of TSS and TKN increased (by 102% and 38%) over the period monitored, although we cannot state, from the available data, if this is true year round.
- Nobleton WRRF effluent flows are still increasing, and the facility is operating at 47% of its approved capacity. The annual average concentration of ECA regulated parameters are below their limits; however concentrations of many effluent parameters are increasing from one year to the next as effluent volume increases.
- Mass-balance modelling found that effluent limits of 10 mg/L for cBOD and TSS, 1 mg/L TAN (May 1 – October 31), and 0.12 mg/L TP (objective of 0.1 mg/L) will maintain water quality in the Humber River below their PWQO under 7Q20 conditions, and still provide capacity for additional discharges downstream.
- Near field predictions made by CORMIX modelling do not reflect actual receiving water conditions at and immediately downstream of the effluent discharge. We therefore do not recommend that CORMIX modelling be used to predict the nearfield mixing zone. Field measurements confirm that the effluent mixes rapidly after discharge.

Distribution List

FILE NO.	REVNO	# COPY	PDF RQ	ISSUED TO	DATE	ISSUE/REVISION DESCRIPTION
170008	2	1		Ted Beleyneh	21/01/2019	N/A

Revision Log

FILE NO.	REVNO	PREPARED BY	REVIEWED BY	AUTHORIZED BY	ISSUE/REVISION DESCRIPTION
170008	1	Deborah Sinclair	Neil Hutchinson	Neil Hutchinson	Review of first draft
170008	2	Deborah Sinclair	Neil Hutchinson	Neil Hutchinson	Review of second draft

Signatures

Prepared By

Deborah L. Sinclair
Senior Aquatic Scientist

QC Review By

Neil Hutchinson, Ph.D.
Principal

Appendix D. QUAL2K Inputs and Results

QUAL2K

Stream Water Quality Model

Humber River (8/1/2017)

Constituent (Average) Summary

Tributary													
Label	*Reach Label*	*x(km)*	*cond (umhos)*	*ISS (mgD/L)*	*DO(mgO2/L)*	*CBODs (mgO2/L)*	*CBODf (mgO2/L)*	*NH4(ugN/L)*	*NO3(ugN/L)*	*Po (ugP/L)*	*Inorg P (ugP/L)*	*Phyto (ugA/L)*
main	Mainstem headwa	2.48	510.00	3.60	12.84	2.00	2.00	36.00	160.00	9.50	7.30	2.57
	HR1	2.40	516.87	3.54	12.72	1.99	2.01	34.67	261.35	9.60	8.17	2.55
	HR1	2.23	516.87	3.47	12.64	1.98	2.01	33.30	263.09	9.49	8.11	2.54
	HR2	2.03	516.87	3.40	12.21	1.98	2.01	32.93	263.52	9.38	8.02	2.52
	HR2	1.79	516.87	3.32	11.82	1.98	2.01	32.57	263.95	9.27	7.94	2.51
	HR3	1.64	516.87	3.29	11.79	1.98	2.01	32.01	264.66	9.23	7.91	2.50
	HR3	1.56	516.87	3.26	11.75	1.98	2.01	31.46	265.37	9.18	7.88	2.49
	HR4	1.40	516.87	3.20	11.61	1.98	2.01	30.79	266.22	9.08	7.81	2.48
	HR4	1.18	516.87	3.13	11.48	1.98	2.01	30.14	267.05	8.99	7.74	2.46
	HR5	0.90	516.87	3.02	11.10	1.98	2.01	29.55	267.75	8.82	7.60	2.44
	HR5	0.58	516.87	2.91	10.77	1.98	2.01	28.98	268.44	8.65	7.47	2.42
	HR6	0.31	516.87	2.84	10.65	1.97	2.01	28.35	269.24	8.54	7.39	2.40
	HR6	0.10	516.87	2.78	10.54	1.97	2.01	27.74	270.02	8.44	7.31	2.38
	Terminus	0.00	516.87	2.78	10.54	1.97	2.01	27.74	270.02	8.44	7.31	2.38

QUAL2K

Stream Water Quality Model

Humber River (8/1/2017)

Water Column Rates

Parameter	Value	Units	Symbol
Stoichiometry:			
Carbon	40	gC	gC
Nitrogen	7.2	gN	gN
Phosphorus	1	gP	gP
Dry weight	100	gD	gD
Chlorophyll	1	gA	gA
Inorganic suspended solids:			
Settling velocity	2	m/d	v_i
Oxygen:			
Reaeration model	O'Connor-Dobbins		
User reaeration coefficient α	0		α
User reaeration coefficient β	0		β
User reaeration coefficient γ	0		γ
Temp correction	1.024		θ_a
Reaeration wind effect	None		
O2 for carbon oxidation	2.69	gO_2/gC	r_{oc}
O2 for NH4 nitrification	4.57	gO_2/gN	r_{on}
Oxygen inhib model CBOD oxidation	Exponential		
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2	K_{socf}
Oxygen inhib model nitrification	Exponential		
Oxygen inhib parameter nitrification	0.60	L/mgO2	K_{sona}
Oxygen enhance model denitrification	Exponential		
Oxygen enhance parameter denitrification	0.60	L/mgO2	K_{sodn}
Oxygen inhib model phyto resp	Exponential		
Oxygen inhib parameter phyto resp	0.60	L/mgO2	K_{sop}
Oxygen enhance model bot alg resp	Exponential		
Oxygen enhance parameter bot alg resp	0.60	L/mgO2	K_{sob}
Slow CBOD:			
Hydrolysis rate	0.05	/d	k_{hc}
Temp correction	1.07		θ_{hc}
Oxidation rate	0.05	/d	k_{dcs}
Temp correction	1.047		θ_{dcs}
Fast CBOD:			
Oxidation rate	0.05	/d	k_{dc}
Temp correction	1.047		θ_{dc}
Organic N:			
Hydrolysis	0.1	/d	k_{hn}
Temp correction	1.07		θ_{hn}

Settling velocity	0.1	m/d	v_{on}
Ammonium:			
Nitrification	5	/d	k_{na}
Temp correction	1.07		θ_{na}
Nitrate:			
Denitrification	0.1	/d	k_{dn}
Temp correction	1.07		θ_{dn}
Sed denitrification transfer coeff	0	m/d	v_{di}
Temp correction	1.07		θ_{di}
Organic P:			
Hydrolysis	0.1	/d	k_{hp}
Temp correction	1.07		θ_{hp}
Settling velocity	1	m/d	v_{op}
Inorganic P:			
Settling velocity	1	m/d	v_{ip}
Inorganic P sorption coefficient	0	L/mgD	K_{dpi}
Sed P oxygen attenuation half sat constant	0.05	mgO_2/L	k_{spi}
Phytoplankton:			
Max Growth rate	2.5	/d	k_{gp}
Temp correction	1.07		θ_{gp}
Respiration rate	1	/d	k_{rp}
Temp correction	1.07		θ_{rp}
Death rate	0	/d	k_{dp}
Temp correction	1.07		θ_{dp}
Nitrogen half sat constant	15	ugN/L	k_{sPp}
Phosphorus half sat constant	2	ugP/L	k_{sNp}
Inorganic carbon half sat constant	2.00E-05	moles/L	k_{sCp}
Light model	Half saturation		
Light constant	57.6	langleys/d	K_{Lp}
Ammonia preference	25	ugN/L	k_{hnxp}
Settling velocity	0.5	m/d	v_a
Bottom Algae:			
Growth model	Zero-order		
Max Growth rate	50	$mgA/m^2/d$ or /d	C_{gb}
Temp correction	1.07		θ_{gb}
First-order model carrying capacity	1000	mgA/m^2	$a_{b,max}$
Respiration rate	0.1	/d	k_{rb}
Temp correction	1.07		θ_{rb}
Excretion rate	0.5	/d	k_{eb}
Temp correction	1.07		θ_{db}
Death rate	0.09	/d	k_{db}
Temp correction	1.07		θ_{db}

External nitrogen half sat constant	100	ugN/L	k_{sPb}
External phosphorus half sat constant	96.379	ugP/L	k_{sNb}
Inorganic carbon half sat constant	0.00E+00	moles/L	k_{sCb}
Light model	Half saturation		
Light constant	76.319	langleys/d	K_{Lb}
Ammonia preference	25	ugN/L	k_{hnxb}
Subsistence quota for nitrogen	2.2524	mgN/mgA	q_{0N}
Subsistence quota for phosphorus	0.002	mgP/mgA	q_{0P}
Maximum uptake rate for nitrogen	15	mgN/mgA/d	ρ_{mN}
Maximum uptake rate for phosphorus	3	mgP/mgA/d	ρ_{mP}
Internal nitrogen half sat constant	0.384	mgN/mgA	K_{qN}
Internal phosphorus half sat constant	0.102	mgP/mgA	K_{qP}
Detritus (POM):			
Dissolution rate	0.01	/d	k_{dt}
Temp correction	1.07		θ_{dt}
Fraction of dissolution to fast CBOD	0.99		F_f
Settling velocity	0.01	m/d	v_{dt}
Pathogens:			
Decay rate	0.8	/d	k_{dx}
Temp correction	1.07		θ_{dx}
Settling velocity	1	m/d	v_x
Light efficiency factor	1.00		α_{path}
pH:			
Partial pressure of carbon dioxide	347	ppm	p_{CO2}

QUAL2K

Stream Water Quality Model

Humber River (8/1/2017)

Reach Data:

Reach for diel plot	2													
Element for diel plot	1	Reach	Headwater	Reach			Location		Element	Elevation		Downst		
Reach	Downstream	Number	Reach	length	Downstream		Upstream	Downstream	Number	Upstream	Downstream	Latitude		
Label	end of reach label			(km)	Latitude	Longitude	(km)	(km)	>=1	(m)	(m)	Degrees	Minutes	Seconds
HR1		1	Yes	0.33	43.88	79.70	2.477	2.152	2	205.000	204.999	43.00	52	51
HR2		2		0.48	43.88	79.69	2.152	1.675	2	204.999	204.834	43.00	52	50
HR3		3		0.16	43.88	79.69	1.675	1.515	2	204.834	204.833	43.00	52	49
HR4		4		0.45	43.88	79.69	1.515	1.069	2	204.833	204.823	43.00	52	41
HR5		5		0.66	43.88	79.69	1.069	0.411	2	204.823	204.753	43.00	52	32
HR6		6		0.41	43.87	79.69	0.411	0.000	2	204.753	204.743	43.00	52	24

	Hydraulic Model (Weir Overrides Manning Formula; Manning Formula Override Rating Curves)														
tream			*Weir*				Rating Curves				Manning Formula				
Longitude			*Height*	*Width*	*adam*	*bdam*	*Velocity*		*Depth*		*Channel*	*Manning*	*Bot Width*	*Side*	*Side*
Degrees	*Minutes*	*Seconds*	*(m)*	*(m)*			*Coefficient*	*Exponent*	*Coefficient*	*Exponent*	*Slope*	*n*	*m*	*Slope*	*Slope*
79.00	41	43.82			1.2500	0.9000					0.0000	0.0350	11.70	1.4500	0.6800
79.00	41	35.17			1.2500	0.9000					0.0092	0.0350	10.80	0.5800	0.5100
79.00	41	31.4			1.2500	0.9000					0.0001	0.0350	11.40	1.0500	0.9050
79.00	41	30.09			1.2500	0.9000					0.0007	0.0350	9.10	1.3500	1.0063
79.00	41	38.3			1.2500	0.9000					0.0044	0.0350	12.60	0.7333	1.2517
79.00	41	34.37			1.2500	0.9000					0.0006	0.0350	12.70	0.8444	0.6167

QUAL2K
Stream Water Quality Model
Humber River (8/1/2017)
Constituent (Average) Summary

Tributary Label	Reach Label	x(km)	cond (umhos)	ISS (mgD/L)	DO(mgO2/L)	CBODs (mgO2/L)	CBODf (mgO2/L)	No(ugN/L)	NH4(ugN/L)	NO3(ugN/L)	Po (ugP/L)	Inorg P (ugP/L)	Phyto (ugA/L)
main	Mainstem headwa	2.48	510.00	3.60	12.84	2.00	2.00	324.00	36.00	160.00	9.50	7.30	2.57
	HR1	2.40	516.87	3.54	12.72	1.99	2.01	328.64	34.67	261.35	9.60	8.17	2.55
	HR1	2.23	516.87	3.47	12.64	1.98	2.01	327.96	33.30	263.09	9.49	8.11	2.54
	HR2	2.03	516.87	3.40	12.21	1.98	2.01	327.48	32.93	263.52	9.38	8.02	2.52
	HR2	1.79	516.87	3.32	11.82	1.98	2.01	327.01	32.57	263.95	9.27	7.94	2.51
	HR3	1.64	516.87	3.29	11.79	1.98	2.01	326.70	32.01	264.66	9.23	7.91	2.50
	HR3	1.56	516.87	3.26	11.75	1.98	2.01	326.39	31.46	265.37	9.18	7.88	2.49
	HR4	1.40	516.87	3.20	11.61	1.98	2.01	325.87	30.79	266.22	9.08	7.81	2.48
	HR4	1.18	516.87	3.13	11.48	1.98	2.01	325.35	30.14	267.05	8.99	7.74	2.46
	HR5	0.90	516.87	3.02	11.10	1.98	2.01	324.56	29.55	267.75	8.82	7.60	2.44
	HR5	0.58	516.87	2.91	10.77	1.98	2.01	323.77	28.98	268.44	8.65	7.47	2.42
	HR6	0.31	516.87	2.84	10.65	1.97	2.01	323.17	28.35	269.24	8.54	7.39	2.40
	HR6	0.10	516.87	2.78	10.54	1.97	2.01	322.58	27.74	270.02	8.44	7.31	2.38
	Terminus	0.00	516.87	2.78	10.54	1.97	2.01	322.58	27.74	270.02	8.44	7.31	2.38

Detritus (mgD/L)	Pathogen	Alk	pH	TOC	TN	TKN	TSS (mgD/L)	NH3	DO sat	pHsat	TP
3.00	100.00	223.00	8.33	2.79	538.50	378.50	6.86	2.79	8.89	8.77	16.80
2.98	87.34	222.86	8.32	2.78	643.05	381.70	6.78	2.65	8.89	8.77	17.77
2.98	78.00	222.84	8.32	2.78	642.61	379.52	6.71	2.55	8.89	8.77	17.61
2.98	74.02	222.84	8.34	2.78	642.09	378.57	6.63	2.59	8.88	8.77	17.41
2.98	70.45	222.84	8.35	2.78	641.57	377.62	6.55	2.64	8.88	8.77	17.21
2.98	67.77	222.83	8.35	2.78	641.36	376.70	6.52	2.60	8.88	8.77	17.13
2.98	65.32	222.83	8.35	2.77	641.16	375.79	6.49	2.56	8.87	8.77	17.06
2.98	62.30	222.82	8.35	2.77	640.71	374.49	6.42	2.52	8.87	8.77	16.89
2.98	59.58	222.82	8.36	2.77	640.26	373.21	6.36	2.49	8.87	8.77	16.73
2.98	56.15	222.81	8.37	2.77	639.42	371.67	6.24	2.52	8.87	8.77	16.42
2.98	53.13	222.81	8.38	2.77	638.58	370.14	6.13	2.55	8.86	8.77	16.12
2.98	50.68	222.80	8.39	2.77	638.05	368.81	6.06	2.51	8.86	8.77	15.93
2.98	48.50	222.80	8.39	2.77	637.52	367.50	5.99	2.48	8.85	8.77	15.74
2.98	48.50	222.80	8.39	2.77	637.52	367.50	5.99	2.48	8.85	8.77	15.74

QUAL2K
Stream Water Quality Model
Humber River (8/29/2017)
Headwater Data:

Note: ** required field*

ID	Number of Headwaters*	1													
No. 1	Reach No.*	Headwater Name	Flow*	Elevation	Weir				Rating Curves				Manning Formu		
			Rate		Height	Width	adam	bdam	Velocity		Depth		Channel	Manning	Bot Width
			(m^3/s)	(m)	(m)	(m)			Coefficient	Exponent	Coefficient	Exponent	Slope	n	m
	1	Mainstem headwater	1.308	205.000			1.2500	0.9000					4.55E-05	3.50E-02	11.7000
	Headwater Water Quality	Units	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM
	Temperature	C	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11	19.11
	Conductivity	umhos	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00	519.00
	Inorganic Solids	mgD/L	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	Dissolved Oxygen	mg/L	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35
	CBODslow	mgO2/L	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
	CBODfast	mgO2/L	2.00	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
	Organic Nitrogen	ugN/L	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00
	NH4-Nitrogen	ugN/L	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
	NO3-Nitrogen	ugN/L	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00	137.00
	Organic Phosphorus	ugP/L	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90
	Inorganic Phosphorus (SRP)	ugP/L	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Phytoplankton	ugA/L	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
	Detritus (POM)	mgD/L	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Pathogen	cfu/100 mL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Alkalinity	mgCaCO3/L	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00	227.00
	pH	s.u.	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41

ula		***Prescribed***								
Side	***Side***	***Dispersion***								
Slope	***Slope***	***m2/s***								
1.45	**0.68**									
1:00 PM	***2:00 PM***	***3:00 PM***	***4:00 PM***	***5:00 PM***	***6:00 PM***	***7:00 PM***	***8:00 PM***	***9:00 PM***	***10:00 PM***	***11:00 PM***
19.11	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**	**19.11**
519.00	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**	**519.00**
2.00	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**
12.35	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**	**12.35**
2.10	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**
2.10	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**	**2.10**
130.00	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**	**130.00**
20.00	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**	**20.00**
137.00	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**	**137.00**
9.90	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**	**9.90**
3.00	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**
1.38	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**	**1.38**
3.00	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**
100.00	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
227.00	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**	**227.00**
8.41	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**	**8.41**

QUAL2K
Stream Water Quality Model
Humber River (8/29/2017)
Constituent (Average) Summary

Tributary Label	Reach Label	x(km)	cond (umhos)	ISS (mgD/L)	DO(mgO2/L)	CBODs (mgO2/L)	CBODf (mgO2/L)	NH4(ugN/L)	NO3(ugN/L)	Po (ugP/L)	Inorg P (ugP/L)	Phyto (ugA/L)	Detritus (mgD/L)	Alk
main	Mainstem headwater	2.48	519.00	2.00	12.35	2.10	2.10	20.00	137.00	9.90	3.00	1.38	3.00	227.00
	HR1	2.40	523.56	1.96	12.22	2.10	2.10	19.29	222.50	9.83	3.02	1.37	2.99	226.83
	HR1	2.23	523.56	1.91	12.12	2.09	2.10	18.42	223.55	9.68	2.99	1.35	2.99	226.83
	HR2	2.03	523.56	1.84	11.61	2.09	2.10	18.18	223.80	9.52	2.95	1.34	2.99	226.82
	HR2	1.79	523.56	1.78	11.18	2.09	2.09	17.95	224.05	9.35	2.90	1.33	2.99	226.82
	HR3	1.64	523.56	1.76	11.14	2.09	2.09	17.59	224.47	9.28	2.89	1.32	2.99	226.82
	HR3	1.56	523.56	1.73	11.11	2.09	2.09	17.25	224.89	9.22	2.88	1.31	2.99	226.82
	HR4	1.40	523.56	1.68	10.96	2.09	2.09	16.83	225.38	9.08	2.85	1.30	2.98	226.81
	HR4	1.18	523.56	1.64	10.83	2.09	2.09	16.42	225.87	8.94	2.82	1.28	2.98	226.81
	HR5	0.90	523.56	1.55	10.46	2.09	2.09	16.05	226.26	8.69	2.75	1.26	2.98	226.81
	HR5	0.58	523.56	1.47	10.17	2.09	2.09	15.70	226.64	8.45	2.68	1.24	2.98	226.80
	HR6	0.31	523.56	1.42	10.07	2.08	2.09	15.31	227.10	8.29	2.64	1.23	2.98	226.80
	HR6	0.10	523.56	1.37	9.98	2.08	2.09	14.93	227.54	8.14	2.61	1.22	2.98	226.80
	Terminus	0.00	523.56	1.37	9.98	2.08	2.09	14.93	227.54	8.14	2.61	1.22	2.98	226.80

pH	*TOC*	*TN*	*TP*	*TKN*	*NH3*	*DO sat*	*pHsat*	*TP*
8.41	2.81	296.94	14.28	159.94	1.74	9.04	8.78	12.90
8.41	2.81	383.63	14.22	161.13	1.67	9.04	8.78	12.85
8.41	2.81	383.34	14.03	159.79	1.60	9.04	8.78	12.68
8.42	2.81	382.99	13.80	159.19	1.63	9.04	8.78	12.46
8.44	2.80	382.64	13.58	158.59	1.65	9.04	8.78	12.25
8.44	2.80	382.50	13.49	158.03	1.62	9.04	8.78	12.18
8.44	2.80	382.36	13.41	157.48	1.59	9.05	8.78	12.10
8.44	2.80	382.07	13.22	156.68	1.56	9.05	8.77	11.93
8.45	2.80	381.77	13.04	155.90	1.53	9.06	8.77	11.76
8.46	2.80	381.21	12.70	154.94	1.54	9.06	8.77	11.44
8.47	2.80	380.64	12.37	154.00	1.55	9.06	8.77	11.13
8.48	2.79	380.29	12.17	153.19	1.52	9.07	8.77	10.94
8.48	2.79	379.93	11.97	152.39	1.50	9.07	8.77	10.75
8.48	2.79	379.93	11.97	152.39	1.50	9.07	8.77	10.75

QUAL2K

Stream Water Quality Model

Humber River (8/1/2017)

Headwater Data: Future Scenario

Note: ** required field*

ID	*Number of Headwaters**	1													
No. 1	*Reach No.**	*Headwater Name*	*Flow**	*Elevation*	*Weir*				Rating Curves				Manning Formu		
			Rate		*Height*	*Width*	*adam*	*bdam*	*Velocity*		*Depth*		*Channel*	*Manning*	*Bot Width*
			(m^3/s)	*(m)*	*(m)*	*(m)*				*Exponent*	*Coefficient*	*Exponent*	*Slope*	*n*	*m*
	1	Mainstem headwater	0.459	205.0000			1.2500	1.2500	0.9000				4.55E-05	0.0350	11.70
	Headwater Water Quality	*Units*	*12:00 AM*	*1:00 AM*	*2:00 AM*	*3:00 AM*	*4:00 AM*	*5:00 AM*	*6:00 AM*	*7:00 AM*	*8:00 AM*	*9:00 AM*	*10:00 AM*	*11:00 AM*	*12:00 PM*
	Temperature	C	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88
	Conductivity	umhos	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00
	Inorganic Solids	mgD/L	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60
	Dissolved Oxygen	mg/L	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32
	CBODslow	mgO2/L	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
	CBODfast	mgO2/L	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	Organic Nitrogen	ugN/L	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00
	NH4-Nitrogen	ugN/L	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
	NO3-Nitrogen	ugN/L	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00
	Organic Phosphorus	ugP/L	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
	Inorganic Phosphorus (SRP)	ugP/L	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
	Phytoplankton	ugA/L													
	Detritus (POM)	mgD/L	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	Pathogen	cfu/100 mL													
	Alkalinity	mgCaCO3/L	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50
	pH	s.u.	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41

ula		Prescribed								
Side	Side	Dispersion								
Slope	Slope	m2/s								
1.45	0.68									
1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88
521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00	521.00
4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60
8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32	8.32
2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00	425.00
85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00	513.00
9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50	242.50
8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41

QUAL2K

Stream Water Quality Model

Humber River (8/1/2017)

Constituent (Average) Summary:Future Scenario

Tributary			cond	DO	CBODs	CBODf	NH4	NO3	Phyto	Detritus							TSS	
Label	Reach Label	x(km)	(umhos)	(mgO2/L)	(mgO2/L)	(mgO2/L)	(ugN/L)	(ugN/L)	(ugA/L)	(mgD/L)	Alk	pH	TOC	TN	TP	TKN	(mgD/L)	CBODu
main	Mainstem headwa	2.48	521.00	8.32	2.15	2.00	85.00	513.00	0.00	4.00	242.50	8.41	3.14	1023.00	16.50	510.00	8.60	8.45
	HR1	2.44	625.27	8.27	1.95	2.73	163.14	2486.83	0.00	3.63	237.19	8.39	3.19	3035.20	28.34	548.37	8.59	8.59
	HR1	2.38	625.27	8.26	1.95	2.73	157.63	2491.64	0.00	3.63	237.15	8.39	3.19	3033.69	27.95	542.04	8.45	8.59
	HR1	2.31	625.27	8.25	1.95	2.73	152.30	2496.28	0.00	3.63	237.11	8.39	3.19	3032.17	27.56	535.90	8.32	8.59
	HR1	2.25	625.27	8.24	1.95	2.73	147.16	2500.73	0.00	3.63	237.07	8.39	3.19	3030.66	27.18	529.93	8.19	8.58
	HR1	2.18	625.27	8.24	1.95	2.73	142.19	2505.02	0.00	3.63	237.04	8.39	3.19	3029.16	26.81	524.14	8.07	8.58
	HR2	2.03	625.27	8.44	1.94	2.72	138.69	2505.77	0.00	3.63	237.01	8.43	3.19	3024.51	25.67	518.75	7.70	8.57
	HR2	1.79	625.27	8.57	1.94	2.72	135.25	2506.52	0.00	3.63	236.99	8.46	3.18	3019.94	24.58	513.42	7.36	8.57
	HR3	1.64	625.27	8.55	1.94	2.72	130.27	2510.73	0.00	3.63	236.95	8.46	3.18	3018.23	24.17	507.50	7.24	8.56
	HR3	1.56	625.27	8.54	1.94	2.72	125.47	2514.75	0.00	3.62	236.92	8.46	3.18	3016.52	23.78	501.77	7.13	8.56
	HR4	1.40	625.27	8.56	1.94	2.71	119.63	2518.62	0.00	3.62	236.87	8.46	3.18	3012.79	22.94	494.16	6.88	8.55
	HR4	1.18	625.27	8.57	1.94	2.71	114.08	2522.23	0.00	3.62	236.83	8.47	3.18	3009.09	22.13	486.85	6.66	8.54
	HR5	0.90	625.27	8.65	1.93	2.71	109.02	2523.17	0.00	3.62	236.80	8.50	3.17	3001.93	20.64	478.76	6.27	8.53
	HR5	0.58	625.27	8.69	1.93	2.70	104.16	2523.98	0.00	3.61	236.76	8.53	3.17	2994.86	19.26	470.88	5.93	8.52
	HR6	0.31	625.27	8.68	1.93	2.70	98.99	2526.78	0.00	3.61	236.72	8.53	3.17	2990.40	18.42	463.62	5.74	8.52
	HR6	0.10	625.27	8.67	1.93	2.70	94.07	2529.34	0.00	3.61	236.69	8.54	3.16	2985.97	17.62	456.63	5.56	8.51
	Terminus	0.00	625.27	8.67	1.93	2.70	94.07	2529.34	0.00	3.61	236.69	8.54	3.16	2985.97	17.62	456.63	5.56	8.51