TOWN OF ERIN

SERVICING AND SETTLEMENT MASTER PLAN

WEST CREDIT RIVER ASSIMILATIVE CAPACITY STUDY

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ASSIMILATIVE CAPACITY STUDY

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1.0 INTRODUCTION

The Town of Erin has initiated a community-based process for completing a Servicing and Settlement Master Plan (SSMP). The Plan aims to address servicing, planning and environmental issues within the Town. Strategies developed through the SSMP process for community planning and municipal servicing over the next 25 years are intended to be developed consistent with municipal, county, and provincial policies.

There are currently no communal sewage systems servicing the communities in the Town of Erin. One option available for servicing of the existing and future community is to provide a wastewater treatment plant (WWTP) with a surface water discharge to the West Credit River. In order to add a new wastewater treatment facility with effluent discharge directed to the West Credit, it is necessary to establish the capacity of the river to receive treated effluent without adversely impacting downstream water quality. The intent of this Assimilative Capacity Study (ACS) is to summarize existing quantity and quality conditions in the West Credit River; determine the expected effluent characteristics and estimate the resulting change to in-stream flow and concentration associated with the addition of treated effluent.

1.1 History

In February of 2013, BMROSS completed the first draft of the ACS which concluded that a surface water discharge was a viable alternative to providing service for the Erin community and suggested that a future WWTP outfall to the West Credit River would be better suited downstream of the 10th Line, probably closer to Winston Churchill (municipal boundary line) as the water quality records indicate lower contaminant concentrations than in other locations upstream.

The majority of the background information utilized in preparing the draft ACS document, for both river quality and low flow (i.e., 7Q20) values, was extracted from the Credit Valley Conservation (CVC) report entitled “Erin SSMP, Environmental Component – Existing Conditions (2010)”, (Existing Conditions Report).

The review of the draft ACS, by the CVC and the Ministry of Environment (MOE), was completed in the spring of 2013. At that time, comments provided by the CVC recommended that further review of the 7Q20 flow values be undertaken, particularly downstream of the community of Erin (at the 10th Line) where the ACS calculations had been targeted. It was felt that the correlation method used to transpose the 7Q20 flows from the historic gauge site (8th Line) to the 10th Line needed to be reviewed in further detail. It was suggested that, in order to provide confidence in correlating the flows between the 8th and 10th Line, additional flow monitoring should be undertaken.

In late spring of 2013, and upon approval from Council, the installation of a new flow gauge at the 10th Line was coordinated by the CVC. Updated 7Q20 flow values were prepared by the CVC near the end of the year for both the 8th Line and the 10th Line. Details of the process that led to the new 7Q20 flow information is included in Section 3.3 of the report.

The ACS summary and discussion that follows has been prepared on the basis of the new 7Q20 values (CVC, January 2014), as well as the inclusion of more recent river quality data through to the fall of 2013. Attachment 1 includes full details in support of the information presented herein.

2.0 BACKGROUND

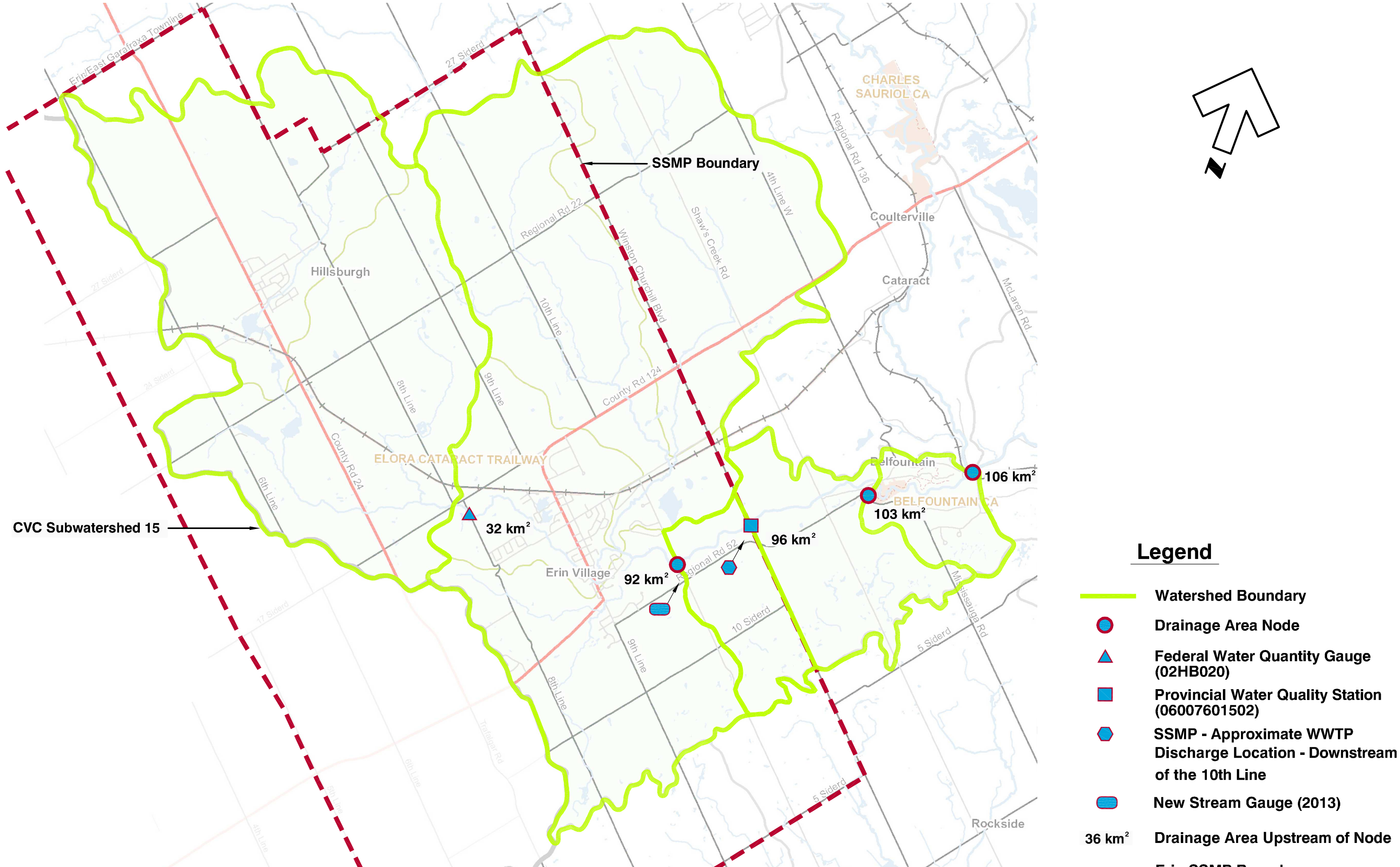
2.1 Study Location

The Erin SSMP study area, shown on Figure ACS-1, is within the West Credit Subwatershed and is bounded by Fifth Line, Fifth Sideroad, and Shaw's Creek Road to the west, south and east, respectively. The northern boundary occurs at East Garafraxa-Erin Townline, between Fifth Line and Eighth Line, and Sideroad 27, between Eight Line and Shaw's Creek Road.

2.2 Watershed Characteristics

The West Credit Subwatershed (Subwatershed 15) drains significant portions of the Town of Erin, flowing through the communities of Hillsburgh and Erin towards Belfountain. The subwatershed is about 106 square kilometers in area and runs from northwest of Hillsburgh to the Forks of the Credit. Approximately 96 square kilometers of the subwatershed contributes flow under the bridge at Winston Churchill Boulevard (Town of Caledon/Town of Erin boundary line). The limits of the subwatershed relative to the study limits for the SSMP are shown on Figure ACS-1.

This reach of the West Credit River currently does not receive direct surface effluent discharge from any existing Wastewater Treatment Plant (WWTP), however, existing development within the watershed is serviced by septic systems which discharge effluent to the groundwater.



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Town of Erin SSMP

Assimilative Capacity Study

West Credit River Watershed Area Plan

DATE	PROJECT No.
August 2014	08128
SCALE	FIGURE No.
1:100,000	ACS-1

2.3 Historical Studies

In 1995, the West Credit River Assimilative Capacity Report (Triton Engineering) was completed in conjunction with a Class EA undertaken related to sewage servicing for the community of Erin. The report included frequency analysis of low flow gauge data (02HB020) at the 8th Line as well as water quality data from the provincial sampling station at Winston Churchill Boulevard (#06007601502).

The 1995 study concluded that the addition of a WPCP serving an expanded population of 4,100 people in the community of Erin, with a direct discharge (at the 10th Line), would have no overall detrimental impact on water quality in the West Credit River. In conjunction with their review of the report, the MOE provided preliminary Effluent Quality Criteria (EQC) which they suggested could be utilized in the evaluation of options through the Class EA process that was ongoing at the time. Based on a council decision at the time, the 1995 EA process was not finalized.

In May 2011, the CVC completed the Environmental Component of the "Existing Conditions Report". This document is divided into several disciplines including hydrogeology, hydrology, hydraulics, benthic environment, fisheries, and water quality. The work completed is extensive and summarizes the current environmental conditions for the Erin SSMP study area. The majority of the low flow and water quality background information required to complete the current ACS has been taken from the CVC document.

More recently, and as noted above, additional analysis was undertaken related to the calculation of 7Q20 flow values on the West Credit River at the 10th Line. Further details related to the derivation of the updated 7Q20 flows are provided below in Section 3.3.

3.0 STUDY APPROACH

The study was completed on the basis of the following main components:

- Population Scenarios and Average Sewage Flow
- Existing Background Data – West Credit River:
    - Monthly Water Quantity - 7Q20 Flows (Provided by the CVC)
    - Monthly Water Quality - Obtained from the Provincial Water Quality Monitoring Network station at Winston Churchill Boulevard.
- Treatment Requirements - Effluent Quality Criteria
- Scenario Impact of an Effluent Discharge

It is noted that monthly data is available for both quantity and quality of the West Credit River. Given that the monthly data provides a more detailed representation of river characteristics than what can be obtained from annual parameters, the study has been completed based on the monthly information.

The assessment of impact on the West Credit was completed based on mass-balance calculations using the background river concentrations, monthly 7Q20 flows, and anticipated effluent concentrations for a surface water discharge downstream of the 10th Line.

3.1 Population Scenarios and Average Sewage Flow

Three scenarios were considered in the study in order to assess water quality under various populations for the communities of Erin and Hillsburgh.

- Scenario 1: Represents an existing population value of 3,087 people. (Existing Village of Erin)
- Scenario 2: Represents an existing population value of 4,481 people. (Existing Village of Erin and Hillsburgh)
- Scenario 3: Represents a future population of 6,000 people.

Average sewage flows for the communities were determined based on the Town's water usage records. The average water usage between the two communities is conservatively estimated at approximately 345 Litres per capita per day.

To account for extraneous flow, an allowance of 90 Litres per capita per day, is proposed in accordance with the 2008 MOE Design Guidelines (resulting design average day flow = 435 Litres per capita per day).

The resulting average sewage flows for each scenario are summarized below:

- Scenario 1: 15.6 L/s = 1,350 m^3/d
- Scenario 2: 22.6 L/s = 1,950 m^3/d
- Scenario 3: 30.2 L/s = 2,610 m^3/d

3.2 Existing Background Data – West Credit River

The Environmental Component of the Existing Conditions Report included an extensive review of water quality and water quantity monitoring locations throughout the West Credit watershed. The water quality data available included several CVC sampling stations as well as a lengthy record associated with the Provincial Water Quality Monitoring Network (PWQMN) sampling station at Winston Churchill Boulevard.

The water quantity data includes information from the Water Survey of Canada (WSC) gauge at the 8^{th} Line (above Erin) as well as a new gauge installed at the 10^{th} Line by the CVC in 2013. The WSC flow gauge station (02HB020) located on the West Credit upstream of Erin (at the 8^{th} Line) provides real-time flow data with over 32 years of historical information. Historically, the 7Q20 flow values for the West Credit River have been calculated based on the WSC flow gauge station data and then transposed downstream as required. This historical transposition (or scaling) of the 7Q20 flows has primarily been based on a comparison of drainage areas between the 8^{th} Line and the location along the watercourse under consideration. This approach to transposing of the flows is often referred to as areal reduction.

3.3 River Water Quantity – 7Q20 Flow

In April of 2013, and following review of the draft ACS, the MOE and the CVC suggested that, due to geological dissimilarities, accurately transposing flows downstream to the proposed WWTP discharge point, between 10th Line and Winston Churchill Boulevard, requires a more comprehensive approach than that provided by a comparison of drainage areas. For this reason, the following approach to develop a flow correlation between the 8th and 10th Line was suggested and supported by both review agencies:

- Complete the installation of a new stream gauge at the 10th Line including the development of a rating curve for the data as required.
- Update the calculations associated with the 7Q20 flows at the 8th Line using the most recent flow data gathered at the long term WSC gauge (02HB020).
- Following collection of a representative data set from the new gauge at the 10th Line, complete a regression analysis between the two gauges which would result in a factor that could be used to transpose the calculated 7Q20 flow values from the 8th Line to the 10th Line.

In early summer of 2013, the new stream gauge was installed at the 10th Line and on July 23, 2013 it was activated by the CVC. Data analysis, by the CVC and their engineers, was undertaken later in the year and included the development of a low flow transposition factor between the 8th Line and the 10th Line. A review of the calculations in the fall/winter of 2013 was completed by the MOE and the project team and accepted for use in the updated ACS. Pertinent correspondence and supporting information related to the development of the 7Q20 flow values has been included in the attachment.

The outcome of the new gauge and data analysis resulted in an updated set of monthly 7Q20 values for the 10th Line:

Table 1
Monthly 7Q20 Flow Values (L/s) – 10th Line

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
366	347	464	568	395	293	305	261	224	334	458	462

The updated flow values, summarized above, represent an average decrease of over 25% from the 7Q20 values used in the 2013 draft ACS report.

3.4 Climate Change

As part of discussions with the CVC and the MOE there was a suggestion that the influence of climate change be considered in the analysis, as there appears to be a climate trend towards drier, more drought prone summers. If this trend continues it is believed that climate change will have a two-fold impact on water bodies such as the West Credit River, resulting in lower stream flow values and higher background contaminant concentrations.

Although it is recognized that it is difficult to be definitive with respect to how the anticipated effect of climate change will impact the 7Q20 flows in Southern Ontario watercourses, discussions with the CVC suggested the use of a 10 to 15% reduction factor (similar to what is being used in some municipalities to adjust their rainfall-intensity curves upward).

Support for the use of a climate change factor is provided in the "Guide for Assessment of Hydrologic Effects of Climate Change in Ontario, EBNFLO Environmental AquaResource Inc, 2010". In this document, the authors looked at how various hydrologic indicators, including 7Q20 flow values, would be impacted using 57 different climate models. The simulations were based on a calibrated streamflow generation model of a subwatershed in Southwestern Ontario.

The report findings suggested that the impact to 7Q20 streamflow is estimated to range from -50% to +25%. While this appears to be a large range of uncertainty, statistical methods help to better describe this change. From this example, the authors noted that it is possible to make statements such as "70% of the climate change scenarios project that 7Q20 will decrease, and 50% project that 7Q20 will decrease by up to 25% of the current value" (EBNFLO Environmental AquaResource Inc.).

Recognizing the uncertainty associated with establishing a definitive projection related to climate change and 7Q20 streamflow, and through consultation with both the MOE and the CVC, a 10% reduction of stream flows was agreed to and ultimately incorporated into the final monthly 7Q20 streamflow (Table 1.1).

Table 1.1
Adjusted Monthly 7Q20 Flow Values (L/s) – 10th Line
(With Climate Change Factor)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
329	312	418	511	355	264	274	235	202	301	412	416

The above noted monthly 7Q20 flows are the values carried forward in the impact assessment completed for the area downstream of the 10th Line.

3.5 River Water Quality

Historical stream quality data was collected and analyzed by the CVC. The CVC reviewed a significant amount of data through the watershed and the results generally indicate good water quality conditions in the river. By the Town boundary, at Winston Churchill, the water quality results show background concentrations typically well below the Provincial Water Quality Objective PWQO for most parameters.

Based on the data available, it is suggested that a WWTP discharge would be better suited downstream of the 10th Line and closer to Winston Churchill, where background conditions reflect lower concentrations. Because of this, the analyzed data available from the PWQMN station at Winston Churchill Blvd (#06007601502) for the period from 1996 to 2013 will be used in the mass balance calculations for review of the impacts of a possible WWTP outlet. The station is located approximately 1.5 km downstream of the 10th Line and monitors approximately 96 km^2 of the watershed.

It is noted that the CVC, in their Existing Conditions report, included a review of data from the PWQMN station up to 2008. More recently, BMROSS has updated the background information to include sampling data through to the fall of 2013. The current ACS results incorporate this recently updated data.

The following table summarizes the existing river water quality and compares it to the Ontario Provincial Water Quality Objective (PWQO), where one exists. As discussed, these values are based on long term monitoring at Winston Churchill Boulevard and the data analyzed by the CVC.

Table 2
Summary of Existing Conditions – Winston Churchill Boulevard

Parameter	**Background Concentrations**				
	Avg.	**Min.**	**Max.**	**75th**	**PWQO**
Total Phosphorus (mg/L)	0.013	0.002	0.058	0.016	0.03
Nitrate-Nitrogen (mg/L)	1.78	0.32	3.38	2.01	3.00 [1]
Un-ionized Ammonia (µg/L)	0.29	0.01	2.15	0.35	20
BOD_5 (mg/L)	0.75	0.20	4.80	0.90	DO>5
E. coli (cts/100mL)	40	4	1400	110	100
TSS (mg/L)	3.79	0.50	30.30	4.15	25 [1]
TKN (mg/L)	0.38	0.03	1.80	0.42	N/A

Note: 1. Indicates value noted is not a PWQO but refers to CCME suggested limits instead.

The long-term monitoring data, indicates that the West Credit River is a Policy 1 stream. Under the MOE's Policy 1 statement, for those water quality parameters that are less than their PWQO, some minimal degree of degradation may be accepted; however, degradation beyond the PWQO is not acceptable (Ontario Ministry of Environment and Energy, 2004).

3.6 Effluent Quality Criteria

As noted previously, and in conjunction with the 1995 Class EA for sanitary servicing within the Town of Erin, the MOE provided preliminary EQC for the sewage treatment alternative being considered at that time. Discussions with the MOE, throughout the SSMP process, resulted in an agreement that the 1996 Effluent Quality Criteria remain reasonable for current study purposes.

Some modifications to the 1996 EQC have been proposed through the development of the ACS and the impact assessment and these changes include modifications to the phosphorus, nitrogen, and E. coli limits.

The following table summarizes the preliminary EQC limits provided by the MOE in 1996, as well as the proposed EQC values used throughout the current assessment.

Table 3
Effluent Quality Criteria (Historic and Current Study Values)

Parameter	Historic Design Values 1996 MOE Suggestion		Proposed Design Values (Current Assessment)	
	Treatment Objective	Non-Compliance	Treatment Objective	Non-Compliance
pH	8.2	<7 and >8.6	<7 and >8.6	<7 and >8.6
Total Suspended Solids (mg/L)	3.0	10	3.0	10
Total Phosphorous (mg/L)	0.1	0.20*	0.1	0.15
Total Ammonia (mg/L)	0.4	2.0	0.4	2.0
Total Kjeldahl Nitrogen (mg/L)		3.0		3.0
Nitrate Nitrogen (mg/L)	7.6*	10*	5	6
E. coli (org/100 mL)	100	200*	100	100
Dissolved Oxygen (mg/L)	5 (min)	4 (min)	5 (min)	4 (min)
BOD_5 (mg/L)	3.6	7.5	3.6	7.5
Temperature	17	<8 and >19	17	<8 and >19

Note: * 1996 amounts as noted. Value adjusted in the proposed design column.

4.0 SCENARIO IMPACT CALCULATIONS

Graphical plots of the critical water quality parameters for which there are Provincial Water Quality Objectives (PWQOs) were developed to review the impact of introducing effluent discharge from a WWTP to the West Credit River. The following data was used in the analysis:

- Monthly 7Q20 River flows.
- 75th percentile background river concentrations for most parameters except dissolved oxygen (where 25th percentile information was used).
- Proposed Effluent Quality Criteria (both objective and non-compliance values were considered).

The graphs show how the in-stream concentration is anticipated to change under the various population scenarios and effluent quality treatment parameters.

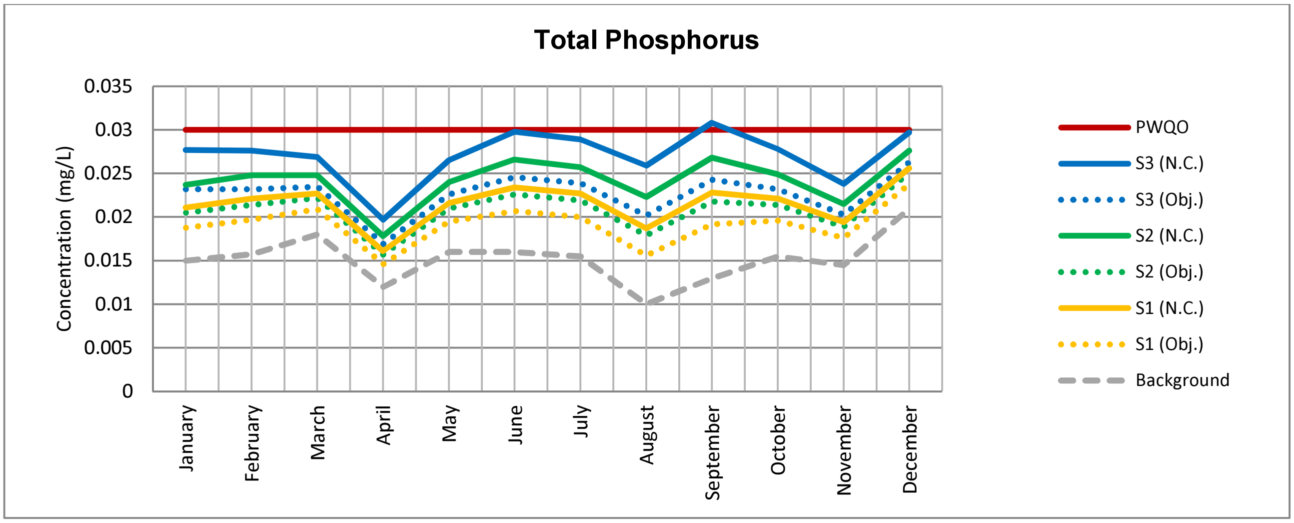
Monthly values for both quality and quantity (7Q20) have been used in lieu of yearly averages to more accurately reflect the seasonal characteristics of the watercourse than what can be provided through an annual based analysis.

Based on the mass-balance approach, the following provides a summary of the review completed for the parameters of concerns. Conclusions and further discussions related to the graphs are presented in Section 6.

4.1 Total Phosphorus

Under the three population scenarios considered, and using the total phosphorus effluent non-compliance concentration of 0.15 mg/L, the monthly 7Q20 analysis demonstrates that the PWQO of 0.03 mg/L will generally be met during all months.

Under an effluent objective concentration of 0.10 mg/L, the resulting concentration will be below 0.026 mg/L.

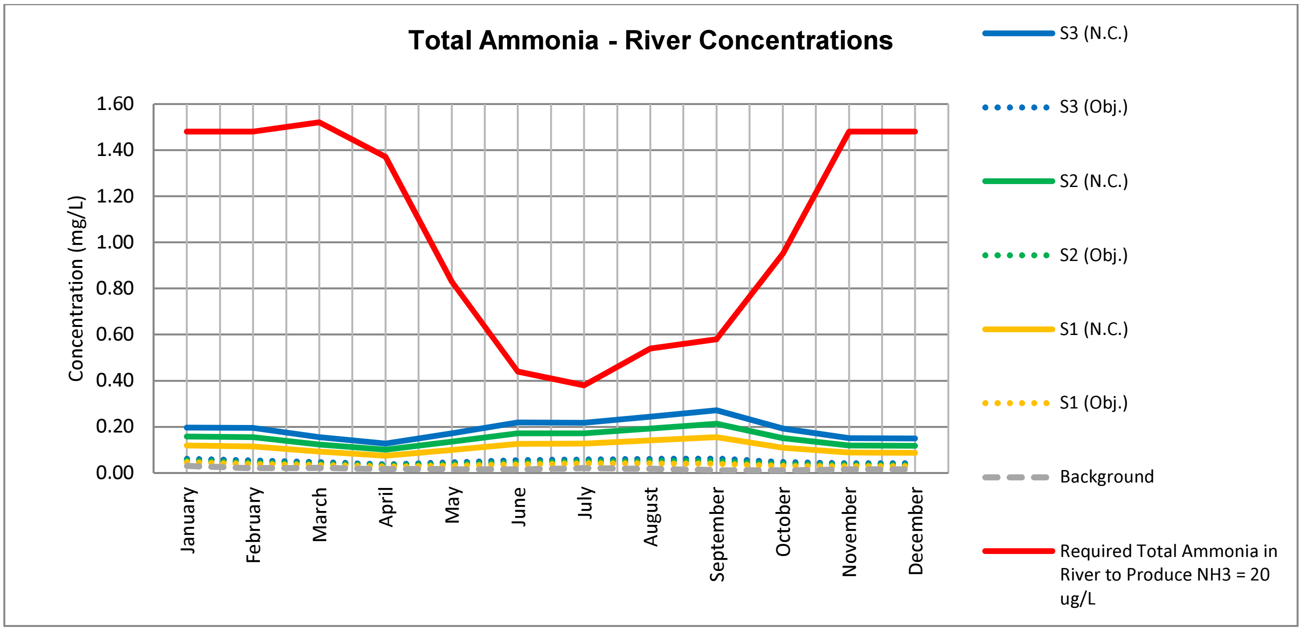


4.2 Un-ionized Ammonia

The following graph provides an illustration of the total ammonia that would be required in the river to produce a river concentration of un-ionized ammonia greater than the PWQO value of 20 µg/L.

The anticipated, mixed, river concentration of total ammonia is shown under the three effluent discharge scenarios for both an objective and a non-compliance situation.

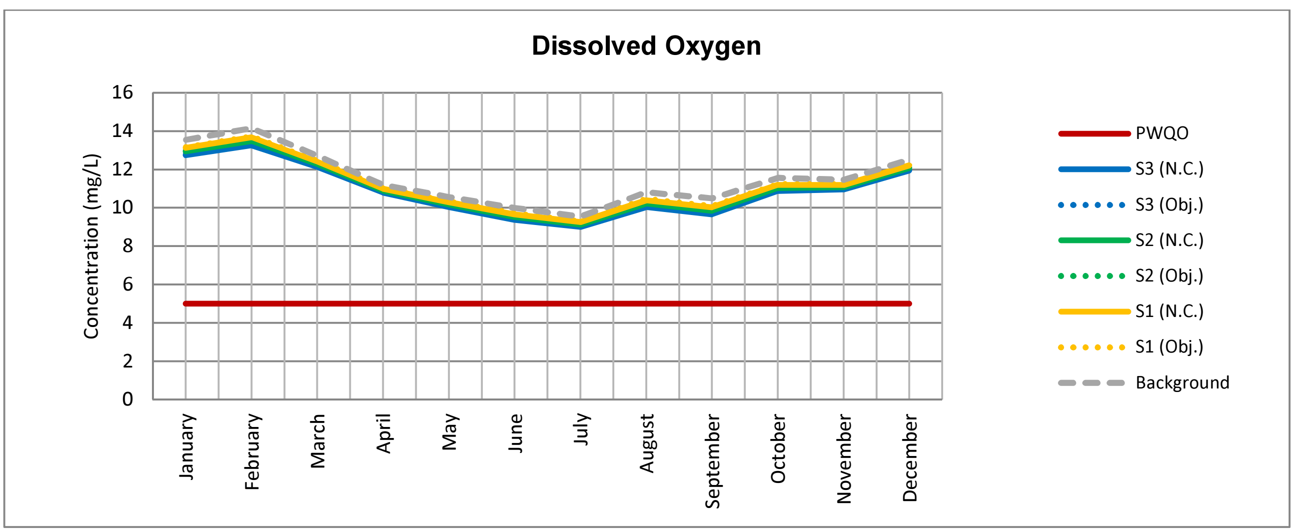
It is shown that the total ammonia that would be required in the river to produce toxic levels of un-ionized ammonia is greater than what will be obtained from the effluent discharge when mixed with the 75th percentile background concentrations in the river.



4.3 Dissolved Oxygen

A mass balance approach was used to predict the dissolved oxygen (DO) concentration using 7Q20 monthly flows and the 25th percentile background concentrations of DO for each month. The non-compliance effluent concentration of 4 mg/L was used in the calculations as was a value of 5 mg/L for comparison with the objective value.

The dissolved oxygen concentrations are projected to decline by a maximum of about 1.0 mg/L under the worst-case scenario with the effluent dissolved oxygen (DO) at the non-compliance value.



It is recognized that the impact assessment for dissolved oxygen has not been fully evaluated in this phase of the Class EA process as details of a WWTP design and location have not been determined. It is suggested that detailed dissolved oxygen modelling should be completed once WWTP locations and details are determined through additional phases of the Class EA.

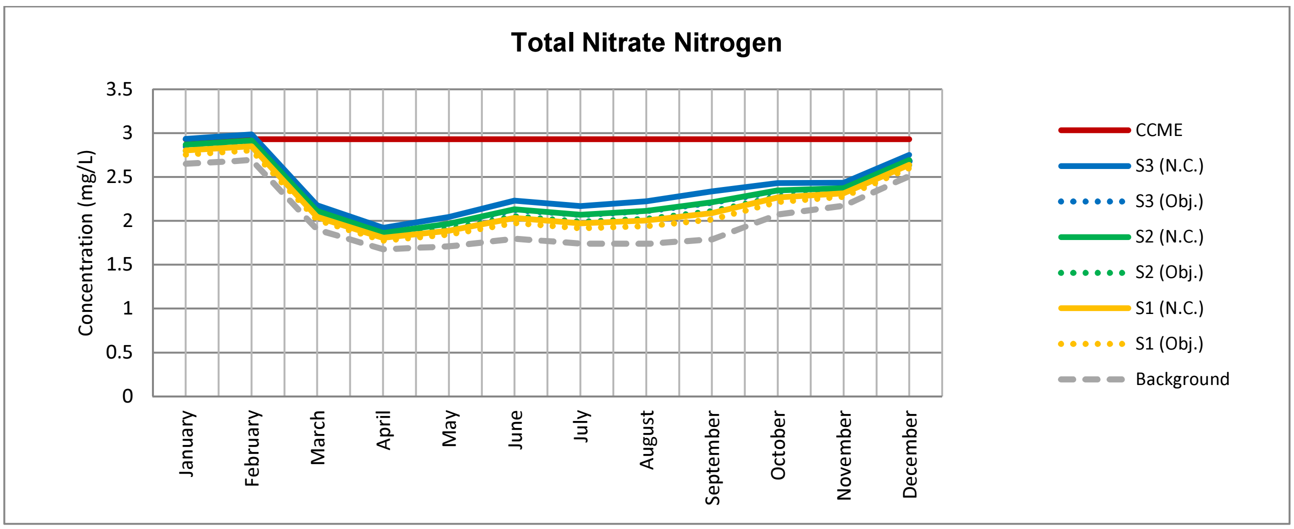
We expect that future analysis will incorporate water temperature, plant respiration, design flows and channel morphology on a monthly basis.

4.4 Nitrate Nitrogen

Although, the un-ionized ammonia is deemed to be the limiting nitrogen variable because of its acute toxicity, calculations were completed to predict the nitrate nitrogen (NO_3-N) concentration in the receiving stream.

The non-compliance effluent concentration of 6 mg/L and the objective value of 5 mg/L was used in the calculations.

During the non-growing season (winter months) there is a slight exceedance in the CCME suggested concentration but for the remainder of the year the results will be below the CCME value.



5.0 MIXING ZONE ANALYSIS

A hydrodynamic mixing zone model was developed to review the mixing zone downstream of a proposed effluent discharge location between the 10th Line and Winston Churchill Boulevard. Given the broad scope of Phase 1 and 2 study work for the SSMP, the exact location of the effluent discharge location has not been selected as the site location exercise will be a requirement of Phase 3 of the MEA Class EA process. As noted, however, it is suggested that a WWTP discharge would be better suited downstream of the 10th Line and closer to Winston Churchill where background conditions reflect lower concentrations and higher 7Q20 flows.

The photograph that follows is representative of the reach characteristics found between the 10th Line and Winston Churchill Boulevard.

West Credit River – Reach between the 10th Line and Winston Churchill Blvd.

Channel characteristics were extrapolated from the CVC Existing Conditions Report. The channel within the reach downstream of the 10th Line is described as having moderate to low sinuosity, with coarse substrate in a matrix of fine sediment. The channel is well connected to the floodplain, with dense rooting structure tight to the bank. Average channel flow near Winston Churchill has a width and depth of 9 metres and 0.3 metres, respectively. The slope of the channel in this reach is relatively flat, with a grade of approximately 0.2% as it traverses through the wooded area. The bank full capacity is estimated at 3,400 L/s, with a corresponding velocity of approximately 0.7 m/s. With a future WWTP discharge that may be in the range of 30 L/s (Population Scenario 3), it is not expected that the channel thresholds and related erosions rates will be impacted.

5.1 Un-ionized Ammonia and Mixing Zone

The extent of the mixing zone is important when reviewing acute toxicity immediately downstream of any proposed WWTP outlet and primarily relates to un-ionized ammonia and the effects on aquatic life.

The following data was used in the mixing zone analysis (completed using the Cormix hydrodynamic model) for the month of July:

- 7Q20 flow in the river of 274 L/s (see note);
- 75th percentile pH and temperature river values of 8.2 and 18.2 °C;
- 75th percentile background concentrations of un-ionized ammonia 0.00041 mg/L;
- Estimated average flows from a proposed WWTP under Scenario 3 of 30.2 L/s;
- Non-Compliance effluent ammonia concentration of 2.0 mg/L.

Un-ionized ammonia (NH_3) and ammonium (NH_4) exist together in equilibrium in an aqueous solution. The fraction of un-ionized ammonia in an aqueous solution is dependent on temperature and pH according to the following equations:

$f = 1/\{(10^{pKa-pH}) + 1)\}$, where f is the fraction of NH3 in solution, and

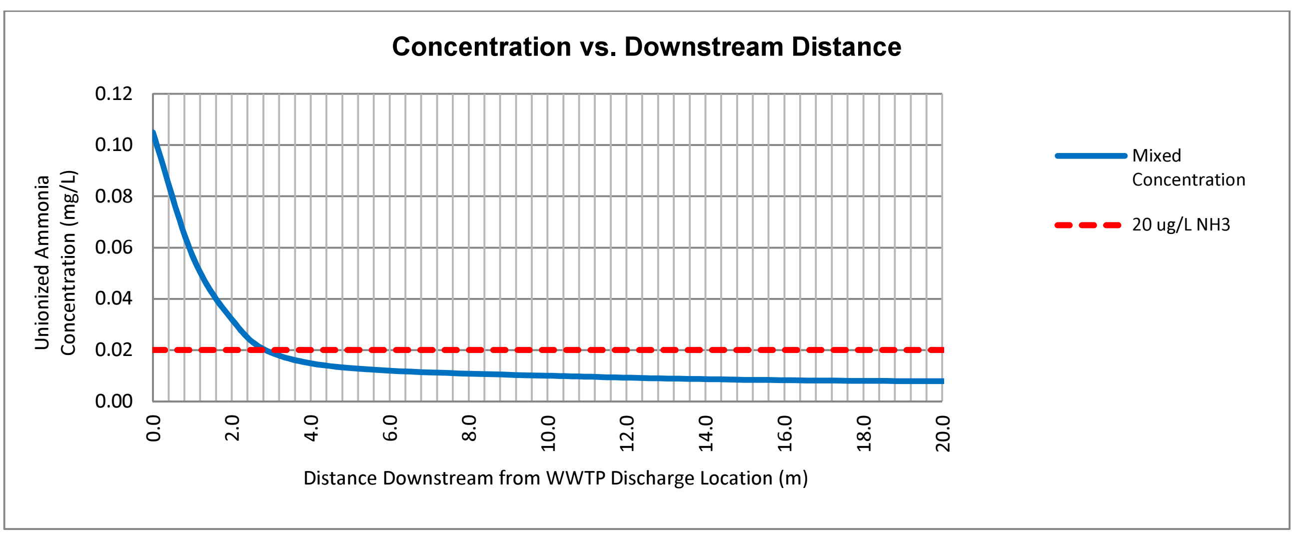
$pKa = 0.09018 + (2729.92/(T+273.16))$, where T is temperature in degrees Celsius.

Note: It is recognized that lower 7Q20 flow amounts have been calculated for the months of August and September, however the river temperature and pH values during those months result in an un-ionized fraction of the total ammonia that is much less than what would occur during the month of July. For this reason and based on modelling results, July has been assumed to be the worst case scenario for reviewing the end of pipe mixing zone and un-ionized ammonia impacts in the river.

Based on the mass balance calculations completed for Scenario 3, during the month of July, the maximum effluent ammonia allowable to maintain an un-ionized ammonia less than 0.02 mg/L (20 µg/L) would be 3.75 mg/L (assuming complete mixing in the river). As a comparison, the proposed non-compliance effluent ammonia is 2.0 mg/L.

Mixing zone modelling was completed to determine the downstream distance where the concentration of un-ionized ammonia (based on non-compliance effluent ammonia concentration) would be mixed to a value below the PWQO of 0.02 mg/L. By applying the above noted equations, an un-mixed end of pipe un-ionized ammonia concentration of 0.105 mg/L (2.0 mg/L x f, where f = 0.0527) has been determined. Results from the modelling indicate that mixing to a concentration less than the PWQO for un-ionized ammonia (0.02 mg/L) would occur at a distance less than 4 metres from the proposed WWTP discharge location and the width of the plume is expected to be less than 2 metres of the 9 metre wide channel.

Refer to the following graph for an illustration of the concentration versus downstream distance to dilution.



6.0 SUMMARY AND DISCUSSION

6.1 Summary

The Town of Erin has initiated a community-based process for completing a Servicing and Settlement Master Plan (SSMP). The community is presently not serviced by any communal sewage disposal system. One option available for servicing of the existing and future community is to provide a sanitary collection system and wastewater treatment plant (WWTP) with a surface water discharge to the West Credit River. The purpose of this report is to summarize the results of an analysis completed to review the ability of the West Credit River to accept effluent from such a proposed WWTP (i.e. the assimilative capacity of the West Credit River).

The investigation considered projected effluent discharge for population scenarios ranging from 3,087 people to 6,000 people. Monthly characteristics of the receiving stream, including flow conditions and water quality were taken from the CVC Environmental Component of the "Existing Conditions Report - 2010" and updated recently, with respect to river flow and quality.

A monthly analysis has been undertaken to more accurately reflect the seasonal characteristics of the watercourse. It is suggested that this approach provides a greater level of precision than what could be provided through an annual analysis.

Appendix 1 provides further details related to the mass-balance calculations completed for each parameter.

6.2 Scenario Impact

As noted, three scenarios were considered in the study to assess water quality impacts from a proposed WWTP on the West Credit River:

- Scenario 1: Population = 3,087 people.
- Scenario 2: Population = 4,481 people.
- Scenario 3: Population = 6,000 people.

The analysis was completed using:

- Monthly 7Q20 flows.
- 75th percentile background river concentrations for most parameters except dissolved oxygen (where 25th percentile information was used).
- Proposed effluent quality criteria for a WWTP.

The suggested EQC for study purposes is summarized in the following table:

Table 4
Effluent Quality Criteria (Current Study Values)

Parameter	**Proposed Design Values (Current Assessment)**	
	Treatment Objective	**Non-Compliance**
pH	<7 and >8.6	<7 and >8.6
Total Suspended Solids (mg/L)	3.0	10
Total Phosphorous (mg/L)	0.1	0.15
Total Ammonia (mg/L)	0.4	2.0
Total Kjeldahl Nitrogen (mg/L)		3.0
Nitrate Nitrogen (mg/L)	5	6
E. coli (org/100 mL)	100	100
Dissolved Oxygen (mg/L)	5 (min)	4 (min)
BOD_5 (mg/L)	3.6	7.5
Temperature	17	<8 and >19

A parameter by parameter evaluation of the impact of the proposed effluent discharge established the following:

- Total Phosphorus:

  Under population Scenario 3 and during the months where 7Q20 flows are at their lowest, total phosphorus levels in the West Credit rise close to the PWQO when applying a WWTP non-compliance discharge concentration of 0.15 mg/L. The objective value for effluent total phosphorus results in a final concentration less than the PWQO under all scenarios considered. The EQC for total phosphorus of 0.10 mg/L is considered achievable using the best available treatment technology.

- Ammonia:

  Following mixing of a WWTP discharge, river ammonia concentrations will be below the PWQO for un-ionized ammonia under all population scenarios considered. Mixing zone modelling confirms that non-toxic levels of un-ionized ammonia be achieved in relative proximity to the end of the WWTP discharge and less than 4 metres from the proposed pipe outfall.

- Biochemcal Oxygen Demand and Total Suspended Solids:

  Given the proposed EQC levels for any plant, it is not anticipated that significant impacts related to suspended solids will occur and BOD_5 concentrations are expected to be below 2 mg/L.

- Dissolved Oxygen:

  As details of a WWTP design and location have not been established as part of this phase of the Class EA process, the impact assessment for dissolved oxygen cannot be fully evaluated. A mass balance approach has been completed however to obtain a general idea of how DO may be affected.

  On this basis, the addition of an effluent discharge does not appear to reduce in-stream DO levels below 9.0 mg/L and should not have an overall negative impact, as the DO values remain substantially above the 5 to 6 mg/L preferred for coldwater fisheries.

  It is suggested that detailed dissolved oxygen modelling be completed once WWTP specifics (type and location) are determined as part of future Class EA work. The study work at that time should incorporate water temperature, plant respiration, design flows and channel morphology on a monthly basis.

- E. coli:

  An effluent discharge with an E. coli concentration of 100 org/100 mL will not increase instream concentrations above current levels.

- Nitrates:

  Given the effluent quality criteria being considered for total nitrogen, it is anticipated that the design for a WWTP will need to incorporate denitrification.

6.3 Stream Erosion

The potential for stream erosion to increase was examined. Because peak flows will only increase nominally (i.e., bank-full flow of 3,400 L/s plus effluent discharge of 30 L/s) and the effluent discharge is such a small proportion of the total peak stream flows, there should be no increase in erosion as a result of a future WWTP outfall.

6.4 Wastewater Treatment

Preliminary investigations undertaken related to available treatment technologies would indicate that the proposed effluent quality criteria can be achieved through the use of a state-of-the-art system.

6.5 Possible Expanded Population

Through the development of the ACS, it became apparent that there is available assimilative capacity during the spring and fall of the year. Effluent storage and a time controlled discharge could be considered as a method of increasing the population serviced.

Effluent could be stored during periods where there is potential for a WWTP discharge to result in river water quality values that may exceed objectives and then released when river conditions are less restrictive. In theory, this could provide the ability to treat a larger population.

Through trial and error of population amounts in the model it is anticipated that there is the opportunity for future seasonal effluent storage and discharge equating to an additional equivalent population of approximately 500 or more people.

It is recognized that consideration to water quality changes, including temperature, of the stored effluent will need to be considered further. Investigation through Phase 3 of a future Class EA process will be required to review and confirm the feasibility of providing effluent storage.

6.6 Future Study Work

Further investigation through the next phases of the Class EA process will be required to review and select a preferred treatment method as well as a preferred plant and outfall location.

Once details become finalized, it is suggested that further review of the following be undertaken:

- Dissolved Oxygen Modelling and Thermal Impacts:

  Dissolved oxygen is a parameter of concern in the West Credit due the sensitive aquatic habitat that it supports. Detailed dissolved oxygen modelling should be completed incorporating water temperature, plant respiration, design flows and channel morphology on a monthly basis, to evaluate the impact of wastewater flows on the dissolved oxygen regime of the West Credit River.

- Effluent Storage:

  The feasibility of providing effluent storage and a seasonally timed discharge of stored effluent will need to be investigated further as part of future phases of Class EA study work. This may be an opportunity to increase the serviced population of the treatment system. Among other aspects, consideration will need to be given to the water quality and temperature changes that may occur during storage and how that will impact upon the West Credit River.

The CVC and the MOE should both be consulted in the development of a work plan for future study work during the next phase of the Class EA study process.

7.0 CONCLUSION

This report summarizes the work completed to understand the assimilative capacity of the West Credit River through Erin. The study considered the impacts to the river under various population scenarios using proposed effluent quality criteria and existing river water quality and quantity characteristics.

Based on the completed analysis, it would appear that a surface water discharge is a viable alternative to service annual average daily discharge rates in the order of 2,610 m^3/day (6,000 people), while not negatively impacting on the stream as habitat for aquatic life.

Further investigation through the next phases of the Class EA process will be required to review and select a preferred treatment method as well as a preferred plant and outfall location. Once details become finalized, it is suggested that further review of dissolved oxygen, thermal impacts, and effluent storage be considered through consultation with the CVC and the MOE.

All of which is respectfully submitted.

LICENSED PROFESSIONAL ENGINEER
AUG. 8 - 2014
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S. D. BURNS
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DLE
Encl.

ATTACHMENT 1

ASSIMILATIVE CAPACITY STUDY DETAILS

Town of Erin
SSMP
Assimilative Capacity Study
Notes and Calculations

Job # :	08128
Date :	February 2013
Revised :	August 1, 2014

FINAL

1.0 INTRODUCTION

The Town of Erin has initiated a community-based process for completing a Servicing and Settlement Master Plan (SSMP). The Plan aims to address servicing, planning and environmental issues within the Town. Strategies developed through the SSMP process for community planning and municipal servicing over the next 25 years are intended to be developed consistent with municipal, county, and provincial policies.

The Erin SSMP study area is within the West Credit Subwatershed and is bounded by Fifth Line, Fifth Sideroad, and Shaw's Creek Road to the west, south and east, respectively. The northern boundary occurs at East Garafraxa-Erin Townline, between Fifth Line and Eighth Line, and Sideroad 27, between Eight Line and Shaw's Creek Road.

The West Credit Subwatershed (Subwatershed 15) drains significant portions of the Townships of Erin, flowing through the communities of Hillsburgh and Erin towards Belfountain. The subwatershed is about 106 square kilometers in area and runs from the northwest of Hillsburgh to the Forks of the Credit. Approximately 96 square kilometers of the subwatershed flow under the bridge at Winston Churchill Boulevard (Town of Caledon/Town of Erin boundary line). The limits of the subwatershed relative to the study limits for the SSMP are shown on Figure ACS-1.

1.1 History

In February of 2013, BMROSS completed a Draft Assimilative Capacity Study (ACS) of the West Credit River downstream of the community of Erin. The study was based on background river information (quality and quantity) contained in the CVC document from 2010 entitled "Erin SSMP, Environmental Component - Existing Conditions" (CVC Existing Condition Report). The CVC Existing Condition Report included a summary of the statistical analysis completed of the federal gauge data (8th Line) related to the estimation of the 7Q20 river flow value upstream of the community of Erin. For downstream of Erin (where the ACS calculations have been focused), areal reduction was applied to the 7Q20 values established at the 8th Line. It was these estimated areal reduced flow values that were used in the original ACS report completed by BMROSS.

The 2013 draft assimilative capacity study concluded that a surface water discharge was a viable alternative to service the Erin community and further suggested that a future WWTP discharge would be better suited downstream of the 10th Line and closer to Winston Churchill Boulevard where background conditions for both flow and quality are optimal.

A review of the draft ACS by the CVC and MOE was completed in the spring of 2013 and among other suggestions it was highly recommended that further review of the 7Q20 flow values be undertaken particularly downstream of the community of Erin (at the 10th Line). It was agreed that in order to provide confidence in correlating the flows between the 8th and 10th Line additional flow monitoring (downstream of Erin) should be considered.

Subsequently, and upon approval from Council, a flow gauge was installed at the 10th Line and monitoring began in late spring of 2013. In the fall of 2013 flow correlation work was completed by the CVC (and reviewed by the MOE and the project team) for comparing flow data between the long term gauge at the 8th Line (upstream of Erin) and the recently installed gauge at the 10th Line (downstream of Erin). Data analysis and calculations related to the monthly 7Q20 flows at the 8th Line were also updated by the CVC at that time based on data available up to the fall of 2013. Appendix 'A' includes select CVC correspondence related to the derivation of the 7Q20 flow at the 8th Line and the extrapolated flows downstream of the 10th Line.

The technical update of the ACS that follows has been prepared on the basis of these new 7Q20 values as well as the inclusion of quality data through to 2013. Further details related to the flow derivation of the 7Q20 values are summarized below.

1.2 Updated Assimilative Capacity Study

As noted above, the Town of Erin has an interest in completing a Settlement and Servicing Master Plan related to both existing and future growth areas in the communities of Hillsburgh and Erin. In order to do so, provision of sanitary servicing is needed to meet the needs of a both the existing and potentially growing population. One option is to provide a wastewater treatment plant (WWTP) to service the new and existing population in Erin with a surface water outfall to the nearest major watercourse (i.e. West Credit River). In order to add a new wastewater treatment facility with surface water outfall directed to the West Credit, among other requirements, it must first be established that the river has the capacity to receive treated effluent without adversely impacting water quality. The intent of this assimilative capacity study (ACS) is to summarize existing conditions in the West Credit River with respect to flow and water quality; determine the expected effluent characteristics and estimate the resulting change to in-stream flow and concentration associated with a proposed WWTP discharge. The proposed outfall location is on the West Credit River, downstream of the 10th Line (probably close to Winston Churchill Boulevard). This approximate location is preferred and is supported on the basis of the past study work. It is anticipated that the final discharge location would be subject to further review under the Class EA process.

2.0 DESIGN POPULATION AND SEWAGE FLOW

2.1 Existing and Forecast Population (Wellington County)

The following summarizes the existing and forecast populations values provided by the County of Wellington for the Town of Erin including the breakdowns for each of the main communities. The 2031 projections are from the County Official Plan document while the 2011 existing population values are from an update provided by the County in March of 2014.

Table 2.1 County Population Projections

Community		2011 (Existing)	2031 (Projected)
Erin	Population	3,087	4,400
Hillsburgh	Population	1,394	2,080
Totals	Population	4,481	6,480

The population density per household (as per 2011) is as noted below:

Erin	2.8	people per household
Hillsburgh	3.0	people per household
Combined	2.9	people per household

Table 2.2 Population Scenarios for Assimilative Capacity Study

As a matter of comparison, the Wellington County existing population values will be used in scenarios reviewed in the ACS. Scenario 1 and 2 represent the existing population figures for Erin and Hillsburgh. Scenario 3 is the limiting river assimilation population value.

Development Scenario	Equivalent Population	
	Incremental	Total
	People	People
Scenario 1 - Erin	3,087	3,087
Scenario 2 - Erin and Hillsburgh	1,394	4,481
Scenario 3 - Limiting Population	1,519	6,000

2.2 Average Sewage Design Flows

Wastewater Treatment Plant (WWTP) capacity is expressed as an annual average value. To establish a design capacity for a proposed Erin WWTP and subsequent plant discharge rate for the ACS several factors need to be considered including anticipated per capita flow and infiltration allowance. Water usage provides a reasonable approach to establishing average per capita flow rates.

Each of the main communities of Erin (Hillsburgh and Erin) are supplied with water through their own designated well supply systems. The water for the Hillsburgh system is presently supplied from two wells as is the Erin system.

As confirmed by the Town, both communities, Hillsburgh and Erin, are metered at the well supply. A summary of the total yearly volumes in each community and for all uses (residential and non-residential) are noted in the following table:

Table 2.3 Water Usage - Demands and Supply

Year	Yearly Volume (m^3) - All Uses (Residential and Non-Residential)		
	Well Supply		
	Hillsburgh	Erin	Total
2011	66,960	425,240	492,200
2012	75,500	349,760	425,260
2013	61,590	353,290	414,880
Average	68,020	376,100	**444,120**

In 2009, reserve capacity calculations were completed for both the Hillsburgh and Erin water systems. The serviced population values at that time were completed on the basis of the following:

Erin The Erin Municipal Water System is a ground water supply system serving 872 residential and 108 non-residential properties. The Erin Water System also supplies water to Stanley Park that contains 97 mobile homes and 11 cottages.

Hillsburgh The Hillsburgh Municipal Water System is a ground water supply system serving approximately 275 residential and 4 non residential properties.

Based on a review of the 2010 to 2013 data the number of total service connections has not changed significantly from the 2009 information used in the reserve capacity calculations and has only increased marginally with approximately 1010 connections (all uses) in Erin and 280 connections in Hillsburgh (all uses). In both communities there are few multi-dwelling residential facilities that have been included in the total connected population estimate as summarized in Table 2.4.

As noted above, in both of the communities there are some non-residential properties connected to the water system. In most cases, apart from a few larger users (i.e., Centre 2000, High School, Public School, Catholic School) the connected non-residential properties are low water users and many are retail stores which staff a moderate number of employees in any given day. For this reason, and for the purpose of providing a conservative estimate of per capita sewage flow, an equivalent population for non-residential connections has not been accounted for in the per capita flow calculation.

Table 2.4 Water Supply Connected Population

Connected Users	People per Property		Estimated Connections		Population		
	Hillsburgh	Erin	Hillsburgh	Erin	Hillsburgh	Erin	Total
Residential	3.0	2.8	276	900	830	2,520	3,350
Stanley Park - Mobile Home	0	2.2	0	97	0	210	210
Stanley Park - Cottages	0	2.2	0	11	0	20	20
Apt - 11 Wellington	0	2.8	0	6	0	20	20
Apt - 15 Wellington	0	2.8	0	3	0	10	10
Apt - 14 Centre St	0	2.8	0	3	0	10	10
Apt - 22 Church Blvd	0	2.8	0	3	0	10	10
Non Profit Housing - 15 Spruce	3	0	16	0	50	0	50
Non-Residential	0	0	4	110	0	0	0

Resulting Total Metered Equivalent Population = 3,680 people

Say: 3,600 people

Given the total water supply demand and population for both systems summarized above, an estimate of the average per capita water usage can be calculated. The average usage per person is determined by dividing the total volume by the total serviced population.

Table 2.5 Estimated Combined System Per Capita Water Usage (Based on 2010 to 2013 Data)

Reference Location	Total Avg. Volume (m^3)	Serviced Population (Eq. People)	Avg Usage (L/Cap./d)
Well Supply	444,120	3,600	338

2.3 Suggested Design Flows

Because of the importance associated with the average usage per capita flow values and to ensure a conservative approach is used in the assimilative capacity calculations it is appropriate to use the higher per capita flow value obtained using the more recent data summarized for 2010 to 2013. Therefore, the average per capita sewage flow used for calculation purposes will reflect the following water usage:

Average Water Usage	340	L/cap.day	
	345	L/cap.day	(Value Rounded)

For comparison purposes the following is noted:

Average Sewage Flow	450	L/cap.day	(Erin Pipe Sizing Design Standards)
	225 - 450	L/cap.day	(MOE Guideline)

The MOE guidelines suggest the following extraneous flow values:

Average Extraneous	90	L/cap.day	(MOE Guideline)
Peak Extraneous	227	L/cap.day	(MOE Guideline)

Considering the above information, it is suggested that the following flow values be used for design purposes:

Average Sewage Flow:	345	L/cap.day	(Avg. Sewage)
	90	L/cap.day	(Extraneous)
	435	L/cap.day	Total Avg. Sewage
Peak Sewage Flow:	345	L/cap.day	(Avg. Sewage)
	Varies [1.]	Harmon Equation	(Sewage Peaking Factor = PF)
	227	L/cap.day	(Extraneous)
	Varies [2.]		Total Peak Sewage (Refer to Table 2.9)

Notes:

1. The Harmon formula is used to determine peaking factors for design flows:

$$PF = 1 + \frac{14}{4 + P^{1/2}}$$ where P = population in 1000's

2. For each population scenario, the total peak sewage is obtained by adding the peak extraneous flow value to the peak sewage flow value. Peak sewage flows have been established by taking the average sewage value from above and applying the Harmon Factor based on population. Peak extraneous flows are based on applying a value of 227 L/cap per day to the total serviced population.

2.4 Summary of Design Flows

Table 2.7 Sewage Flow Calculations

	Serviced Population	Average Day Design Flow			Peak Day Design Flow		
		Sewage 1.	Extraneous 2.	Total 3.	Peaking Factor 4.	Extraneous 5.	Total 6.
	(people)	(m^3/d)	(m^3/d)	(m^3/d)	(PF)	(m^3/d)	(m^3/d)
Scenario 1	3,087	1,070	280	1,350	3.43	700	4,370
Scenario 2	4,481	1,550	400	1,950	3.29	1020	6,120
Scenario 3	6,000	2,070	540	2,610	3.17	1360	7,920

Notes:
1. Average Sewage = Average sewage demand (345 L/cap.day) x Population
2. Average Extraneous = Average extraneous flow (90 L/cap.day) x Population
3. Total Average Design Flow = Average Sewage + Average Extraneous
4. Peaking Factor calculated from Harmon's formula (population based)
5. Peak Extraneous Flow = (227 L/cap/day) x Serviced Population
6. Peak Design Flow = Average Day Sewage Flow x Peaking Factor + Peak Extraneous Flow

The following average day design values are those recommended for use in completing the ACS:

Table 2.8 Sewage Treatment - Average Day Design Flow

Development Scenario	People	Average Day Design Flow	
		(m^3/d)	(L/s)
Scenario 1	3087	1350	15.6
Scenario 2	4481	1950	22.6
Scenario 3	6000	2610	30.2

3.0 TREATMENT REQUIREMENTS

As part of the 1995 Class EA, the MOE was consulted regarding proposed effluent quality criteria (EQC) objectives for a new wastewater treatment plant. Discussions undertaken with the MOE, at the on-set of the ACS study work, confirmed that the 1995 values considered remained appropriate for study purposes and mass balance calculations related to assimilative capacity. The following summarizes the preliminary effluent quality limits, provided by the MOE, in correspondence dated August 1996. It is noted that phosphorus, nitrogen, and the E. Coli limits have been modified as part of the current study work. The suggested study values are summarized below for comparison:

Table 3.1 Treatment Requirements

Parameter	Design Values 1996 MOE Suggestion		Design Values for Current Sudy	
	Treatment Objective	Non Compliance	Treatment Objective	Non Compliance
pH	**8.2**	**7-8.6**	**8.2**	**7-8.6**
Total Suspended Solids (mg/L)	**3.0**	**10**	**3.0**	**10**
Total Phosphorous (mg/L)	**0.10**	**0.20** [1.]	**0.10**	**0.15**
Total Ammonia (mg/L)	**0.4**	**2.0**	**0.4**	**2.0**
Total Kjeldahl Nitrogen (mg/L)		**3.0**		**3.0**
Nitrate Nitrogen (mg/L)	**7.6** [1.]	**10** [1.]	**5**	**6**
E. Coli (org/100 mL)	**100**	**200** [1.]	**100**	**100**
Dissolved Oxygen (mg/L)	**5 (min)**	**4 (min)**	**5 (min)**	**4 (min)**
BOD_5 (mg/L)	**3.6**	**7.5**	**3.6**	**7.5**
Temperature	**17**	**8-19**	**17**	**8-19**

Notes: 1. 1996 value noted but revised as part of current assimilative capacity study (see current study values).

4.0 RECEIVING STREAM

The receiving stream for treated effluent is the West Credit River. Figure ACS-1, illustrates a plan of the watershed limits for the West Credit as well as the approximate drainage areas for a number of key locations along the watercourse both upstream and downstream of the community of Erin.

4.1 Possible WWTP Discharge Location

Based on past reports prepared related to both water quality and low flow conditions in the West Credit, the assimilative capacity potential of the river is optimal near Winston Churchill Boulevard at the downstream limit of Erin. Given the broad based review nature of the master plan process for the SSMP, the calculations that follow assume a WWTP discharge location in the general vicinity of Winston Churchill Boulevard.

Future Class EA work will be required to further define a preferred location for a WWTP outlet.

4.2 Receiving Stream Flows

Long-term monitoring of streamflow has been conducted on the West Credit River at 8th Line and 17th Sideroad, since 1983. The gauge is operated and maintained by the Water Survey of Canada (WSC) and is called 02HB020 (Credit River at Erin Branch, Above Erin).

Several hydrology reviews of the gauge data have been completed in the past as summarized below. The 7Q20 flow values noted are based on completed statistical analysis of the gauge data at 02HB020 for the period preceding the year of the analysis extending back to 1983 when the gauge was established. The most recent 7Q20 flow values reflect late 2013 analysis, completed by the CVC, and is based on the most recent available data. It is noted that the more recent analysis will linclude the greatest period of record and therefore should provide a more accurate statistical prediction.

Table 4.1 History of 7Q20 Flows Predicted at the 8th Line

Report	Year	7Q20 Flow
Erin Class Environmental Assessment and ACS	1995	0.166 m^3/s
West Credit Subwatershed Study	1998	0.177 m^3/s
Erin SSMP - Environmental Component - Existing Conditions	2010	0.120 m^3/s
CVC 7Q20 update	2014	0.124 m^3/s

It is important to note that the drainage area of the WSC gauge at the 8th Line represents about 37% of the West Credit River watershed compared to the area upstream of Winston Churchill Blvd. Historically, hydrology work completed downstream of the WSC gauge site has been based on transposition formulas and areal reduction. In April of 2013, the CVC and the MOE suggested that because of geological dissimilarities, accurately transposing flows downstream to a proposed WWTP discharge point between 10th Line and Winston Churchill Boulevard requires a more comprehensive approach that includes downstream flow measurement and correlation. For this reason the following measures were implemented:

- Installation of a stream gauge at the 10th Line to take a continuous record of water stage and measurement of stream discharge.
- Establishment of a regression equation for estimating the relationship between streamflow data at the 8th Line and the 10th Line.

On July 23, 2013 the new stream gauge at the 10th Line was activated and in the winter of 2013, following collection of a moderate data set, a regression analysis of the data comparing flows between the 8th and 10th Line was undertaken by the CVC. A few analytical iterations of the information was undertaken between November 2013 and January 2014 resulting in a suggested data set of 7Q20 flow values for the West Credit River downstream of the 10th Line. These calculations were vetted and accepted through the MOE and project team. Refer to Appendix 'A' for a copy pertinent correspondence related to the development of the monthly 7Q20 flow values provided by the CVC.

4.3 Climate Change

Based on input provided by the CVC and the MOE, it is felt that the influence of climate change should be incorporated into the final ACS results by further reducing the 7Q20 flow values determined downstream of the 10th Line. Climate change factors are often included when reviewing future flow events for either extreme high or extreme low flow conditions and although there is no defined standard as to how the anticipated effect of climate change in Southern Ontario watercourses should be factored, a number of municipalities are using a 10 to 15% allowance factor for river and runoff events. On this basis, as reviewed with the approving agencies and as supported within the document entitled “Guide for Assessment of Hydrologic Effects of Climate Change in Ontario, EBNFLO Environmental AquaResource Inc, 2010” a 10% reduction factor is considered reasonable. Resulting monthly 7Q20 flow values are summarized below:

4.4 7Q20 Flow Values

Given the foregoing discussion, the following table summarizes the 7Q20 flow values used within the analysis.

Month	7Q20 Flow at the 8th Line (02HB020)	7Q20 Flow downstream of the 10th Line (Transposed Data)				
	CVC Analysis Update	CVC Suggested Flow	Reduction Factor [1] 10%	Design Value (Reduced by Reduction Factor)		Correlation 8th to the 10th (No Reduction Factor)
	L/s	L/s	L/s	L/s	m^3/s	
Jan	202	366	37	329	0.329	181%
Feb	192	347	35	312	0.312	181%
Mar	253	464	46	418	0.418	183%
Apr	307	568	57	511	0.511	185%
May	217	395	40	355	0.355	182%
June	164	293	29	264	0.264	179%
July	170	305	31	274	0.274	179%
Aug	147	261	26	235	0.235	178%
Sept	128	224	22	202	0.202	175%
Oct	185	334	33	301	0.301	181%
Nov	250	458	46	412	0.412	183%
Dec	252	462	46	416	0.416	183%

Notes: 1. Reduction factor is an estimation of impacts related to future climate and landuse changes.

4.5 Receiving Stream Quality

Historical stream quality was analyzed by the Credit Valley Conservation Authority (CVC) and summarized in the CVC Environmental Conditions Report. The CVC reviewed a significant amount of data through the watershed based on grab samples obtained by their staff as well as the lengthy record available from the Provincial Water Quality Monitoring Network (PWQMN) station #06007601502 at Winston Churchill Boulevard. The station is located about 1.5 km downstream of the 10th Line and monitors about 96 km^2 of the watershed. In comparison, the watershed at the 10th Line is only 4% smaller (92km^2) than the monitored location.

The CVC Environmental Condition Report included a review the PWQMN station data for the period from 1996 to 2008. Since the completion of that report, the more recent data has become available, and the river quality concentrations have been updated, by BMROSS, to include monitoring information up to the end of 2013. Appendix B includes the updated analysis and summary of the data.

As suggested, a WWTP discharge may be better suited closer to Winston Churchill. The water quality records indicate higher parameter concentrations at the 10th Line compared to those found at Winston Churchill. To demonstrate this difference, the CVC compared data collected from 2007 to 2008 for Winston Churchill and the 10th Line. The comparative data includes same day and same sample counts at both locations.

Table 4.3 Quality Comparison Between the 10th Line and Winston Churchill Boulevard

Parameter	Winston Churchill		10th Line	
	75th Percentile	Maximum	75th Percentile	Maximum
Phosphorous, mg/L	0.013	0.022	0.019	0.030
Nitrate-Nitrogen, mg/L	2.28	2.40	2.20	2.40
Unionized Ammonia, ug/L	0.01	0.013	1.48	10.95
BOD_5, mg/L	0.725	1.1	2	2
E. Coli, cts/100 mg/L	67	820	160	840
TSS, mg/L	3.1	7	ND	ND

Given the above, the analyzed data available from the PWQMN at Winston Churchill Blvd (#06007601502) for the period from 1996 to 2013 will primarily be used in the mass balance calculations for review of the impacts of a possible WWTP outlet.

The following table summarizes the existing water quality and compares it to the Ontario Provincial Water Quality Objectives (PWQO) where one exists. As discussed, these values are based on the long term monitoring at Winston Churchill Boulevard (Station #06007601502) and the data analyzed by the CVC and updated by BMROSS. The parameters listed area noted as the Parameters of Concern (POC) in the CVC Existing Conditions Report.

Table 4.4 West Credit River Water Quality (Station #06007601502) - Includes Data up to 2013

Parameter	Concentrations					
	Average	Min.	Max	25th	75th	PWQO
Phosphorus (mg/L)	0.013	0.002	0.058	0.012	0.016	0.03
Nitrate-Nitrogen (mg/L)	1.777	0.324	3.38	1.44	2.01	3.00 [1]
Un-ionized Ammonia-NH3 (ug/L)	0.258	0.006	2.152	0.067	0.347	20
BOD_5 (mg/L)	0.751	0.2	4.8	0.4	0.9	DO>5
Ecoli (cts/100mL	40	4	1400	13	110	100
TSS (mg/L)	3.79	0.5	30.3	1.5	4.15	25 [1]
TKN (mg/L)	0.383	0.03	1.8	0.3	0.42	N/A

Notes: 1. Indicates value noted is not a PWQO but refers to CCME suggested limits instead.

4.6 Stream Classification

The long-term monitoring data summarized by the CVC in the Existing Conditions Report indicate that the West Credit River is a Policy 1 stream. Under the MOE's Policy 1 statement, for those water quality parameters that are below their PWQO, some minimal degree of degradation may be accepted; however, degradation beyond the PWQO is not accepted (Ontario Ministry of Environment, 2004).

5.0 IMPACT OF A STP DISCHARGE DOWNSTREAM OF THE 10TH LINE

The following section of this report summarizes the results of the mass balance calculations completed under the following population scenarios:

Table 5.1 Arbitrary Population Scenario

Condition	Population
Scenario 1	3,087
Scenario 2	4,481
Scenario 3	6,000

The population scenarios selected are for comparison purposes only and do not reflect results of a detailed planning exercise. As a matter of comparison, the Wellington County existing population values have been used in scenarios 1 and 2 and are representative of the communities of Erin and Hillsburgh. Scenario 3 is the limiting river assimilation population value.

It is important to note that the impact assessment completed for the receiving stream includes non-compliance effluent quality criteria as summarized in Table 3.0 along with estimated 20 year low flow values (7Q20) for each month. The use of these values results in a worse case scenario and do not reflect what could be considered the "normal" operating conditions for a WWTP.

Appendix C includes additional details related to the model calculations which can be referred to should further information or clarification be required.

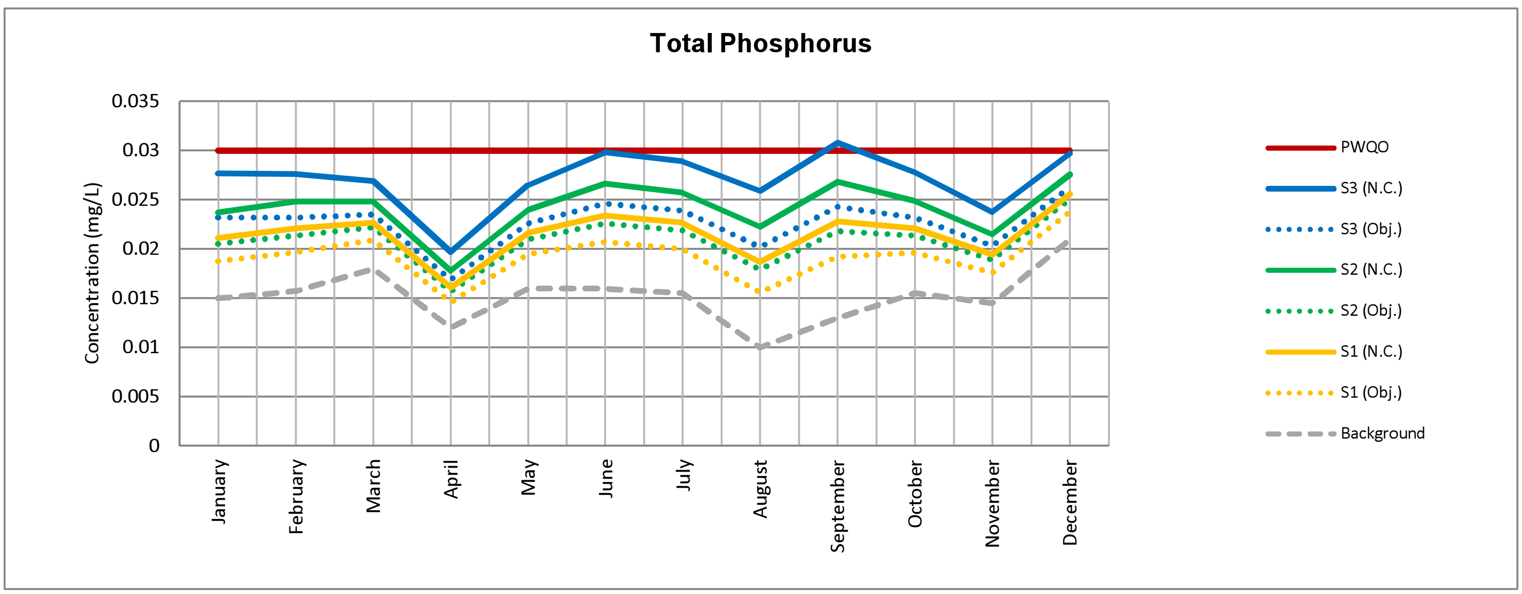
5.1 Total Phosphorus (TP)

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the population scenarios, resulting effluent flow and non-compliance effluent concentration:

Effluent TP Concentration:	0.10 mg/L	Objective
PWQO=0.03 mg/L	0.15 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance EQC		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	0.015	0.0188	0.0205	0.0232	0.0211	0.0237	0.0277
February	0.016	0.0197	0.0214	0.0232	0.0221	0.0248	0.0276
March	0.018	0.0209	0.0222	0.0235	0.0227	0.0248	0.0269
April	0.012	0.0146	0.0157	0.0169	0.0161	0.0178	0.0197
May	0.016	0.0195	0.0210	0.0226	0.0216	0.0240	0.0265
June	0.016	0.0207	0.0226	0.0246	0.0234	0.0266	0.0298
July	0.016	0.0200	0.0219	0.0239	0.0227	0.0257	0.0289
August	0.010	0.0156	0.0179	0.0202	0.0187	0.0223	0.0259
September	0.013	0.0192	0.0218	0.0243	0.0228	0.0268	0.0308
October	0.016	0.0196	0.0214	0.0232	0.0221	0.0249	0.0278
November	0.015	0.0176	0.0189	0.0203	0.0194	0.0215	0.0238
December	0.021	0.0238	0.0251	0.0263	0.0256	0.0276	0.0297

Summary in Graph Form



Discussion

The long-term monitoring data summarized by the CVC in the Existing Conditions Report, indicate that the West Credit River is a Policy 1 stream. Under MOE's Policy 1 statement, the MOE states that for those water quality parameters that are below their PWQO, some minimal degree of degradation may be accepted.

Under Scenario 3, using the phosphorus effluent objective concentration of 0.10 mg/L, the monthly analysis demonstrates that the PWQO of 0.03 mg/L can be met during all months and typically below 0.025 mg/L. The non-objective value results during the months of June and September approach the PWQO for the river.

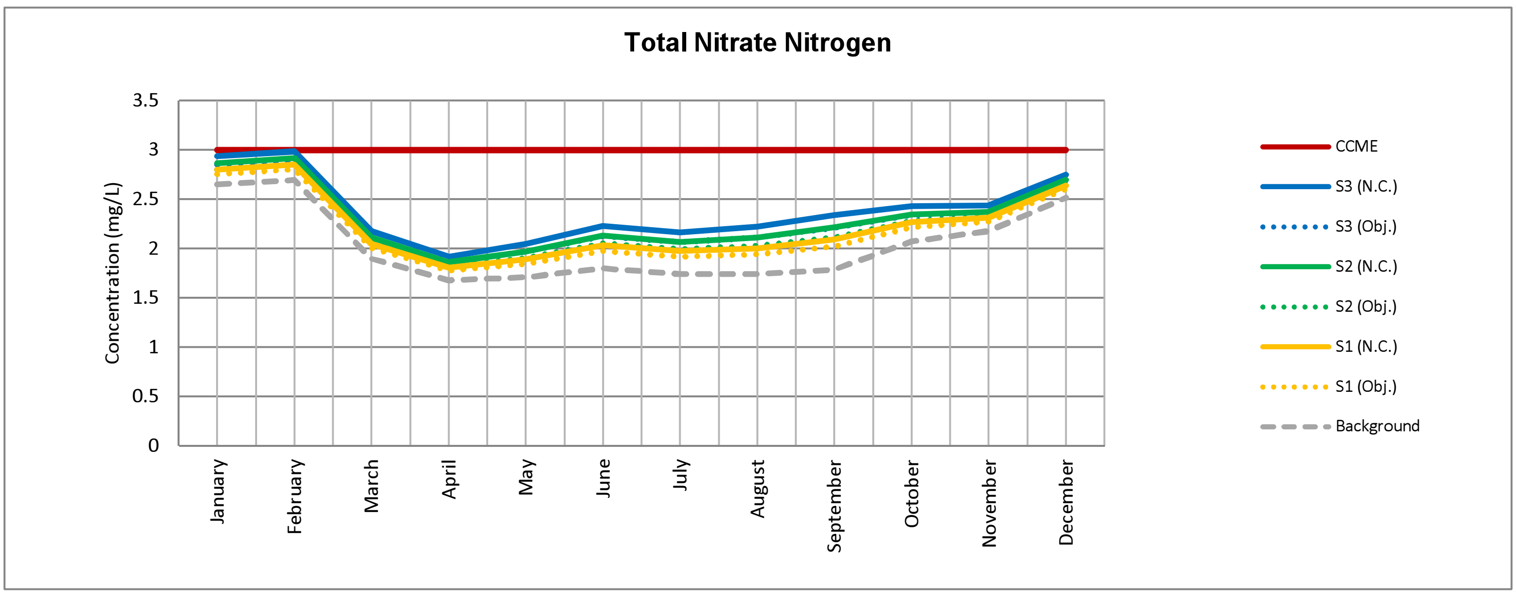
5.2 Nitrate Nitrogen

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Effluent Nitrate Nitrogen Conc.:	5	mg/L	Objective
CCME=3.0 mg/L	6	mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance EQC		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	2.65	2.76	2.80	2.85	2.80	2.87	2.93
February	2.70	2.80	2.85	2.90	2.85	2.92	2.99
March	1.90	2.01	2.06	2.11	2.05	2.11	2.18
April	1.68	1.78	1.82	1.87	1.81	1.86	1.92
May	1.71	1.85	1.91	1.97	1.89	1.97	2.05
June	1.80	1.98	2.05	2.13	2.03	2.13	2.23
July	1.75	1.92	1.99	2.07	1.97	2.07	2.17
August	1.74	1.94	2.03	2.11	2.00	2.11	2.23
September	1.79	2.02	2.11	2.21	2.09	2.21	2.34
October	2.08	2.22	2.28	2.34	2.27	2.35	2.43
November	2.18	2.28	2.32	2.37	2.31	2.37	2.44
December	2.52	2.60	2.64	2.68	2.64	2.69	2.75

Summary in Graph Form



Discussion

The model was used to predict the nitrate nitrogen concentration using 7Q20 monthly flows and the 75th percentile background concentrations for each month. The non-compliance effluent concentration of 6 mg/L and objective value of 5 mg/L was used in the calculations.

As assumed in the 1995 ACS, it is anticipated that with the construction of a collection system and wastewater treatment plant there would be a reduction in the nitrate addition from the urban area due to the elimination of the private disposal systems in the community. The study at that time assumed about a 25% reduction in background nitrate concentrations as a result of reduced inputs from septic systems. Based on this anticipated reduction, the maximum mixed concentration of approximately 3 mg/L (under Scenario 3) would reduce considerably below below the CCME limit. For this reason, it is expected that nitrate nitrogen levels in the river will only nominally increase beyond current background levels.

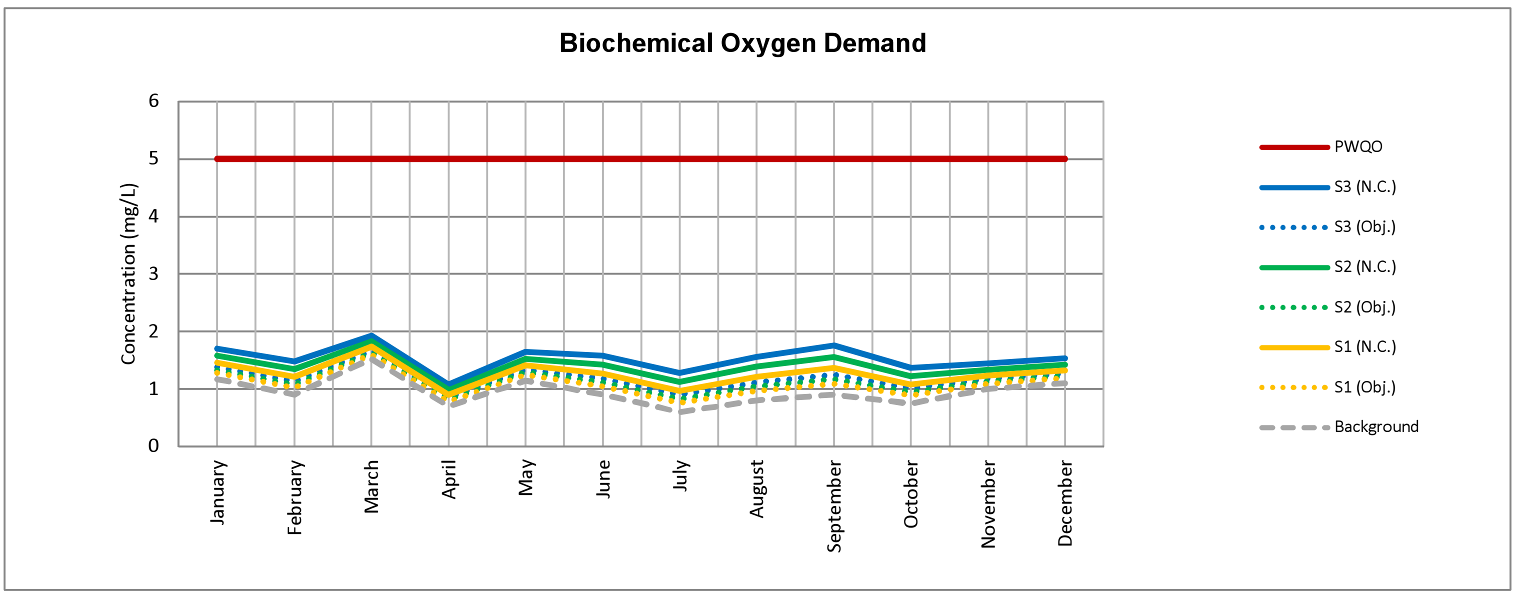
5.3 Biochemical Oxygen Demand (BOD5)

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Biochemical Oxygen Demand	3.6 mg/L	Objective
PWQO=5 mg/L	7.5 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance EQC		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	1.2	1.3	1.3	1.4	1.5	1.6	1.7
February	0.9	1.0	1.1	1.1	1.2	1.3	1.5
March	1.5	1.6	1.6	1.7	1.7	1.8	1.9
April	0.7	0.8	0.8	0.9	0.9	1.0	1.1
May	1.2	1.3	1.3	1.3	1.4	1.5	1.6
June	0.9	1.0	1.1	1.2	1.3	1.4	1.6
July	0.6	0.8	0.8	0.9	1.0	1.1	1.3
August	0.8	1.0	1.0	1.1	1.2	1.4	1.6
September	0.9	1.1	1.2	1.3	1.4	1.6	1.8
October	0.8	0.9	0.9	1.0	1.1	1.2	1.4
November	1.0	1.1	1.1	1.2	1.2	1.3	1.4
December	1.1	1.2	1.2	1.3	1.3	1.4	1.5

Summary in Graph Form



Discussion

The model was used to predict the biological oxygen demand concentration using 7Q20 monthly flows and the 75th percentile background concentrations for each month. The non-compliance effluent concentration of 7.5 mg/L was used in the calculations. For comparison purposes the objective value of 3.6 mg/L was also reviewed.

The above summarized results show that the predicted after-mixing in-stream BOD5 concentrations are expected to increase slightly under the scenarios considered. Generally, it is not anticipated that after mixing BOD5 concentrations will exceed a value of 2.0 mg/L and on average will typically be below 1.8 mg/L.

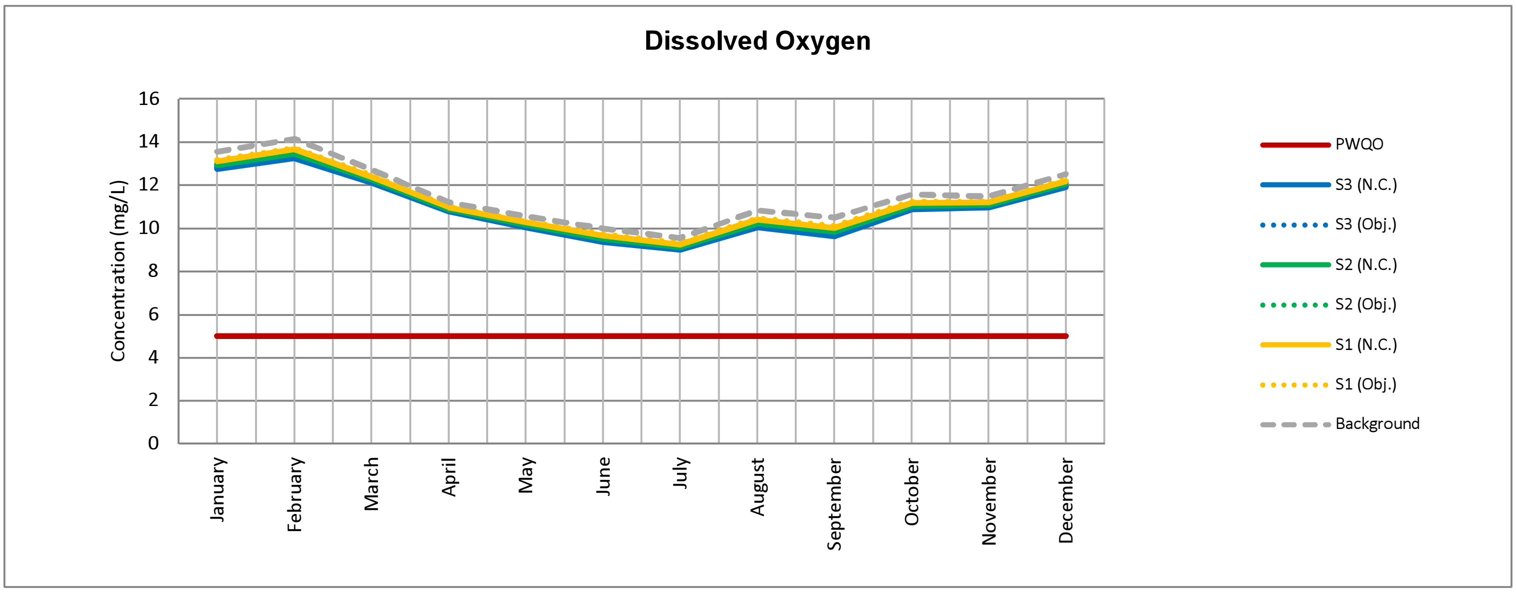
5.4 Dissolved Oxygen

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent

Dissolved Oxygen	5 mg/L	Objective
DO>5 mg/L	4 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance EQC		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	13.6	13.2	13.0	12.8	13.1	12.9	12.7
February	14.2	13.7	13.5	13.3	13.7	13.5	13.3
March	12.7	12.4	12.3	12.2	12.4	12.3	12.1
April	11.2	11.0	10.9	10.9	11.0	10.9	10.8
May	10.6	10.3	10.2	10.1	10.3	10.2	10.0
June	10.0	9.7	9.6	9.5	9.7	9.5	9.4
July	9.6	9.3	9.2	9.1	9.3	9.1	9.0
August	10.8	10.5	10.3	10.2	10.4	10.2	10.0
September	10.5	10.1	9.9	9.8	10.0	9.8	9.7
October	11.6	11.2	11.1	11.0	11.2	11.0	10.9
November	11.5	11.2	11.1	11.0	11.2	11.1	11.0
December	12.5	12.2	12.1	12.0	12.2	12.1	11.9

Summary in Graph Form



Discussion

The model was used to predict the dissolved oxygen concentration using 7Q20 monthly flows and the 25th percentile background concentrations for each month. The non-compliance effluent concentration of 4 mg/L was used in the calculations as was a value of 5 mg/L for comparison with the objective value.

Under a mass balance methodology, the dissolved oxygen concentrations are projected to decline by a maximum of about 1.0 mg/L under the worst case scenario with the effluent dissolved oxygen (DO) at the non-compliance value. Based on the noted approach it is not anticipated that the DO would drop significantly beyond 9 mg/L (and typically stay above 10 mg/L) which is substantially above the PWQO of 5 to 6 mg/L for coldwater fisheries.

The impact assessment for dissolved oxygen has not been fully evaluated in this phase of the Class EA process as details of a WWTP design and location have not been determined. Detailed dissolved oxygen modelling should be completed once WWTP details are determined which incorporates water temperature, plant respiration, design flows and channel morphology on a monthly basis.

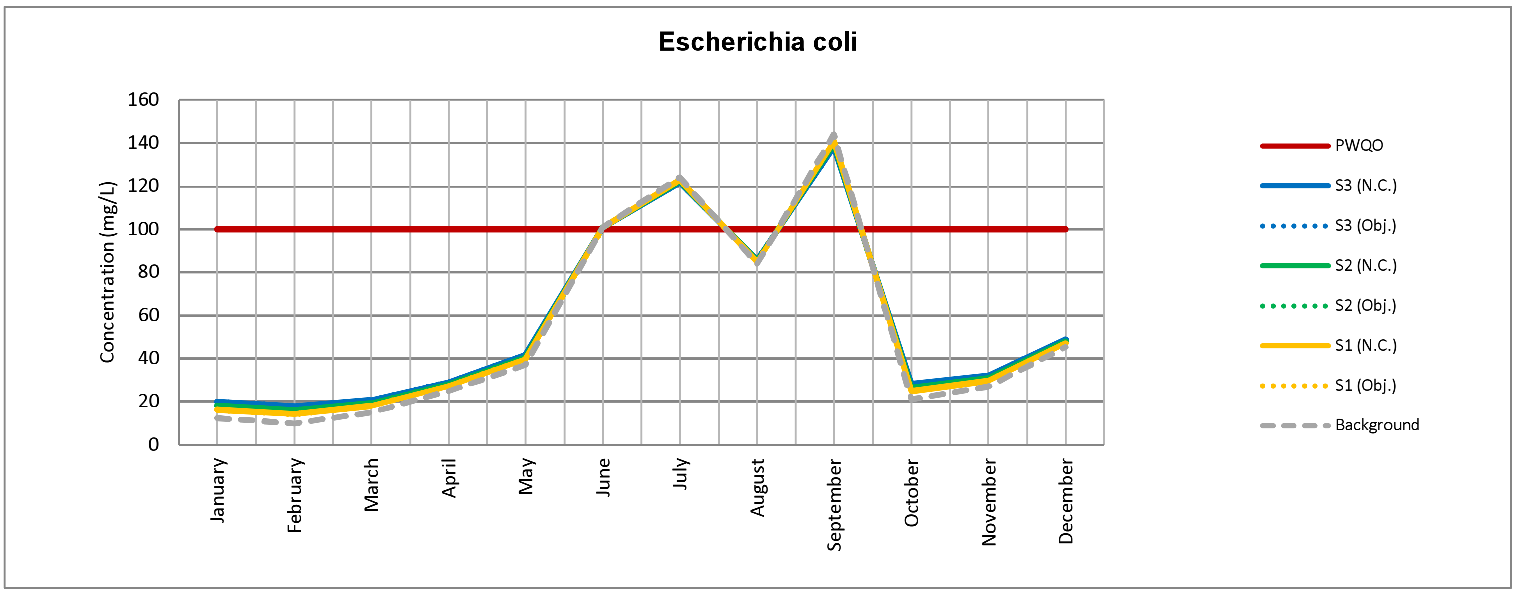
5.5 Escherichia coli

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Escherichia coli	100 mg/L	Objective
PWQO=100 mg/L	100 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	12	16	18	20	16	18	20
February	10	14	16	18	14	16	18
March	15	18	19	21	18	19	21
April	25	27	28	29	27	28	29
May	37	40	41	42	40	41	42
June	101	101	101	101	101	101	101
July	124	123	122	122	123	122	122
August	84	85	85	86	85	85	86
September	144	141	140	138	141	140	138
October	21	25	27	28	25	27	28
November	27	30	31	32	30	31	32
December	45	47	48	49	47	48	49

Summary in Graph Form



Discussion

The model was used to predict the resulting Escherichia coli geomean concentration using 7Q20 monthly flows and the 75th percentile background geomean concentrations for each month. The non-compliance effluent concentration of 100 mg/L was used in the calculations.

The projected Escherichia coli concentrations are not anticipated to result in significant impact beyond current background monthly levels in the West Credit.

Given new federal policies in place, it is anticipated that any new WWTP would be constructed utilizing technology (i.e., UV disinfection) which will provide a treatment level that will readily meet plant objectives for Escherichia coli inactivation.

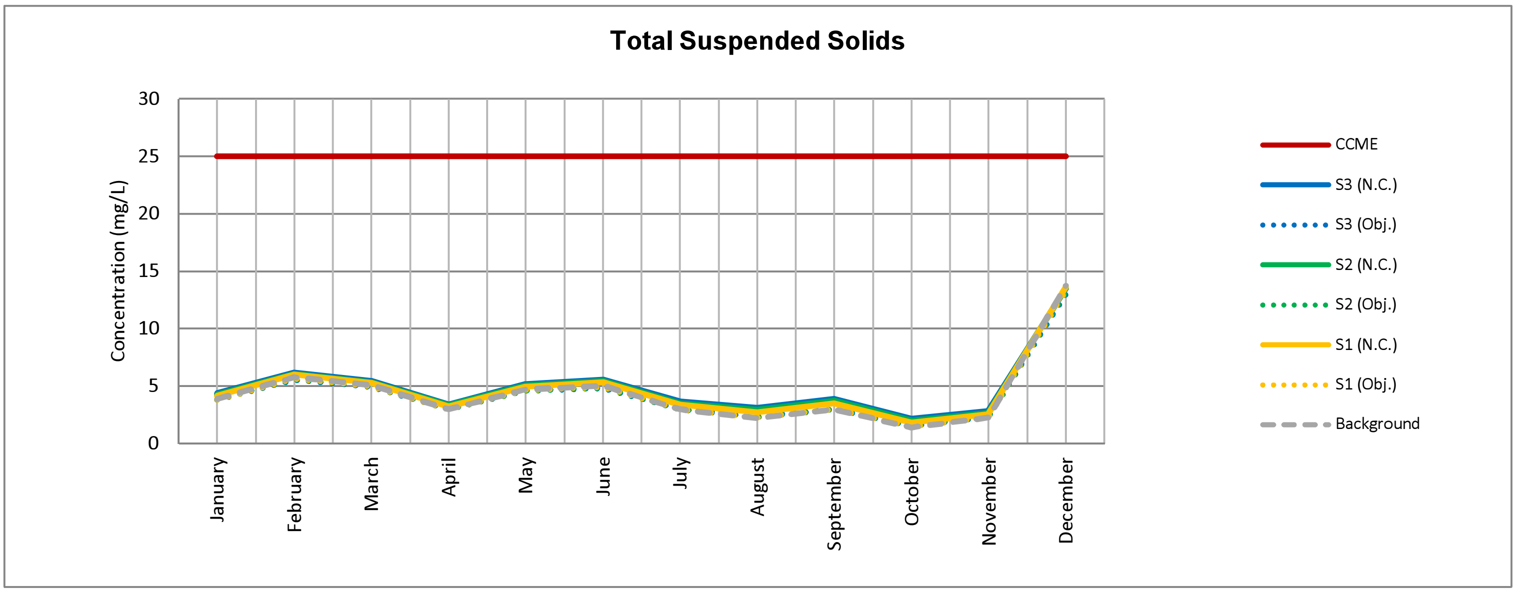
5.6 Total Suspended Solids

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Total Suspended Solids	3 mg/L	Objective
CCME=25 mg/L	10 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	3.9	3.9	3.8	3.8	4.2	4.3	4.4
February	5.8	5.7	5.6	5.6	6.0	6.1	6.2
March	5.1	5.0	5.0	5.0	5.3	5.4	5.4
April	3.0	3.0	3.0	3.0	3.2	3.3	3.4
May	4.8	4.7	4.6	4.6	5.0	5.1	5.2
June	5.1	4.9	4.9	4.8	5.3	5.4	5.6
July	3.0	3.0	3.0	3.0	3.4	3.5	3.7
August	2.3	2.3	2.3	2.3	2.7	2.9	3.1
September	3.0	3.0	3.0	3.0	3.5	3.7	3.9
October	1.4	1.5	1.5	1.6	1.8	2.0	2.2
November	2.3	2.3	2.3	2.3	2.6	2.7	2.8
December	13.8	13.4	13.2	13.0	13.6	13.6	13.5

Summary in Graph Form



Discussion

The model was used to predict the resulting total suspended solid concentration using 7Q20 monthly flows and the 75th percentile background values for each month. The non-compliance effluent concentration of 10 mg/L was used in the calculations and for comparison purposes the objective value of 3 mg/L was considered.

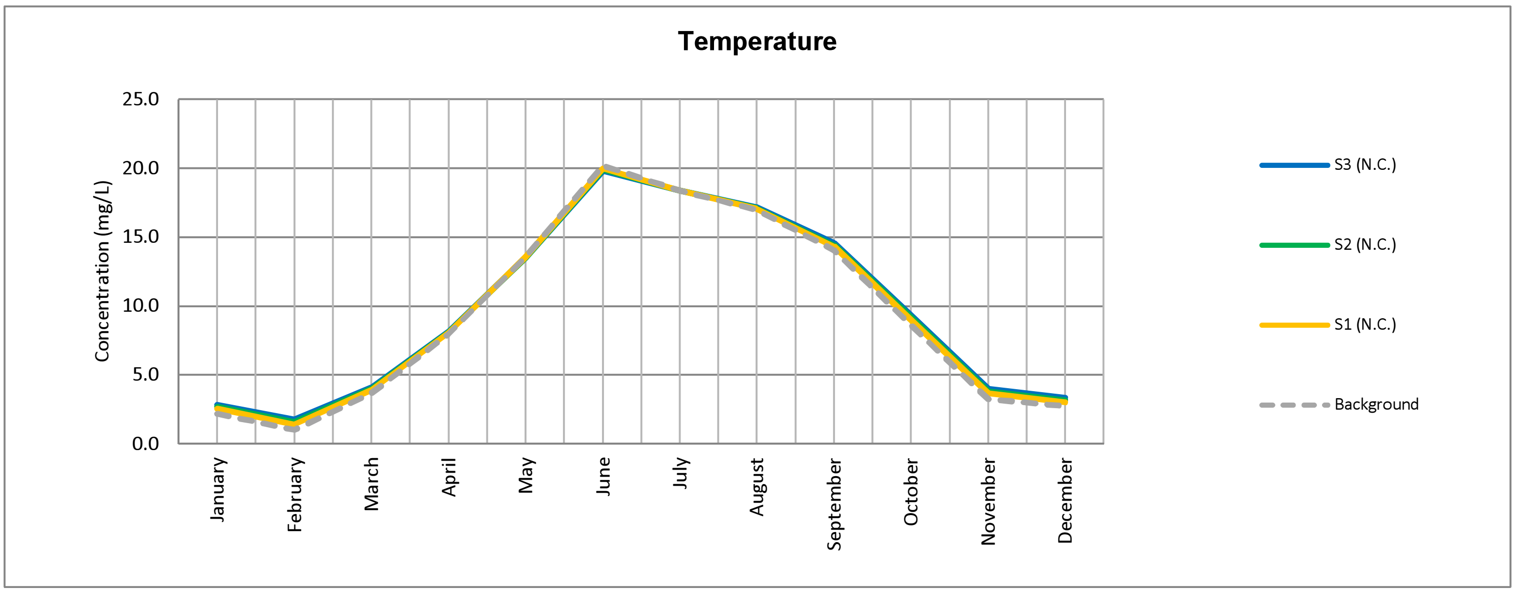
The projected total suspended solids concentrations are not anticipated to result in significant impact beyond current monthly background levels in the West Credit.

5.7 Temperature

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Month	Temperature (°C)				
			Development Scenario		
	Background	Plant	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	2.2	9.9	2.5	2.7	2.8
February	1.0	9.5	1.4	1.6	1.8
March	3.7	10.1	3.9	4.0	4.1
April	8.0	11.2	8.1	8.1	8.2
May	13.6	13.2	13.5	13.5	13.5
June	20.2	16.3	20.0	19.9	19.8
July	18.4	18.5	18.4	18.4	18.4
August	17.0	18.6	17.1	17.1	17.2
September	14.1	18.0	14.3	14.4	14.6
October	8.7	16.3	9.0	9.2	9.3
November	3.3	14.5	3.7	3.8	4.0
December	2.7	11.6	3.0	3.2	3.3

Summary in Graph Form



Discussion

The model was used to predict the resulting river temperature using 7Q20 monthly flows and the 75th percentile background values for each month. Estimated effluent temperature values for each month were derived from WWTP plant information located within a reasonable vicinity to Erin (Orangeville).

Based on the simplified mass-balance approach, the projected river temperature after complete mixing are not anticipated to result in significant impact beyond current monthly background levels in the West Credit.

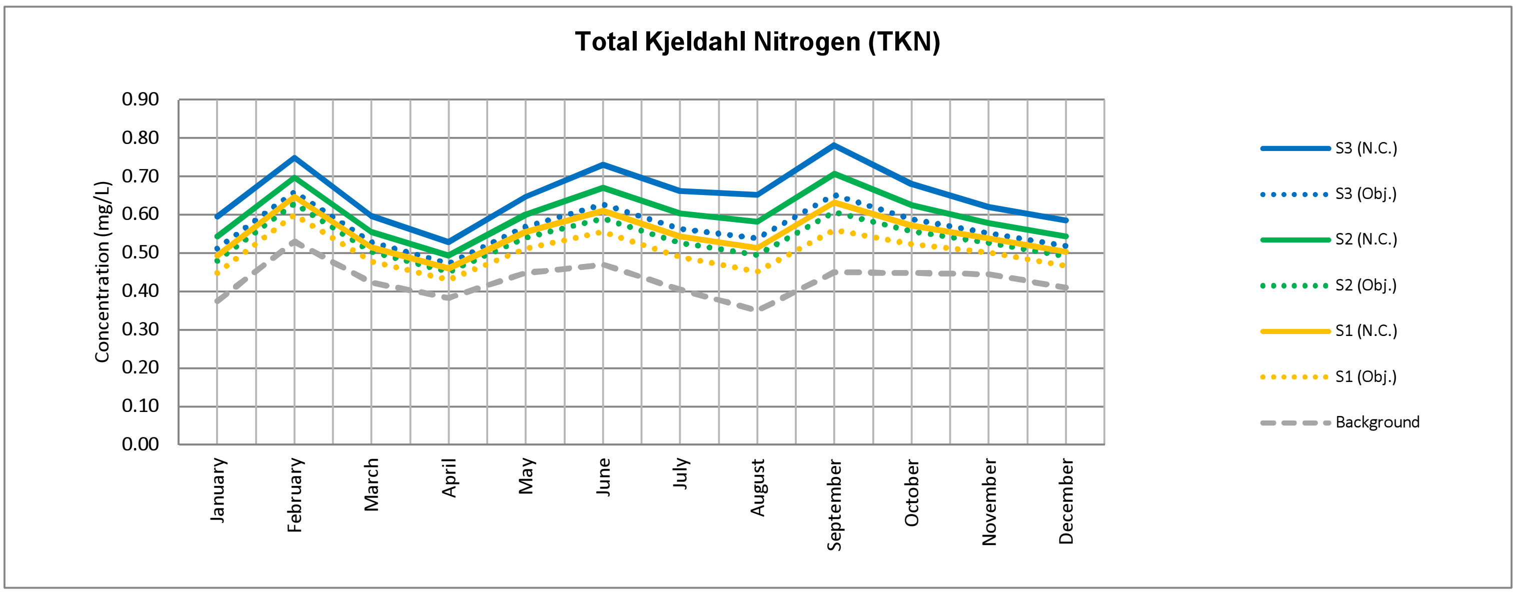
5.8 Total Kjeldahl Nitrogen (TKN)

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Total Kjeldahl Nitrogen (TKN)	2 mg/L	Objective
N/A	3 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	0.38	0.45	0.48	0.51	0.49	0.54	0.60
February	0.53	0.60	0.63	0.66	0.65	0.70	0.75
March	0.42	0.48	0.50	0.53	0.51	0.55	0.60
April	0.38	0.43	0.45	0.47	0.46	0.49	0.53
May	0.45	0.51	0.54	0.57	0.55	0.60	0.65
June	0.47	0.55	0.59	0.63	0.61	0.67	0.73
July	0.41	0.49	0.53	0.56	0.54	0.60	0.66
August	0.35	0.45	0.49	0.54	0.51	0.58	0.65
September	0.45	0.56	0.61	0.65	0.63	0.71	0.78
October	0.45	0.52	0.56	0.59	0.57	0.63	0.68
November	0.45	0.50	0.53	0.55	0.54	0.58	0.62
December	0.41	0.47	0.49	0.52	0.50	0.54	0.59

Summary in Graph Form



Discussion

TKN is the sum of organic nitrogen, ammonia (NH3), and ammonium (NH4+). TKN concentrations give information of the full nitrogen cycle but do not have an associated guideline or objective. The model was used to predict the Kjeldahl Nitrogen concentration using 7Q20 monthly flows and the 75th percentile background concentrations for each month. The non-compliance effluent concentration of 3 mg/L was used in the calculations along with the objective value of 2 mg/L for comparison purposes.

The projected river concentration after complete mixing, and under population Scenario 3, may increase up to 0.81 mg/L (worse case). As discussed above, it is anticipated that background nitrate levels will reduce with the elimination of septic systems in the urban development areas and may ultimately offset the increase associated with the WWTP discharge.

5.9 Total Ammonia

Using monthly 7Q20 flows, the following mixed concentrations were calculated based on the various population scenarios and the noted effluent concentration:

Total Ammonia	0.4 mg/L	Objective
N/A	2 mg/L	Effluent Non-Compliance

Month	Concentrations (mg/L)						
		Development Scenario with Objective EQC			Development Scenario with Non-Compliance		
	Background	S1 (Obj.)	S2 (Obj.)	S3 (Obj.)	S1 (N.C.)	S2 (N.C.)	S3 (N.C.)
January	0.031	0.05	0.05	0.06	0.12	0.16	0.20
February	0.021	0.04	0.05	0.05	0.11	0.15	0.20
March	0.022	0.04	0.04	0.05	0.09	0.12	0.16
April	0.017	0.03	0.03	0.04	0.08	0.10	0.13
May	0.017	0.03	0.04	0.05	0.10	0.14	0.17
June	0.016	0.04	0.05	0.06	0.13	0.17	0.22
July	0.021	0.04	0.05	0.06	0.13	0.17	0.22
August	0.018	0.04	0.05	0.06	0.14	0.19	0.24
September	0.013	0.04	0.05	0.06	0.15	0.21	0.27
October	0.012	0.03	0.04	0.05	0.11	0.15	0.19
November	0.016	0.03	0.04	0.04	0.09	0.12	0.15
December	0.016	0.03	0.04	0.04	0.09	0.12	0.15

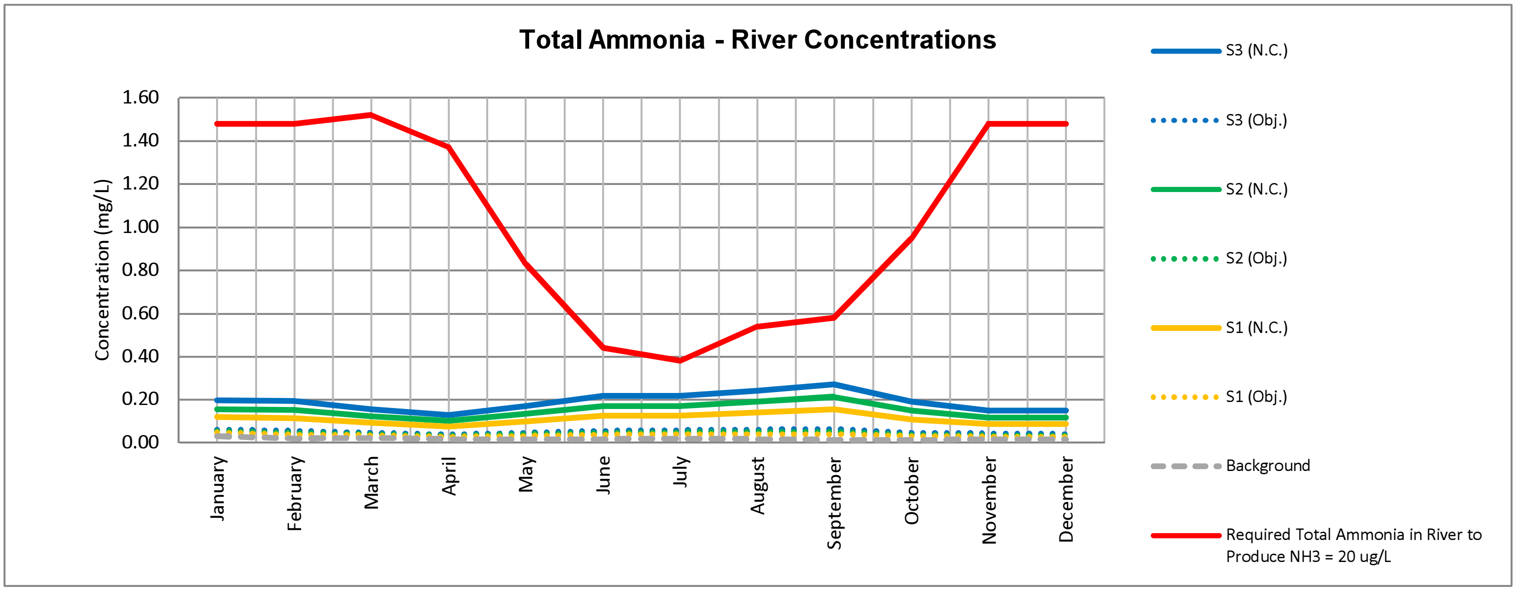
The model was used to predict the Total Ammonia concentration using 7Q20 monthly flows and the 75th percentile background concentrations for each month. The non-compliance effluent concentration of 2 mg/L was used in the calculations and for comparison purposes the effluent objective value of 0.4 mg/L was also used.

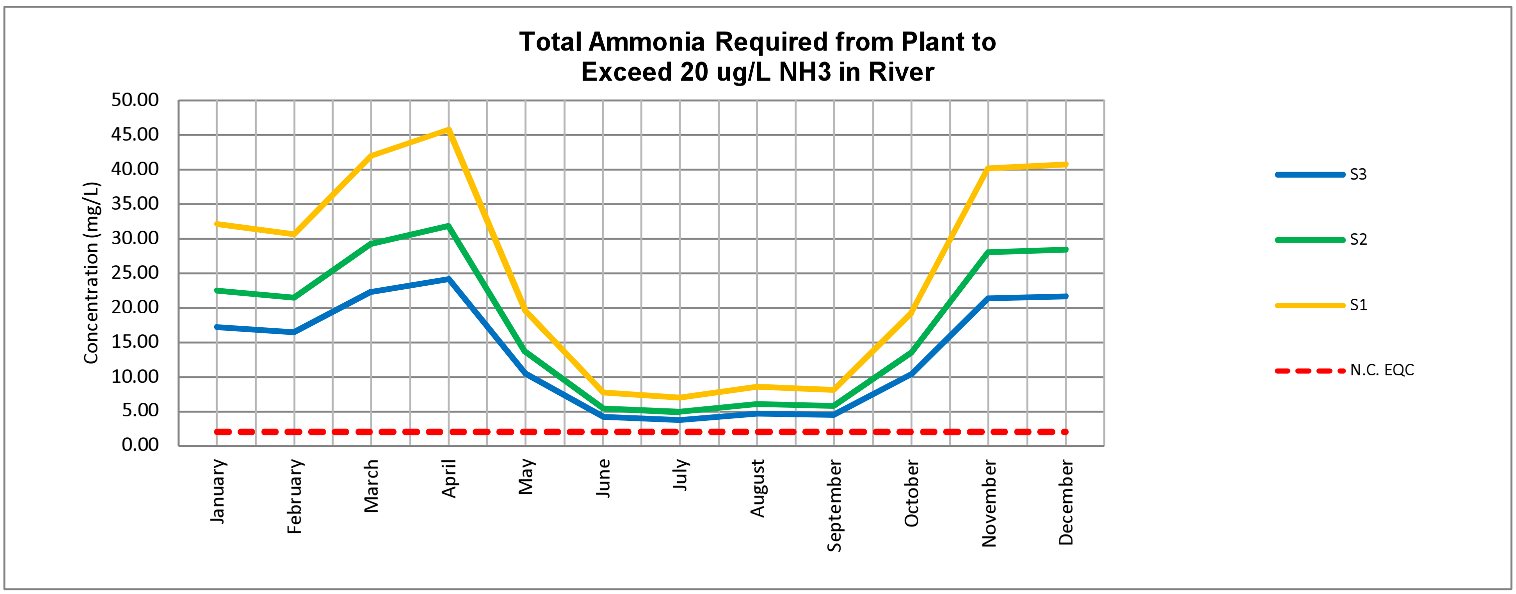
Un-ionized ammonia is calculated using the Emerson equation based on total ammonia, field water temperature, and field pH data. In order to compare how the estimated Total Ammonia, calculated above, relates to the PWQO for un-ionized ammonia in the river, the total ammonia concentration required to produce an un-ionized fraction equal to 20 ug/L was calculated. Refer to the following table for a summary of the calculated values.

Month	Concentrations (mg/L)					
	River pH	River Temp	Required Total Ammonia in River to Produce NH3 = 20 ug/L	Required Effluent Ammonia to Produce River Total Ammonia that would Result in an Exceedance of the PWQO for the Un-Ionized fraction of Total Ammonia		
				S1	S2	S3
January	8.1	2.2	1.48	32.07	22.46	17.18
February	8.2	1.0	1.48	30.63	21.47	16.44
March	8.1	3.7	1.52	41.95	29.25	22.27
April	8.0	8.0	1.37	45.74	31.80	24.14
May	8.0	13.6	0.83	19.46	13.61	10.39
June	8.1	20.2	0.44	7.74	5.44	4.18
July	8.2	18.4	0.38	6.95	4.88	3.75
August	8.1	17.0	0.54	8.56	6.04	4.66
September	8.1	14.1	0.58	8.12	5.75	4.45
October	8.1	8.7	0.95	19.26	13.51	10.35
November	8.1	3.3	1.48	40.22	28.05	21.36
December	8.1	2.7	1.48	40.71	28.39	21.62

Included in the above is an estimate of total plant effluent ammonia that would be necessary to result in a river total ammonia concentration that would meet or exceed the PWQO of 20 ug/L of un-ionized ammonia in the river. The calculations take into account 75th percentile total ammonia concentrations, field river temperature, and field river pH.

Summary in Graph Form





Discussion

As illustrated above, the total ammonia concentrations predicted by the model are well below the total ammonia concentration that would be necessary to produce an un-ionized ammonia concentration in the river greater than the PWQO value of 20 ug/L.

Based upon monthly total ammonia concentrations in the river, the plant ammonia necessary to create a river concentration of un-ionized ammonia greater than the PWQO value of 20 ug/L is typically far greater than the non-compliance concentration for plant total ammonia. It is noted that as the scenarios increase with population (and corresponding effluent flow), the variance between the non-compliance effluent value and the required ammonia from a WWTP decreases (primarily during the summer months) but does not fall below the non-compliance value.

6.0 Mixing Zone

The extent of the mixing zone is important when reviewing acute toxicity immediately downstream of the a proposed WWTP outlet and primarily relates to unionized ammonia and the effects on aquatic life.

A model was prepared to review the possible dispersion plume of the WWTP discharge in the river reach between the 10th Line and Winston Churchill. Based on visual observations and channel geomorphology information contained in the CVC Existing Condition Report.

Channel characteristics were extrapolated from the CVC Existing Conditions Report with the channel located downstream of the 10th Line is described as having moderate to low sinuosity with coarse substrate in a matrix of fine sediment. The channel is well connected to the floodplain with dense rooting structure tight to the bank. The channel has an average width and depth of 9 metres and 0.3 metres, respectively. The slope of the channel in this reach is relatively flat with a grade of approximately 0.2% and traverses through the adjacent wooded area.

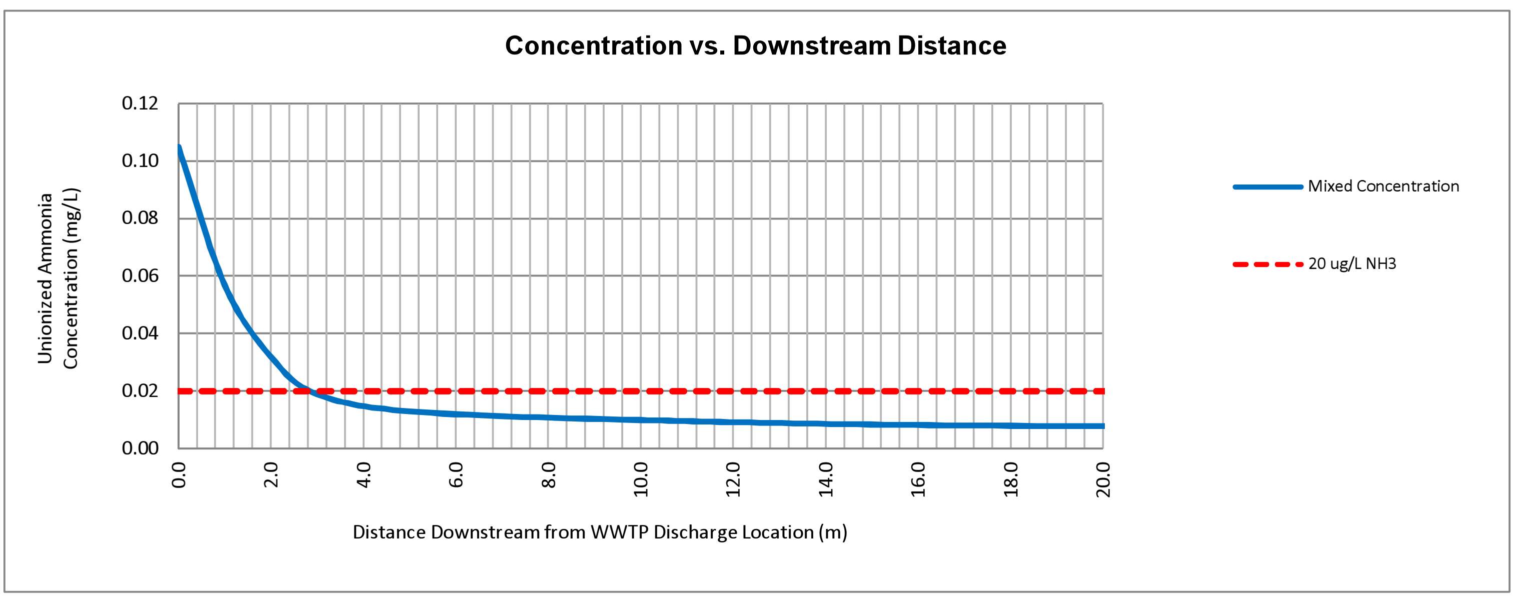
The bank full capacity is estimated at 3.4 m^3/s with a corresponding velocity of approximately 0.7 m/s. With a future WWTP discharge that may range in flow from 0.016 m^3/s (Population Scenario 1) to 0.030 m^3/s (Population Scenario 3) it is not expected that the channel thresholds and related erosions rates will be impacted.

Although the identification of an exact location for a WWTP discharge is beyond the scope of the SSMP, it is anticipated that the preferred discharge location will be close to Winston Churchill where the assimilative capacity of the river is greater than other areas upstream. Review of the mixing zone was completed assuming a below surface discharge from a single pipe resting on the bottom of the channel bottom. It has been assumed that the discharge would be parallel to the stream flow with effluent discharge of about 30.2 L/s (Population Scenario 3). It is anticipated that a final design may consist of a diffuser which would enhance the actual mixing process.

For modelling purposes, a conservative approach has been taken which assumes summer river characteristics for 7Q20 flow, pH, and temperature. Based on the modelling completed for Scenario 3, during the month of July, total effluent ammonia to achieve the PWQO (20 ug/L) for unionized ammonia would have to be 3.75 mg/L assuming complete mixing at the end of the discharge pipe. As a comparison, the non-compliance effluent quality is 2.0 mg/L for total ammonia. Given a 75th percentile ph and temperature river values of 8.2 and 18.4 ^oC, respectively, and assuming a non-compliance situation (i.e., 2.0 mg/L), the end of pipe unionized ammonia concentration would be 0.1054 mg/L (2.0 mg/L x f, where f = fraction of total ammonia = 0.0527 based on river temperature and pH). 75th percentile river background values for NH_3 of 0.00041 mg/L (0.413 ug/L) were used in the modelling. 7Q20 channel flows for the month of July were used in the analysis (0.274 m^3/s).

It is recognized that a lower 7Q20 flow occurs during the month of September, however, the river temperature and pH during that month results in an unionized fraction (0.068 mg/L) that is much less than what can occur in July (0.1054 mg/L) which suggests the July scenario should be considered worse case. Refer to Appendix D for further details related to the mixing zone analysis completed.

The modelling results indicate that mixing to a concentration of less than the PWQO for unionized ammonia (0.02 mg/L) would occur at a distance less than 4 metres from the proposed WWTP discharge location and the width of the plume is expected to be less than 2 metres. Refer to the following graph for an illustration of the concentration versus downstream distance to dilution.



It is noted that the completed modelling has been undertaken assuming a general location for the site discharge (i.e., the reach immediately upstream of Winston Churchill Blvd.). As part of future site selection work during later phases of a Class EA process, additional modelling should be undertaken to incorporate potential dissolved oxygen and temperature changes including further review of the zone of influence.

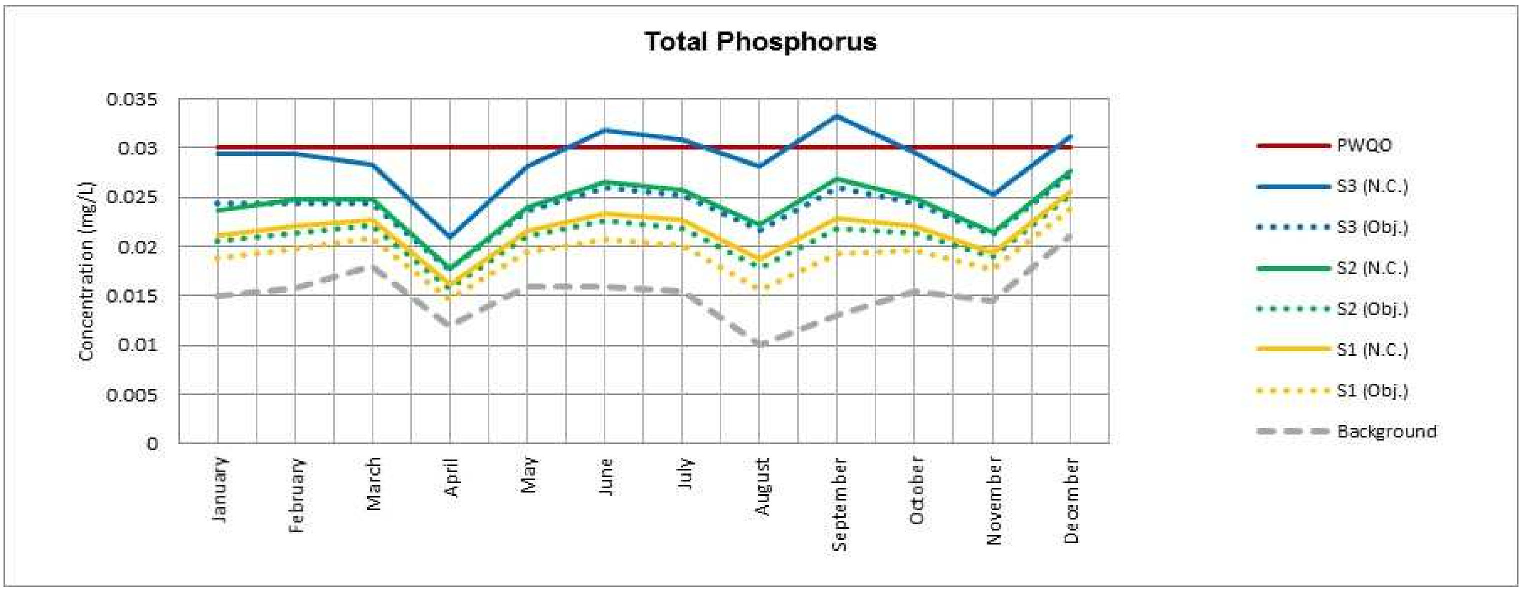
7.0 Possible Effluent Storage

Through the development of the ACS, it became apparent that there may be opportunity to provide effluent storage as a method of increasing the population that could be serviced. Effluent could be stored during periods where there is potential for a WWTP discharge to result in river water quality values that may exceed objectives and then released when river conditions are less restrictive. In theory this could provide the ability to provide treatment for a larger population.

Based on a review of the final river concentrations for phosphorus (one of the main parameters of concern) there appears to be assimilative capacity available in the river during the spring and fall of the calendar year. Through population analysis of the graph it is anticipated that there may be opportunity for future seasonal effluent storage and discharge. It appears possible that treatment capacity could be increased by an additional equivalent population of approximately 500 to 1,000 people.

The following graph illustrates the impact to the phosphorus river concentrations after adding 1,000 more equivalent people to the equation. By analyzing the graph between mid-may and early december it appears that the area above the PWQO is balanced with the area below the PWQO. This would suggest that effluent storage during the summer months followed by additional effluent release during the spring and fall, may provide for the opportunity to treat an additional population beyond the projected West Credit River assimilative capacity of approximately 6,000 people.

It is suggested that effluent storage be considered as part of future Class EA work. The type and location of a facility is beyond the current scope of the Phase 1 and 2 Class EA study work. The feasibility of providing effluent storage will be largely dictated by the location of any proposed WWTP plant, the availability of land, and the social, economic, and environmental impacts.



APPENDIX A
7Q20 Discussion and Calculation Summaries
Information prepared by the CVC
FEDERAL GAUGE 02HB020
ABOVE ERIN

Table 1: 7Q20 monthly flows for the West Credit River at 8th Line and 10th Line (m^3/sec)

Site/ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Summer (Jul-Sep)	Rest of Water Year (Oct-Jun)	Annual (Oct-Sep)
8th Line (WSC Gauge)	0.185	0.250	0.252	0.202	0.192	0.253	0.307	0.217	0.164	0.170	0.147	0.128	0.128	0.150	0.124
10th Line (CVC Gauge)	0.334	0.458	0.462	0.366	0.347	0.464	0.568	0.395	0.293	0.305	0.261	0.224	**0.224**	**0.266**	**0.217**

Notes:

- 7Q20 monthly values for the West Credit River at 10th Line were calculated based on the following linear regression equation:

  $Q_{10th\ Line} = 1.9184 * Q_{8th\ Line} - 0.0213$ (refer to the CVC Review of Ray Blackport from January 10th 2014);
- Summer and annual values of 7Q20 differ only marginally (0.224 m^3/sec and 0.217 m^3/sec respectively at the 10th Line, i.e. difference is 3.5%);
- The value of 7Q20 for the rest of Water Year (i.e. fall-winter-spring period) is 23% higher than the annual 7Q20 (0.266 m^3/sec and 0.217 m^3/sec respectively at 10th Line);
- 7Q20 values for June and July are very close (0.293 m^3/sec and 0.305 m^3/sec respectively at 10th Line);
- September and August are indicated as being the most critical months of the year in terms of minimum flows (0.224 m^3/sec and 0.261 m^3/sec respectively at 10th Line);
- The lowest monthly value of 7Q20 was calculated for September and equal to 0.224 m^3/sec at 10th Line, i.e. only marginally higher (+3.5%) than annual 7Q20 of 0.217 m^3/sec.

Review of Ray Blackport Memo (from December 10, 2013)

1. Why the extended trendline "did not pass through the 7Q20 point"?

The linear regression equation $\mathbf{Q_{10th\ Line} = A*Q_{8th\ Line} - B}$ describes the relationship between flows at 8th Line (independent variable) and flows at 10th Line (dependent /response variable). The unknown parameters A and B in a linear regression model were estimated using the least squares approach. This method minimizes the sum of squared vertical distances between the observed responses in the data set and the responses predicted by the linear approximation.

The above mentioned equation was developed for the 2013 summer - fall flow conditions, which could be considered a wetter than average year. Daily stream flows for this period <u>were considerably higher than the 7Q20 value established</u> for the West Credit River at 8th Line based on historical WSC gauge data.

2. How much the lower portion of this line (rating curve at 10th Line) could change with additional low flow data?

As stated in the CVC October 31st 2013 memo:

> "a preliminary rating curve for the West Credit River at 10th Line was developed by Civica Infrastructure Inc. based on spot flow measurements collected by CVC staff. Efforts were focused on measuring flows during dry conditions, however generally wet conditions have persisted throughout 2013 and flows measured in summer 2013 were higher than typical summer low flows.
> A curve fit equation was used for conversion of continuous water level data to a continuous flow record. As the range of measured discharge rates is limited, the rating curve may require further calibration when more measurements are available, however it is a reasonable fit based on the available data."

3. Review of Scatter Plots provided in the Ray Blackport Memo

a. <u>Figures 5, 7, 10, 11 and Table of findings – exponential trendline</u>:

Exponential regression produces an exponential curve that best fits a set of data that <u>does not change linearly with time;</u> i.e., exponential functions describe how things grow or decay as time passes (exponential growth and exponential decay). It is widely used in physics, chemistry, mathematical biology, economics, and sociology.

However, our goal is to describe the relationship between flows at 8th Line (independent variable) and flows at 10th Line (dependent /response variable) and to obtain a best-fit trend line. <u>The available data definitely suggest a straight line and hence a linear relationship between variables</u> was established. However, if exponential regression is applied to the available flow values, a minimum flow of 0.211 m^3/sec will be computed when there is no flow at 8th Line (i.e. by placing a value of X = 0, which is not possible). Also, if it is assumed that flow at 8th Line equals to 1 m^3/sec, the computed exponential flow value at 10th Line equals ~ 5 m^3/sec, which seems unrealistic. For more details refer to the Table 1.

Table 1: Summary of flow values at 10th Line estimated by exponential trendline

Figure # in Ray B. Memo	Exponential equation	Flows at 8^{th} Line (X - independent variable) m^3/sec	Estimated 10^{th} Line flows (Y - dependent / response variable) m^3/sec
5	$Y=0.2116e^{3.1439X}$	0	0.211
		1	4.91
7	$Y=0.22026e^{3.0407X}$	0	0.220
		1	4.61
10	$Y=0.19916e^{3.35843X}$	0	0.199
		1	5.72
11	$Y=0.16726e^{3.9773X}$	0	0.167
		1	8.93

b. Adding of measured low flow data from 2000 (2 data points)

Ray Blackport proposal to add low flow data from the summer of 2000 CVC survey (2 data points) to the current data set looks rational. Discharges in the year 2000 were measured at almost the same locations as 2013 discharges. Acceptable current meters (Price A, calibrated in WSC center) and methodology were used by CVC staff.

Figure 1 (same as Figure 6 in the Ray Blackport Memo) demonstrates that linear regression has improved through the addition of two low flow data points to the 2013 data set. Moreover, the linear trend line passes very close to the 7Q20 data point. The value of 7Q20 at 10^{th} Line calculated by using the developed linear regression equation will be 0.217 m^3/sec, slightly higher than 7Q20 value proposed in the October 31^{st} 2013 memo. For more details refer to the Table 2.

Table 2: 7Q20 at 10th Line estimated by linear regression equation

Figure # in Ray B. Memo	Linear regression equation	8^{th} Line Flow – 7Q20 (m^3/sec)	Estimated 10^{th} Line flow 7Q20 (m^3/sec)	Q10th / Q8th ratio
6 (added two data points from 2000 survey)	$y = 1.9184x - 0.0213$	0.124	0.217	1.75

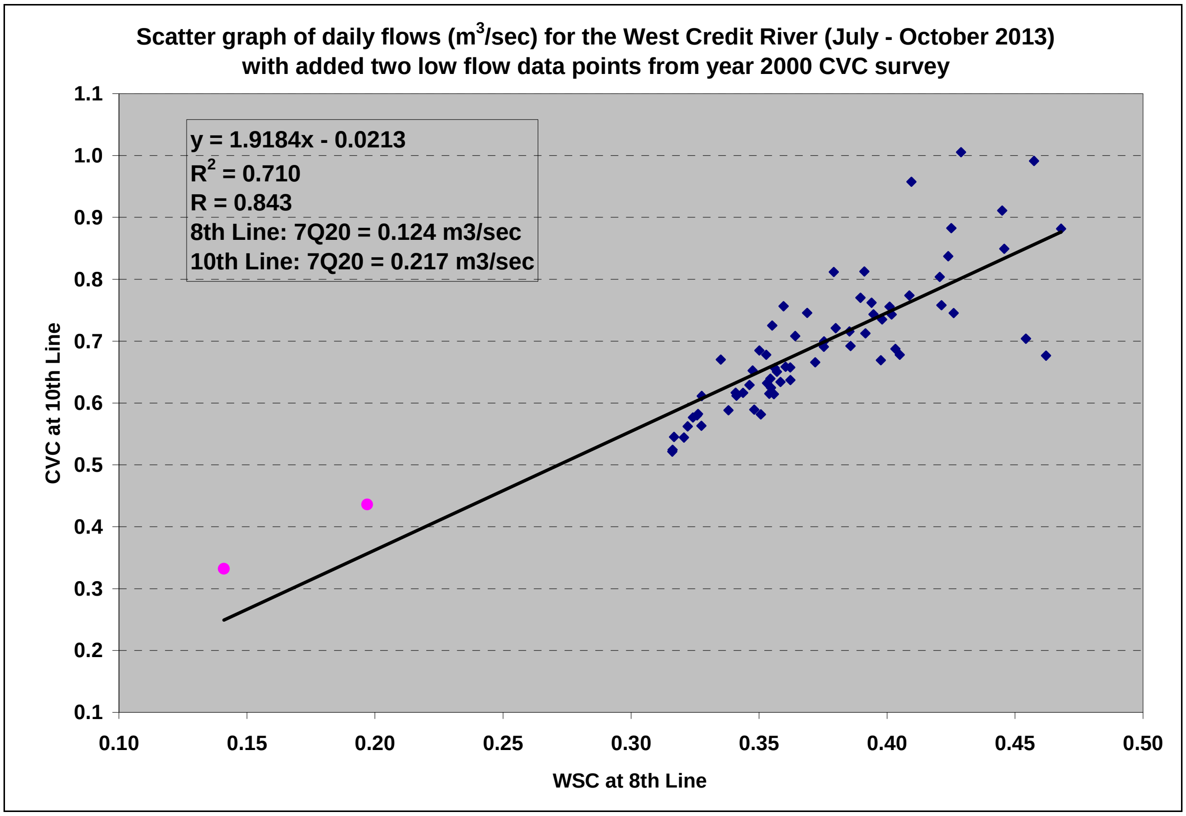


Figure 1: CVC scatter plot with added two data points for low flow in 2000 and Linear Trend Line

4. Conclusion

CVC recomends to use a value of 7Q20 = 0.217 m^3/sec for the West Credit River at 10^{th} Line. This value is consistent with methodology and data used by CVC and simultaniously reflect a rational approach proposed by Ray Blackport.

Assessment of 7Q20 at the 10th Line

Note: This assessment is merely a more detailed look at the way the 7Q20 value was determined to better understand how the number was determined. I am not an expert in hydrology or surface flows, nor am I strong in statistical methods, so feel free to comment or correct the approach/discussion in this document.

Is the 7Q20 value of 195 L/sec at the 10th Line an appropriate value to use to move forward?

Note – It is assumed the 7Q20 value at the 8th Line has been appropriately determined, given the historical data and analyses conducted.

How was the value of 195 l/sec determined for 7Q20 at the 10th Line?

This exercise started with a simple issue. Figure 3 of the October 31st CVC Memo showed a scatter plot of daily flows, with a linear trend line and the equation associated with the Trend Line (y=2.0152x-0.0549). I noticed that if the Trend Line was extended that it did not pass through the 7Q20 data point. Plugging in 0.120 m^3/sec into the equation yielded the number presented for the 10th Line 7Q20 (0.187 m^3/sec). So this apparent discrepancy led to the following review and assessment. This is presented for discussion purposes, so if this discrepancy can be easily clarified and my discussion invalidated that is fine, so long as we are all comfortable with the 7Q20 number, at this time.

From CVC documents:

October 31st 2013 Memo

7Q20 value of 0.120 m^3/sec at the 8th Line was determined to be reasonable from Erin SSMP (later refined to 0.124 m^3/sec, hence the slight difference)

CVC indicated that transposition of the 7Q20 value from 8th Line to the 10th Line was oversimplified using catchment area upscaling, due to hydrogeological dissimilarities between the geographic areas – 7Q20 of 0.311 m^3/sec at 10th line thought to be an overestimate of low flow conditions.

A flow gauge was established at the 10th Line and flow measurements and water level data collected to develop a rating curve from the gauging station. Generally wet conditions persisted throughout the summer of 2013, and the flows were higher than typical summer flows. Measured discharge at the 10th Line ranged from 0.580 m^3/sec to 2.630 m^3/sec, and at the 8th Line from 0.326 m^3/sec to 0.582 m^3/sec with a ratio of 10th Line /8th Line flow ranging from 1.78 to 4.97. As a result there was no opportunity to obtain low flow measurements to aid in developing the rating curve.

As noted by CVC, with respect to developing a rating curve:

"*Each discharge measurement and corresponding stage is plotted, and a smooth curve is drawn that best represents these points. To develop and maintain the rating curve, a minimum of 10 discharge* *measurements per year, **well distributed through the range of flows** is recommended (Hydrometric Field Manual – Measurement of Streamflow, prepared by Inland Water Resources Branch, 1981*)."

A rating curve was developed and the curve fitting equation was used to convert continuous water level data at the 10th Line to continuous flow data at the 10th Line. The following comment was made by CVC: "*As the range of measured discharge rates is limited, the rating curve may require further calibration when more measurements are available, however it is a reasonable fit based on available data*".

A Memo was provided to CVC from CIVICA (for reference), dated October 16th, 2013, as CIVICA developed the rating curve for use by CVC. Their updated rating curve is shown below:

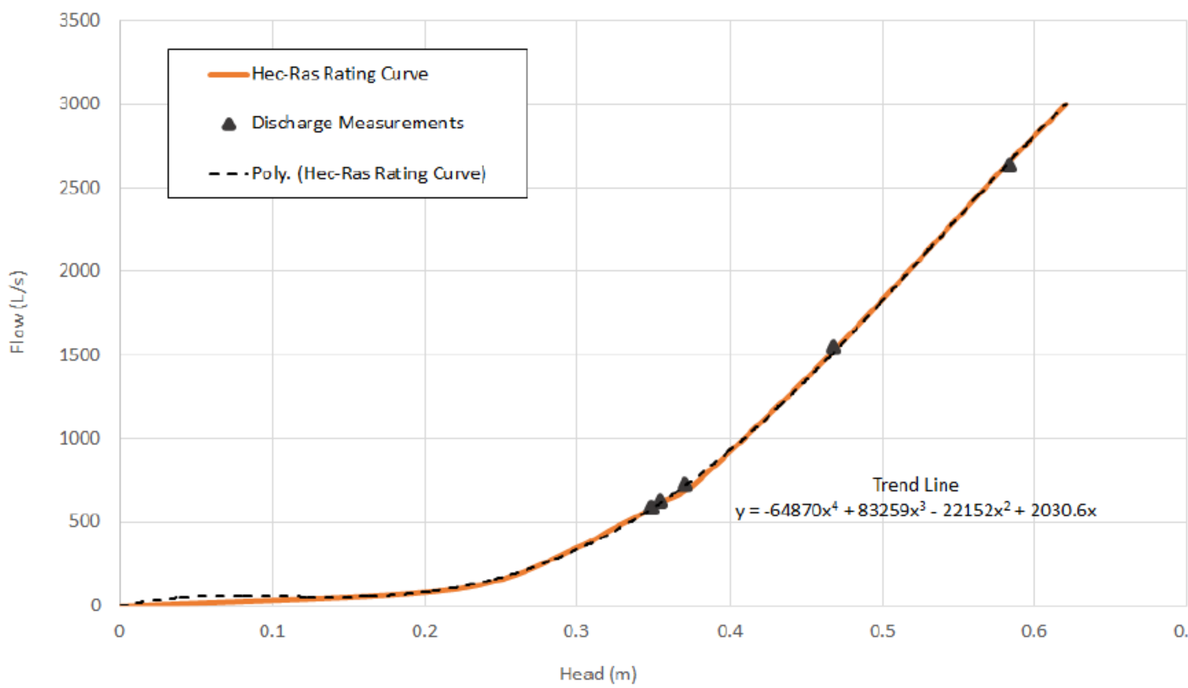


Figure 1: Oct 16 2013 Updated Rating Curve

One of the 6 measured flow data points was removed as it was considered an outlier, so only 5 data points were used to develop the rating curve. It was indicated by CIVICA that the polynomial Trend Line could be applied for a range of 0-0.8 m of Head (i.e. water depth in the river). I note that there are no data points below a flow of 580 L/sec, where the curve fitting is critical in this case, given that is where the greatest curvature in the fitted Trend Line occurs and that is the range of flow most important to deriving an accurate 7Q20 flow number for comparison with the 8th Line flows. It is recognized as stated previously ,that was unfortunately the result of the wet summer. The CIVICA Memo stated that: "*The Hec-Ras model has been developed and calibrated to match the measurement obtained within the range of depth captured during field measurement periods*." It is noted that the flow range of concern is outside (below) the range of data collected. Notwithstanding that there are limited data, it was concluded that this is the best estimate at this time and the interpreted rating curve was used to obtain "calculated" flows from continuous depth to water measurements. I do not know how unique the data set is with respect to fitting of Trend Lines, but it does bring to question how much the lower portion of this line could change with additional low flow data, but perhaps this should be discussed.

A series of data points for flow at the 10th Line was developed for various times, from water depth data collected in the summer of 2013 at the 10th Line (based on the preliminary rating curve above) and paired with flow data from the 8th Line to develop a scatter plot of the data (flows). Using these data points a "trend line" was statistically created with Excel to develop an equation for the relationship between flows at the 10th Line and 8th Line (Figure 3 in the October 31st Memo). The 7Q20 flow for the 8th Line could then be input into the equation to obtain the 7Q20 value at the 10th Line. A series of figures is presented below with respect to trying to understand and validate this correlation, between the flows at the 8th Line and the 10th Line.

It is noted that the data files were the CVC data files provided in Excel. The plots are taken from the CVC data files; however the figures below are screen captures of the plots, modified for this Memo, as they are reduced in size, affecting the labels for axis etc., but the data, trend lines etc are correct.

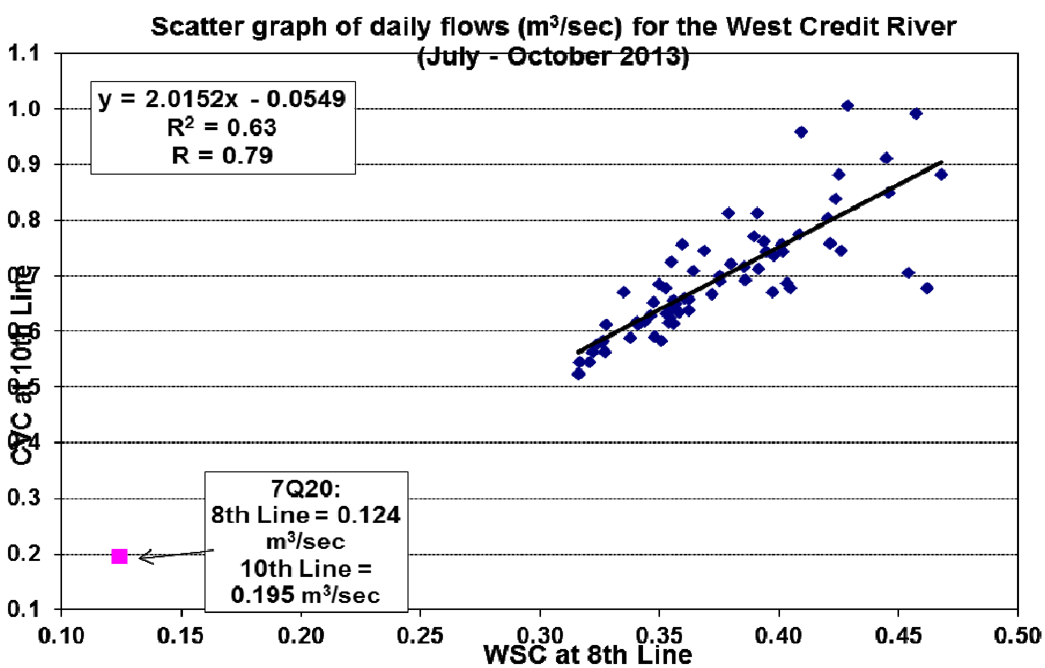


Figure 2 – Scatter plot presented by CVC

Figure 2 is the scatter graph plot some the CVC data files, essentailly the same as Figure 3 from the October 31st Memo, except for the sk=light modification by CVC of the 7Q20 flow at the 8th Line to 0.124

m^3/sec. The Trend Line equation presented was used in the calculation of 7Q20 at the 10th Line and also the monthly 7Q20 in the CVC monthly/seasonal assessment. The next figure (Figure 3) shows Trend Line extended, and it is noted that it does not go through the 7Q20 data point, which it should, if using the linear equation in the figure.

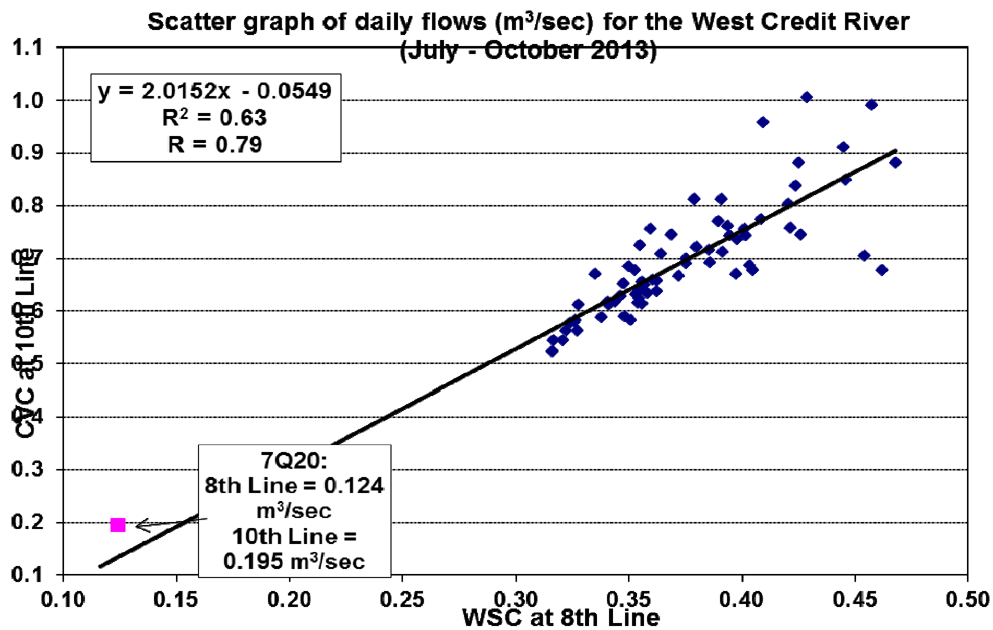


Figure 3 – scatter plot from CVC with the Trend Line extended – does not match

Since this didn't make sense, I looked at the CVC data files (correlation plot) and reset the linear Trend to see if there was an issue with the placement of the Trend Line, but came up with the same trend line and equation. I then deleted the text box for the equation and reset the Trend Line again, creating the same Trend Line showing a different equation as shown in Figure 4 below. The 7Q20 for the 10th Line with this equation is 0.134 L/sec, almost the same flow, which seems unrealistic so I decided to analyze in other ways to see what would result.

Given that the flow value seemed unrealistic, using the linear Trend Line, I set the Trend Line using an exponential fit as shown in Figure 5, below.

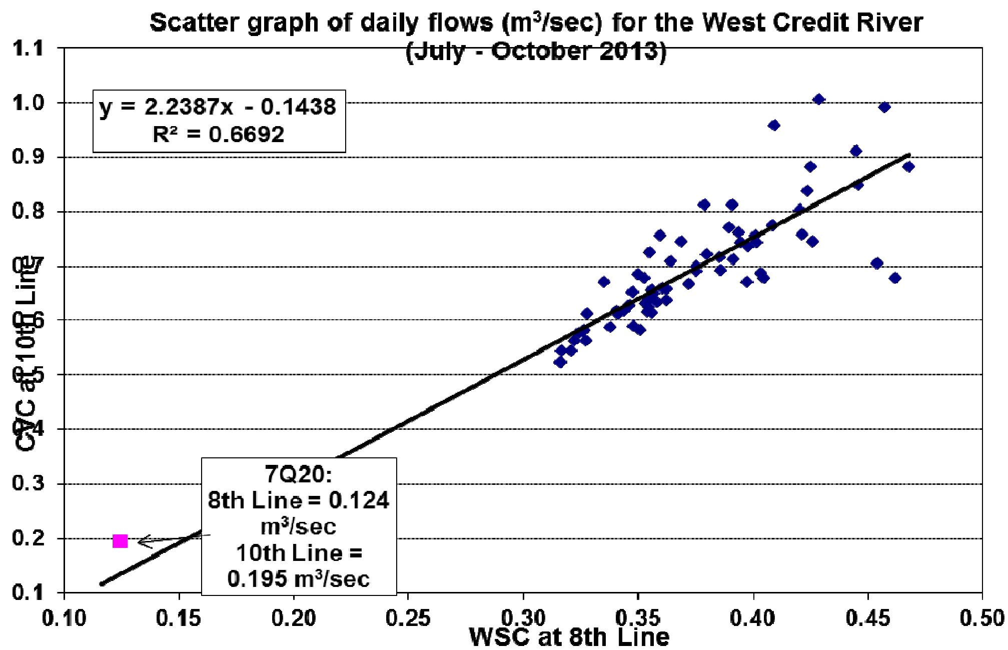


Figure 4 – scatter plot from CVC updated in a reset of the same Trend Line.

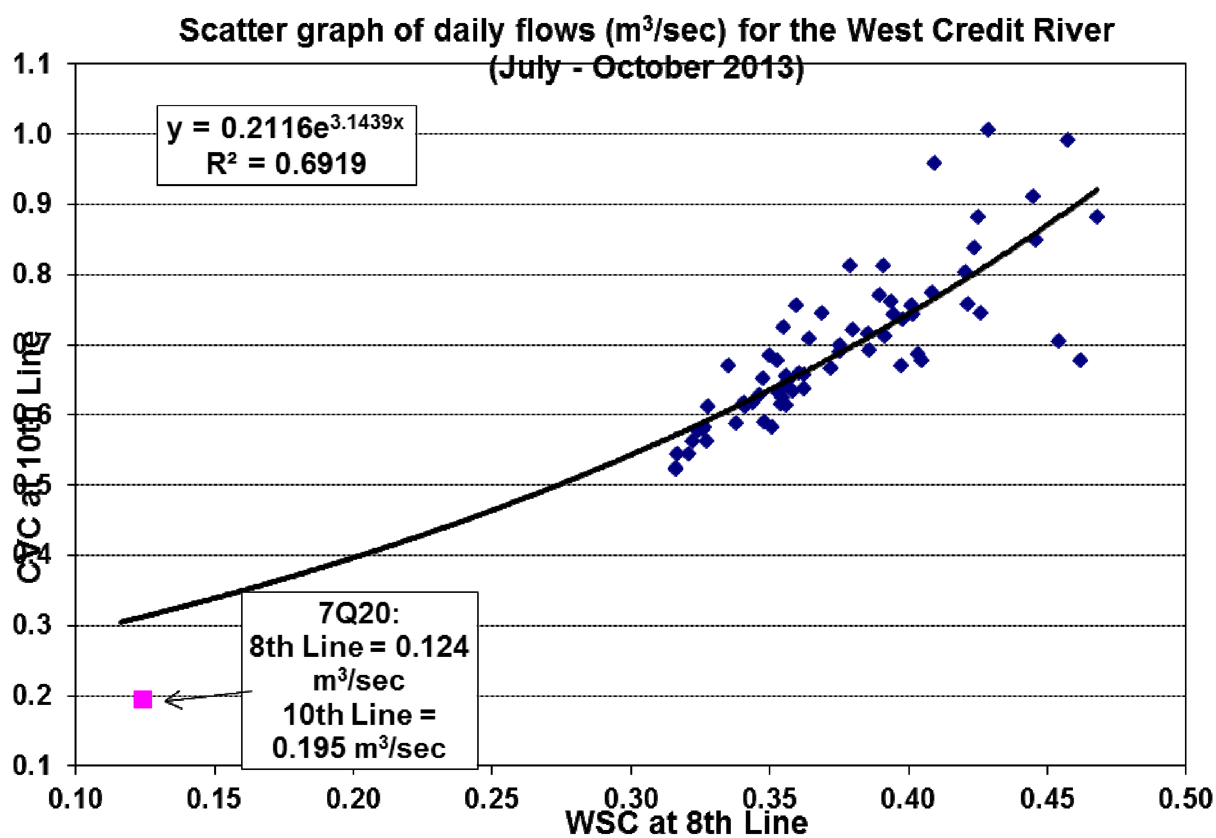


Figure 5 – same data points used by CVC ,using exponential fit for the Trend Line

Figure 5 shows that the 7Q20 for the 10th line would be about 310 L/sec (I did not plug into the equation, number was obtained through a visual estmate on the graph). The resulting flow ratio is 2.5.

Given the large difference in the ratio using the two data fitting approaches (linear and exponential) several other plots were made to determine if this range could be narrowed down. Given the lack of flow data at the lower end of the Trend Line, where we are trying to validate the 7Q20 at the 10th Line, measured low flow data from 2000 (2 data points) was added to the data set. One value was considered an outlier and not used (a 3rd data point was considered an outlier as flow at the 10th Line (554 L/sec) was 4.6 times the flow at the 8th Line (120 L/sec). Figure 6 shows the Linear Trend Line fit with the added low flow data points. The result shows that the calculated 7Q20 at the 10th Line would be 216 L/sec or a ratio of 1.74, similar to the 7Q20 value by the CVC analysis.

Figure 7 shows the same data, (i.e. CVC scatter plot data with the two low flow data points added) using an exponential Trend Line fit. This results in the 7Q20 at the 10th Line of approximately 320 L/sec or a ratio of 2.6

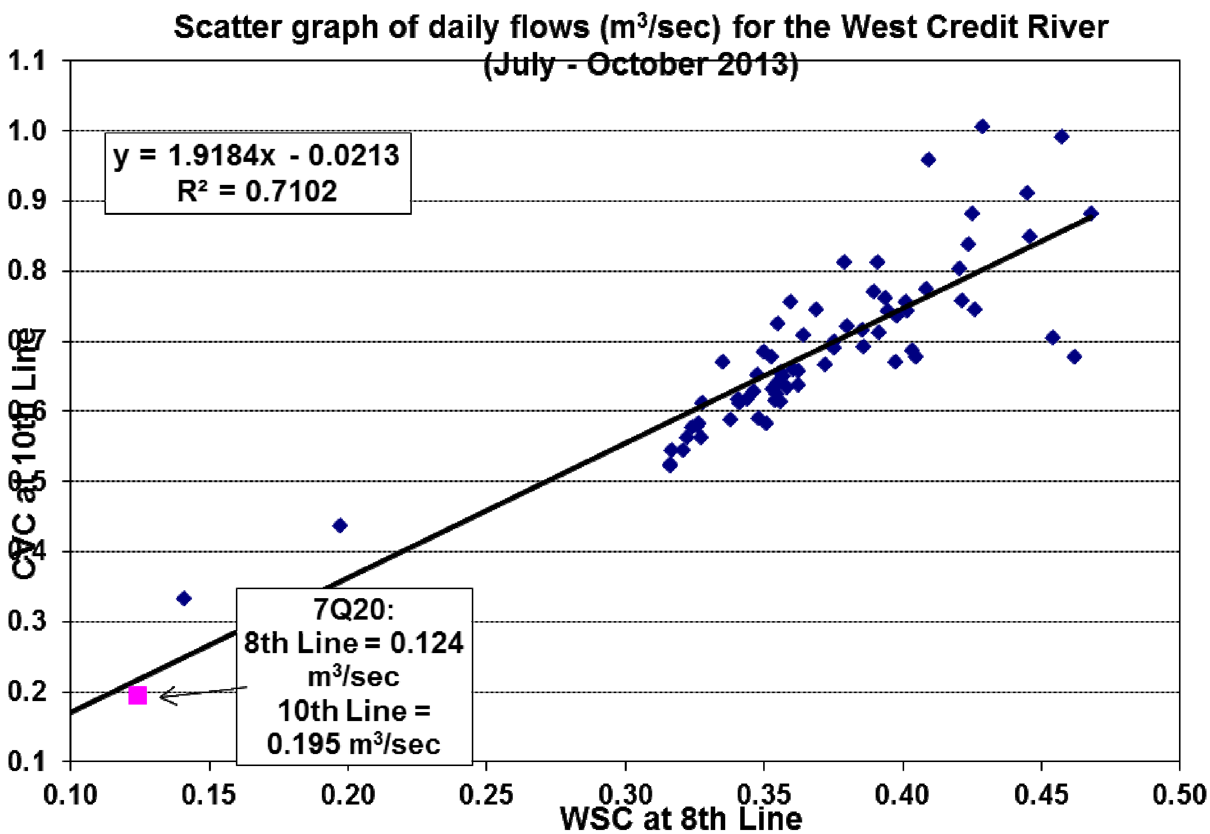


Figure 6 – CVC scatter plot – (Linear Trend Line) adding the two data points for low flow in 2000

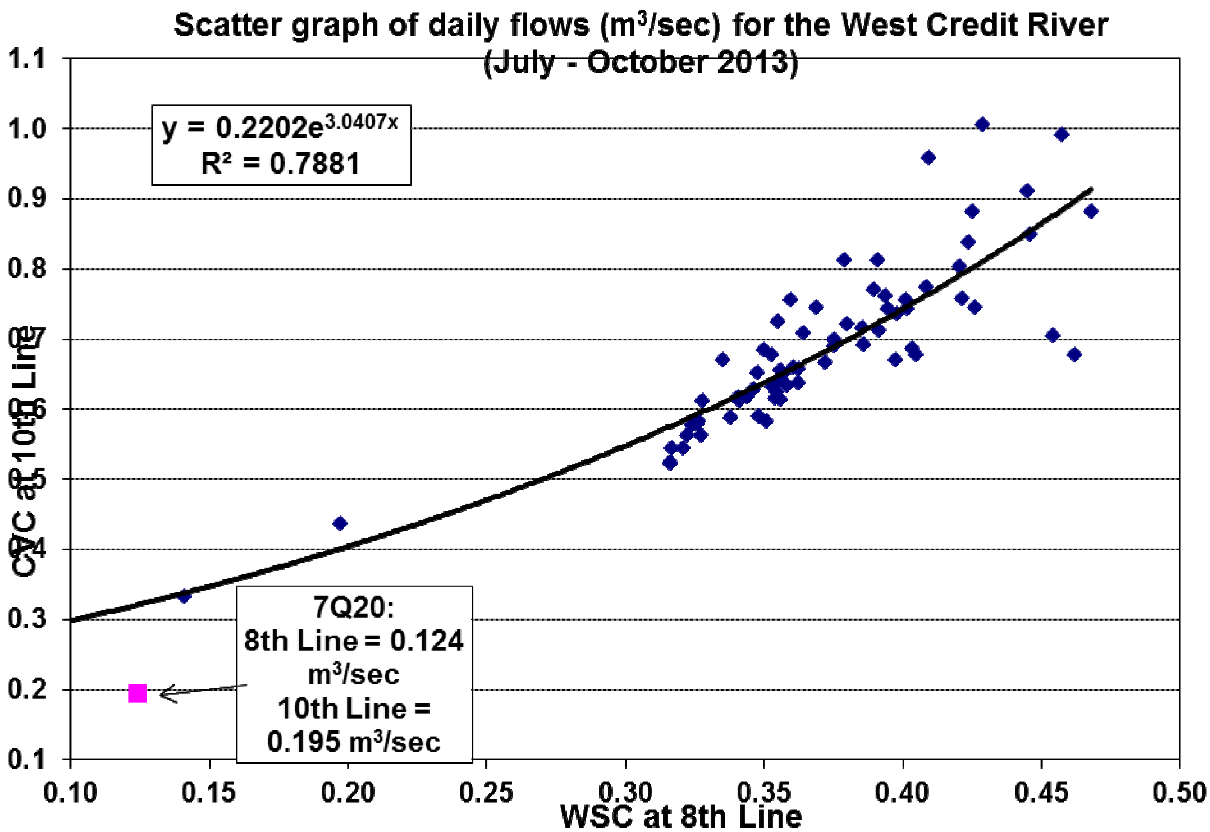


Figure 7 Scatter plot as in Figure 6 but using an exponential Trend Line

The next approach was to not use the data from the scatter plot, as the flow data for the 10th Line were generated by the rating curve previously discussed and the flows beyond the range of data collected may not be valid (at least for this assessment at present, just to look at other approaches). A data set was created using only flows where measurements were obtained at both the8th Line and the 10th Line, although limited, just to compare the limited, but measured data set. Several data points were excluded as they were consider outliers (> than 3.5 ratio), or were in the very high end flow.

Figure 8 shows the Linear Trend Line from a scatter graph plot of measured flows in 2013 and the two low flows in 2000 as previously discussed. The result is similar to Figure 4, the Trend line using CVC data set with the recalculated trend line equation (same Trend Line as CVC). The 7Q20 flow at the 10th Line was calculated to be 147 L/sec or a ratio of 1.19, again very low.

Figure 9 shows the Linear Trend Line and equation without the low flow data from 2000 (i.e. only 2013 data). As can be seen, this fit is not valid as there would be no flow at the 10th Line when the 8th Line is at the 7Q20 flow. This means insufficient data or an inappropriate curve fit to the dataset and shows the importance of having low flow data.

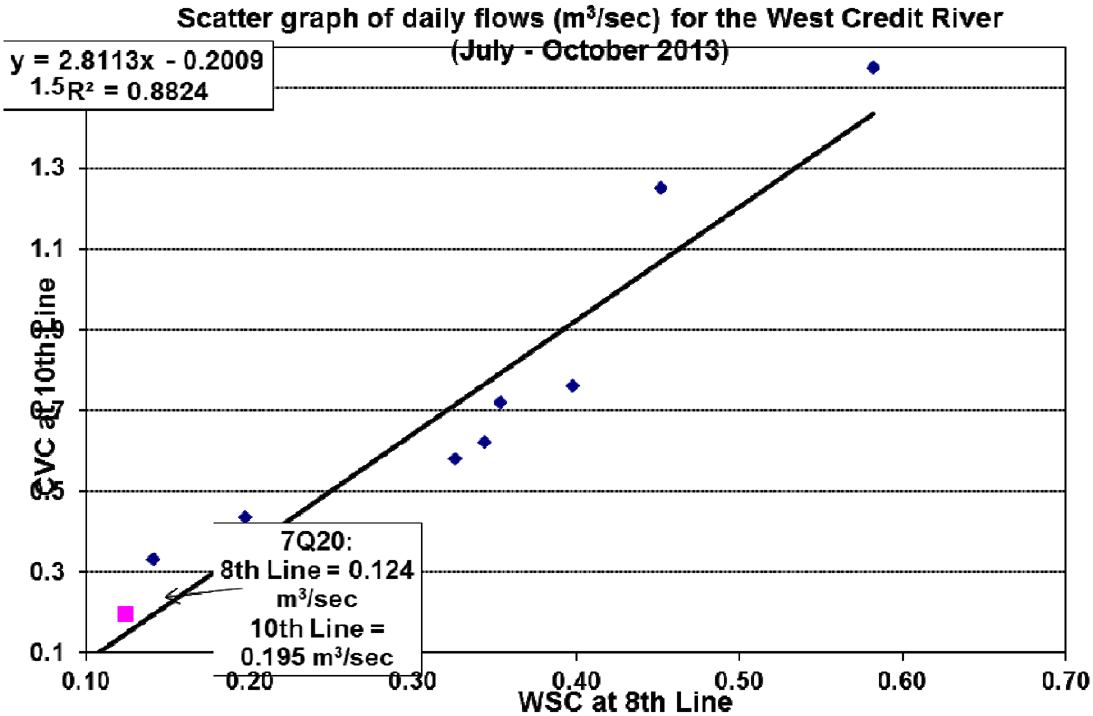


Figure 8 Linear Trend Line and equation using only measured flows (excluding outliers).

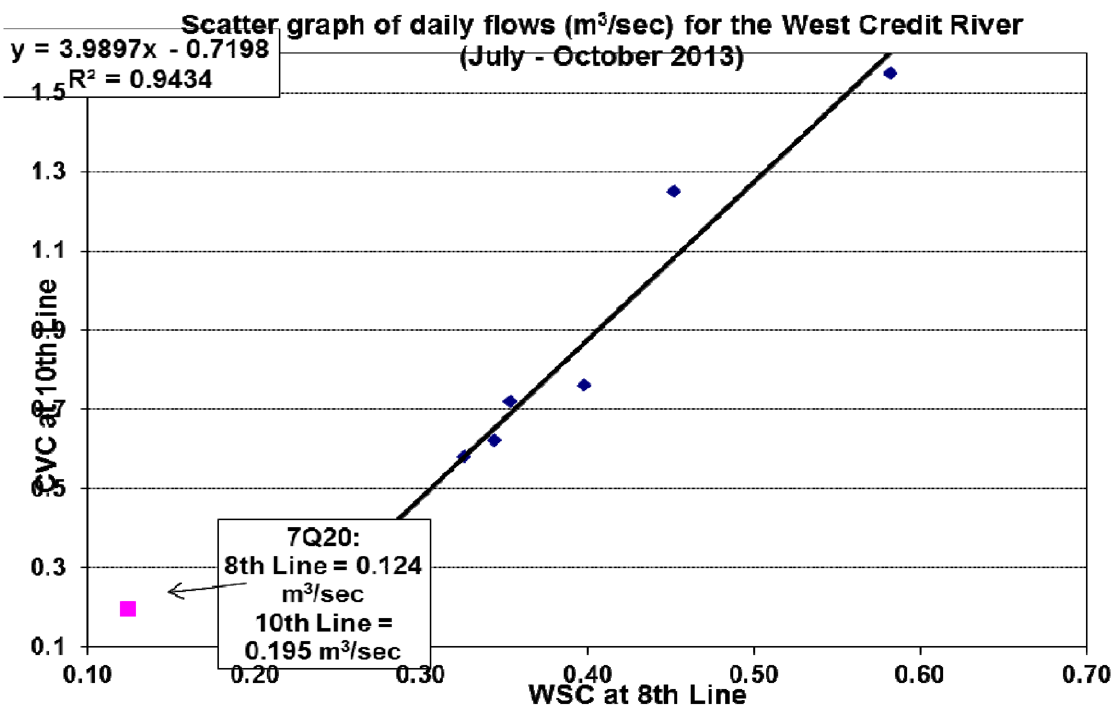


Figure 9 Linear Trend Line and equation using measured flows without the low flow data points i.e. 2013 data only (excluding outliers).

Figures 10 and 11, below show the same two data sets as in Figures 8 and 9, using an exponential curve fit to obtain a Trend Line and Equation. As can be seen with Figure10 there is a good fit with the measured flow data set with the 7Q20 at the 10th line estimated to be 300 L/sec or a ratio of 2.4. Removing the two low flow data points from 2000 (i.e. using only 2013 data), as shown in Figure 11, shows a similar fit the Figure 10 data set with only a slightly lower 7Q20 flow at the 10th Line at about 270 L/sec or a ratio of 2.18.

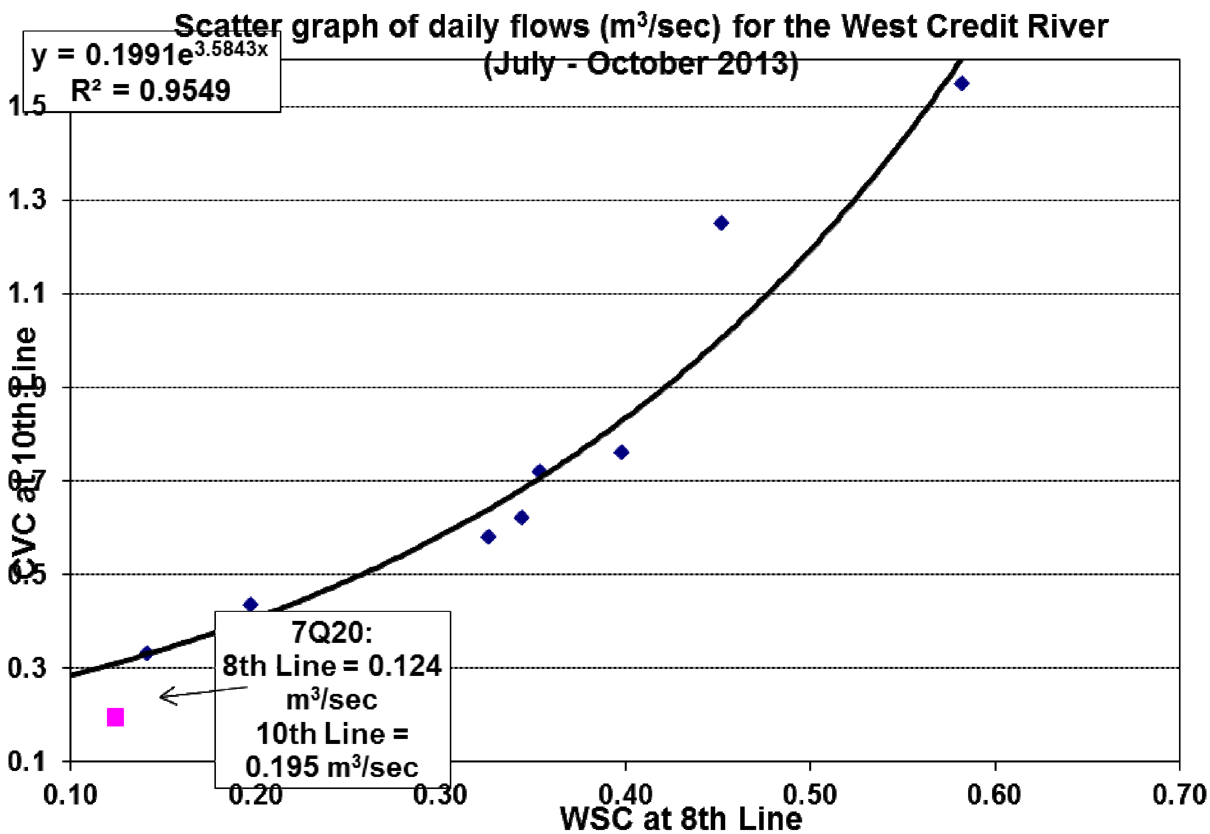


Figure 10 Exponential Trend Line and equation using only measured flows (excluding outliers).

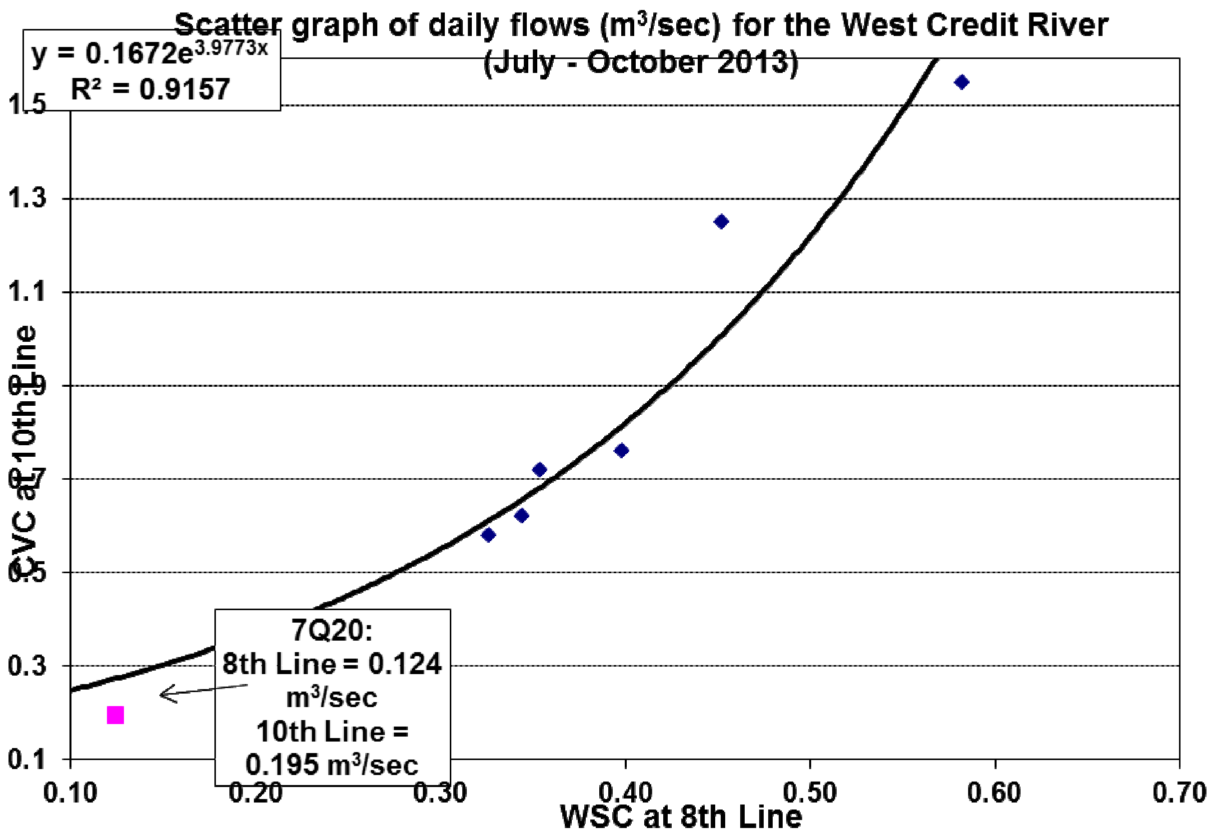


Figure 11 Exponential Trend Line and equation using measured flows, without the two low flows in 2000 (i.e. 2013 data only (excluding outliers).

So What Does all this Mean? I don't know, but the table below is a range of 7Q20 flows and ratios based on the information above. My initial concern was whether the original scatter plot Trend Line and equation, as presented, was correct. If I am correct on the revised flow, there is substantially less flow then anticipated and this resulted in my additional assessments. Any thoughts/corrections etc. would be greatly appreciated, but we need to have a number we can support moving forward, even though it will likely be modified somewhat as more data are collected, but the hope is that we are not substantially different (e.g. 100%), given the planning implications.

Table of findings

Method of assessment	8^{th} Line Flow – 7Q20 (L/sec)	Estimated 10^{th} Line flow 7Q20 (L/sec)	Q10th / Q8th ratio
Original CVC value	124	195	1.58
CVC Corrected Trend Line Equation	124	133	1.07
CVC data – exponential Trend Line	124	310	2.5
Two Low flow data points added (2000 data series) to CVC data set – Linear Trend Line	124	216	1.74
Two Low flow data points added (2000 data series) to CVC data set – Exponential Trend Line	124	320	2.6
Measured data only – Linear Trend Line	124	147	1.19
Measured data only – 2013 data - Linear Trend Line	124	negative	N/A
Measured data only – Exponential Trend Line	124	300	2.41
Measured data only – 2013 data - Exponential Trend Line	124	270	2.18

CREDIT VALLEY CONSERVATION

MEMO

Date:	**November 20, 2013**
From:	**Alexander Pluchik, Water Resources Specialist, CVC**
To:	**John Kinkead, Deputy CAO and Director, Water Resources Management and Restoration, CVC**
Cc:	**Dan Banks, Senior Manager - Water Operations and Geoscience, CVC**
	Neelam Gupta, Manager - Hydrology and Hydraulics, CVC
	Jennifer Dougherty, Manager – Water Quality Protection, CVC
Re:	**West Credit River Low-flow Assessment – 7Q20 Monthly Distribution: Assimilative Capacity Study, Erin SSMP**

I've completed my analyses of 7Q20 monthly/seasonal values for the West Credit River in response to the question raised at the Nov 1st meeting in Guelph regarding the possibility of a seasonal WPCP discharge.

- Minimum monthly 7-day flows for each of year of record were extracted from the annual daily discharge tables for the 8th Line Water Survey of Canada (WSC) Gauge # 02HB020 (Excel spreadsheet, Table 1).
- 2012 flow data are still considered "provisional" (i.e. subject to revision by WSC).
- Each year was divided for two periods i.e. summer season (July – September, as defined in "Ontario Low Water Response, July 2003") and fall - winter – spring period (October-June).
- Minimum seasonal 7-day flows for each year of record were extracted from the minimum monthly 7-day flows table (Excel spreadsheet, Table 2)
- The Cunnane plotting-position formula was used to estimate the empirical exceedance probability (Excel spreadsheet, Table 2). This formula is in use by Environment Canada as described in "Low Flow Frequency Analysis Package – LFA" (Environment Canada, September 1988).
- Low-flow frequency analyses were performed using the Gumbel III distribution. This distribution has been recommended by Environment Canada as the best fit for extreme value analysis of low flows in the streams of Ontario (Condie, Cheng, "Low Flow Frequency Analysis", 1987).
- The results of the low flow frequency analyses are presented in Excel spreadsheet (Table 3 and Figures 1 and 2):
    1. Gumbel III and Cunnane frequency curves show very good fit, as can be seen from Figure 1.

2. Summer season and annual values of 7Q20 differ only marginally (0.128 m^3/sec and 0.124 m^3/sec respectively, i.e. difference ~3%). The fall-winter-spring period 7Q20 is 17% higher than the annual 7Q20 (0.150 m^3/sec and 0.124 m^3/sec respectively).
3. June and July 7Q20 values are very close (0.164 m^3/sec and 0.170 m^3/sec respectively).
4. The lowest recorded 7-day flow values for May, June and July are only marginally different (Excel spreadsheet, Figure 2).
5. September and August are indicated as being the most critical months of the year in terms of minimum flows.

- Monthly and seasonal 7Q20 values for the West Credit River at 10th Line were calculated based on the regression equation ($Q_{10th\ Line} = 2.0152*Q_{8th\ Line} - 0.0549$).

Results are presented in the Table below (next page) and in the spreadsheet attached (Excel spreadsheet, Table 4).

Table: 7Q20 low flow distribution per month and season (m^3/sec)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Fall-Winter-Spring (Oct-Jun)	Summer (Jul-Sep)	Annual min
8th Line (WSC Gauge)	0.202	0.192	0.253	0.307	0.217	0.164	0.170	0.147	0.128	0.185	0.250	0.252	0.150	0.128	0.124
10th Line (CVC Gauge)	0.352	0.332	0.455	0.564	0.382	0.276	0.288	0.241	**0.203**	0.318	0.449	0.453	**0.247**	**0.203**	**0.195**

MEMO

Date:	**November 7, 2013**
From:	**Alexander Pluchik, Water Resources Specialist, CVC**
To:	**Craig Fowler, Surface Water Specialist, MOE (West-Central Region)**
Cc:	**John Kinkead, Deputy CAO and Director, Water Resources Management and Restoration, CVC**
	Dan Banks, Senior Manager - Water Operations and Geoscience, CVC
	Neelam Gupta, Manager - Hydrology and Hydraulics, CVC
	Jennifer Dougherty, Manager – Water Quality Protection
Re:	**West Credit River Low-flow Assessment – Assimilative Capacity Study, Erin SSMP**

I'm forwarding the additional details surrounding CVC's determination of a recommended low-flow value for the West Credit River in response to the request you made at last Friday's meeting in Guelph.

The following notes help explain each of the attached files.

1. 7Q20 calculation spreadsheet
   a. "WSC_7-day minimum" worksheet
      - Minimum annual 7-day flows were extracted from the annual daily discharge tables for the 8th Line Water Survey of Canada (WSC) Gauge # 02HB020 (Table 1).
      - 2012 flow data are still considered "provisional" (i.e. subject to revision by WSC).
      - The Cunnane plotting-position formula was used to estimate the empirical exceedance probability (Table 1). This formula is in use by Environment Canada as described in "Low Flow Frequency Analysis Package – LFA" (Environment Canada, September 1988).
      - The low-flow frequency analysis was performed using the Gumbel III distribution. This distribution has been recommended by Environment Canada as the best fit for extreme value analysis of low flows in the streams of Ontario (Condie, Cheng, "Low Flow Frequency Analysis", 1987).
      - The results of low flow frequency analysis are presented in Table 2 and Figure 2. The Gumbel III and Cunnane frequency curves show very good fit, as can be seen from Figure 2. Re-examination of the 8th Line data following Friday's meeting supports use of a 7Q20 value of 0.124 m^3/sec at this location based on the Gumbel III distribution. This is only marginally different than the 7Q20 value of 0.120 m^3/sec mentioned in my Oct 31st memo.

b. “Flow-correlation” worksheet

- Description of the development of a preliminary rating curve and of the methodology used for the calculation flows at the new 10th Line gauge has been provided in the Oct 31st memo.
- 2013 flow data for the 8th Line gauge are also still “provisional”.
- Real-time flows with a time interval of 15 min were converted to daily flows.
- Daily flows at 8th Line (WSC gauge) were paired with corresponding flows at the 10th Line.
- Daily flows at both 8th and 10th Lines were sorted by flows at 8th Line in ascending order.
- A scatter graph of daily flows was plotted (Figure 3). Streamflow values not exceeding 0.468 m^3/sec (at 8th Line), and corresponding flows at 10th Line were chosen for the regression analysis, based on a visual analysis of the scatter graph (Figure 3).

c. “Correlation-plot” and “Regression” worksheets

- A correlation analysis was performed to explore the relationship between stream flows at 8th Line (WSC gauge) and 10th Line (CVC gauge). The linear regression equation (linear bivariate regression) developed (see plot in “Correlation-plot” worksheet) shows a correlation coefficient (R) equal of 0.79. A correlation coefficient higher than 0.7 indicates the relationship between variables is significant (see Hydrology National Engineering Handbook, Chapter 18, USA, 2000).
- The quality of the regression equation was examined using the following indices: standard deviation of the criterion variable and standard error of estimate, coefficient of determination and **F**-test (“Regression” worksheet). The regression was again deemed to be significant give that the computed **F**-test is greater than **F** value extracted from the **F** values distribution table, i.e. an 0.05 level of significance (respectively 25.1 vs 4.00) [source: Hydrology National Engineering Handbook, Chapter 18, USA, 2000].

d. “Summary”

Low Flow Indicator (m^3/sec)	**Date**	**8th Line (WSC Gauge) (*)**	**10th Line (CVC Gauge) (**)**
Lowest single day	31-Aug-1989	0.071	0.088
Lowest 7-day average	Late Sept 1999	0.092	0.130
7Q20		0.124	0.195

(*) Based on period of record (1983-2012)

(**) Based on the regression equation: $Q_{10th\ Line} = 2.0152*Q_{8th\ Line} - 0.0549$

2. Development of Open Channel Rating Curve

- See attached Civica Infrastructure Inc. memo to CVC dated October 16, 2013.

I trust this encompasses the information you are looking for in order to assess and affirm support for the approach used by CVC staff in arriving at a suggested 7Q20 value for the West Credit in the vicinity of 10th Line. If you require additional information please contact me at your convenience.

MEMORANDUM

Date:	**October 31, 2013**
From:	**Alexander Pluchik, Water Resources Specialist**
To:	**Neelam Gupta, Manager - Hydrology and Hydraulics**
CC:	**Jennifer Dougherty, Manager – Water Quality Protection**
CC:	**Dan Banks, Senior Manager - Water Operations and Geoscience**
CC:	**John Kinkead, Deputy CAO and Director, Water Resources Management and Restoration**
RE:	**Low flow assessment for the Erin SSMP**

Introduction

This memo summarizes the assessment of low flows for the West Credit River at the location of a proposed waste water treatment plant (WWTP) with effluent discharge directed to the West Credit. This assessment has been completed in support of the Town of Erin Servicing and Settlement Master Plan (SSMP) study.

Accordingly to the Ontario Ministry of the Environment (MOE) report ("Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters", July 1994) the low flow statistic 7Q20 should be "used as the basic design flow for the receiving stream." This value can be calculated from the data collected by the Water Survey of Canada (WSC). However, the drainage area of the closest WSC gauge at 8th Line represents only 37% of the West Credit River watershed at the proposed WWTP location (downstream of the 10th Line and upstream of Winston Churchill Blvd as shown on Figure 1).

Background

An initial West Credit River Assimilative Capacity Study (ACS) was completed in 1995 by Triton Engineering. The report included a frequency analysis of low flow data at 8th Line (WSC Gauge). The resulting 7Q20 value of 0.172 m^3/sec at 8th Line was transposed to a potential downstream effluent discharge location using the catchment area method (factor of ~ 2.5). A standard transposition formula of $Qy=Qx(Ay/Ax)^n$, where Qy is the flow at site y with drainage area Ay, Qx and Ax are the corresponding quantities at site x, and n is an exponent (n=0.842) (developed for the South-Western Ontario by Moin and Shaw [1985]) was applied. Subsequently, CVC completed the "Phase I - Environmental Component – Existing Conditions Report" in May 2011 (CVC, Aquafor Beach, and Blackport Hydrology), which reflects a more recent low flow analysis conducted by CVC (i.e., 7Q20 flow at the 8th Line - WSC Gauge = 0.120 m^3/s based on 1983-2008 flow data).

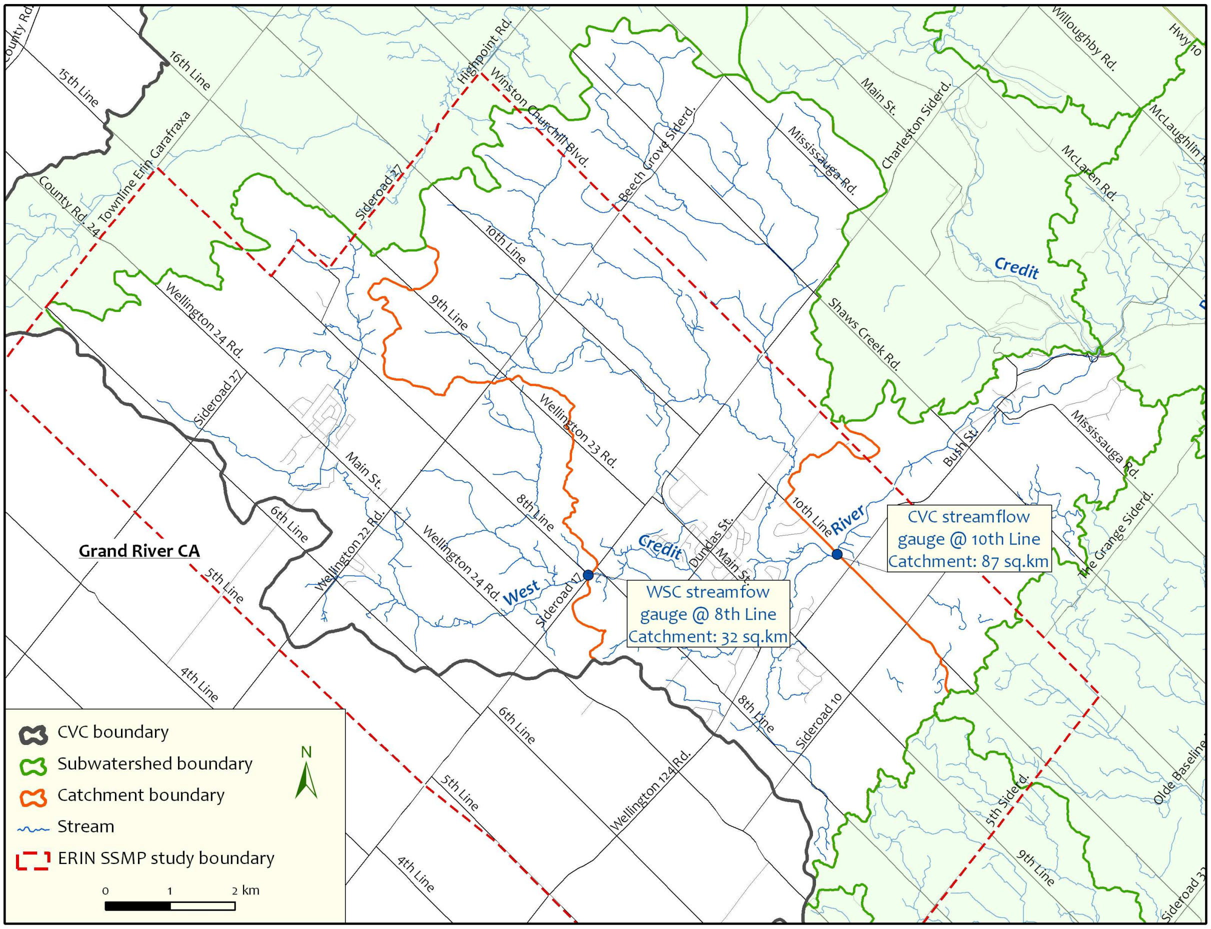


Figure 1: West Credit River watershed relative to the Assimilative Capacity Study limits for the Erin SSMP

B. M. Ross completed a draft ACS for the Erin SSMP in February 2013. The low flow information provided in the May 2011 Phase 1 report was analyzed and the 7Q20 value of 0.120 m^3/sec at 8th Line was accepted. For transposition of the data to the 10th Line, a similar approach was used as in the 1995 ACS Report (i.e. based on catchment areas).

CVC reviewed the draft B. M. Ross ACS report in April 2013. The 7Q20 value of 0.120 m^3/sec reported at 8th Line was considered conservative and consistent with the results of the low flow analyses which utilized the updated historical series with the inclusion of 2009-2012 data.

However, the transposition of the 7Q20 flow from 8th Line to 10th Line has been over simplified by using the catchment area upscaling method. Due to the hydrogeological dissimilarities of the West Credit, the presented 7Q20 = 0.311 m^3/sec at 10th line is believed to be an over estimate of low flow conditions.

It was therefore suggested to establish a new continuous flow monitoring gauge at 10th Line to enhance the accuracy of transposition of the data from the WSC gauge site to the proposed WWTP location.

CVC Analysis

The new CVC real-time streamflow gauge became active and fully operational from July 23, 2013. The gauge is designed to operate remotely year round and consists of the following components:

- Small enclosure with data logger, air bubbler system (level sensor) and battery;
- Single solar panel and small cellular antenna mounted to the pole; and
- Bubbler tubing, which is buried below grade and positioned between the enclosure and the watercourse, where it exits the stream bank below the water level.

A sketch of a typical real-time streamflow gauge is presented in Figure 2.

Conversion of continuous water level data to a continuous discharge record is based on a correlation between water level and discharge called the stage-discharge relationship or rating curve. To develop this relationship, discharge measurements are obtained at the gauging station over the maximum possible range of stream levels. Each discharge measurement and corresponding stage is plotted, and a smooth curve is drawn that best represents these points. To develop and maintain the rating curve, a minimum of 10 discharge measurements per year, well distributed through the range of flows, is recommended (*Hydrometric Field Manual - Measurement of Streamflow, prepared by Inland Waters Directorate Water Resources Branch, 1981)*.

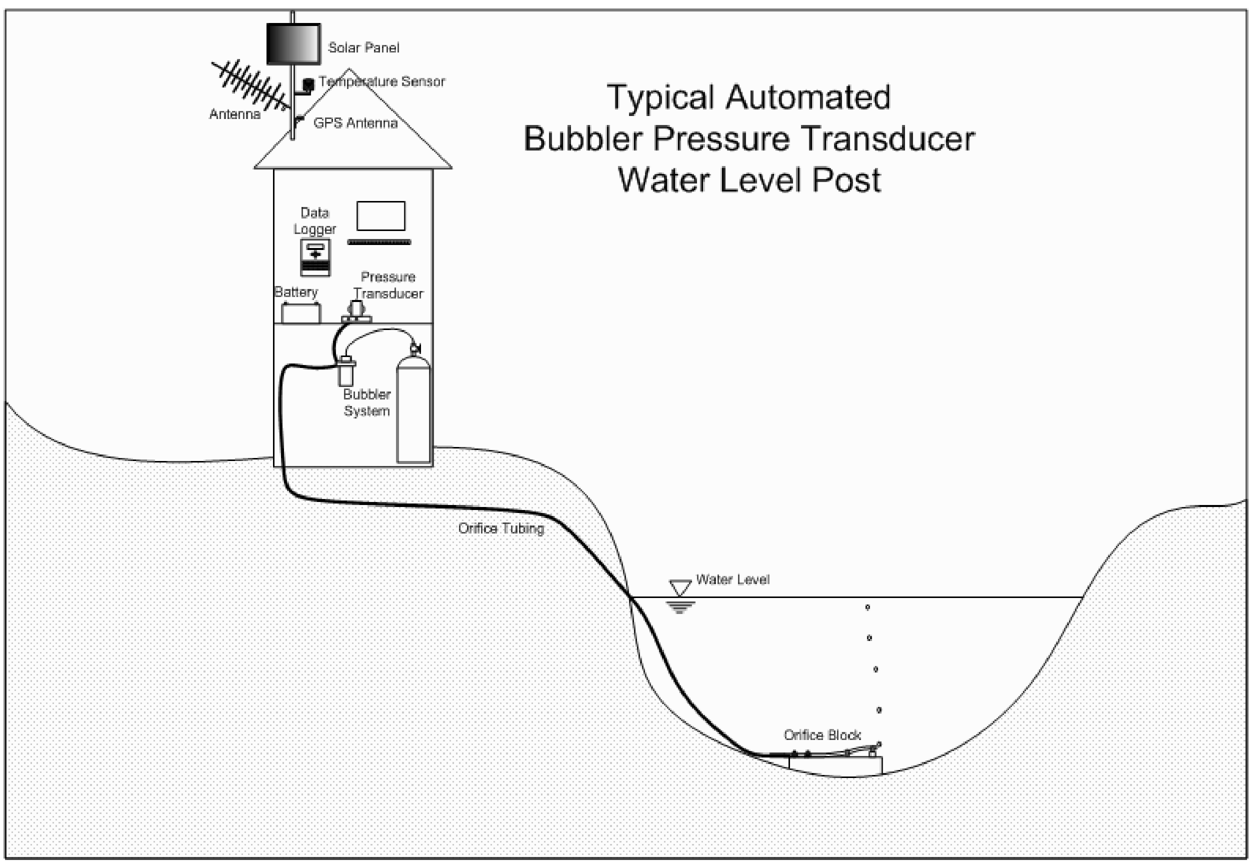


Figure 2: General set up for a real-time water level / streamflow gauge

A preliminary rating curve for the West Credit River at 10th Line was developed by Civica Infrastructure Inc. based on spot flow measurements collected by CVC staff (see Table 1). Efforts were focused on measuring flows during dry conditions, however generally wet conditions have persisted throughout 2013 and flows measured in summer 2013 were higher than typical summer low flows.

Table 1: Measured flows of the West Credit River at 10th Line (CVC Gauge) and corresponding flows at 8th Line (WSC Gauge)

Date	Measured Discharge (m^3/sec) – 10th Line	Measured Discharge (m^3/sec) – 8th Line	Ratio = Q_{10Line} / Q_{8Line}
July 24, 2013 13:00	0.720	0.354	2.03
July 29, 2013 10:30	0.760	0.398	1.91
August 13, 2013 13:15	0.620	0.344	1.80
August 13, 2013 10:45	0.580	0.326	1.78
September 23, 2013 10:00	1.550	0.582	2.66
October 7, 2013 10:35	2.630	0.529	4.97

A curve fit equation was used for conversion of continuous water level data to a continuous flow record. As the range of measured discharge rates is limited, the rating curve may require further calibration when more measurements are available, however it is a reasonable fit based on the available data. A memo prepared from Civica Infrastructure on the development of the preliminary rating curve is provided in Appendix A for reference.

Available water level data at 10th Line (ongoing from July 23, 2013) were converted to streamflow rates and compared to corresponding flows at 8th Line (WSC gauge location). A regression equation was established based on this comparison and describes the relationship between streamflow data at 8th Line and 10th Line (depicted on Figure 3). This equation was developed for the 2013 summer - fall flow conditions, which was considered as a year with wetter than average conditions.

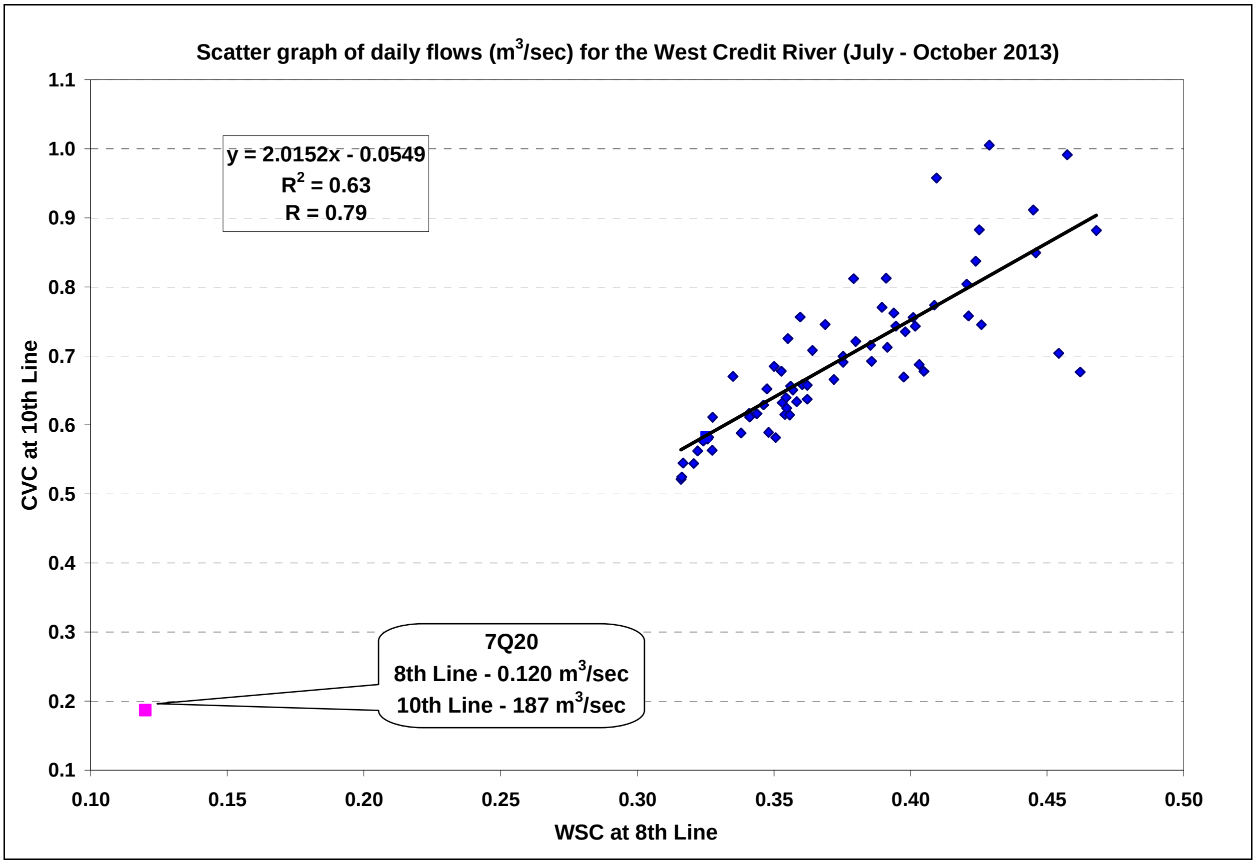


Figure 3: Scatter graph of daily flows (m^3/sec) for the West Credit River (July -October 2013)

Daily stream flows for the period from July to October 2013 were considerably higher than the 7Q20 value established for the West Credit River at 8th Line based on historical WSC gauge data, as shown on Figure 4. Even the lowest average summer month flow value, which is considered by the Province as the streamflow indicator of low water conditions (*Ontario Low Water Response, July 2003*) is less than the minimum daily flow value observed during the summer-fall period this year (see Figure 4). Additionally, observed historical values of the annual minimum daily streamflow and annual minimum 7-day streamflow were significantly lower than stream flows recorded this summer at 8th Line (see Figures 5 and 6).

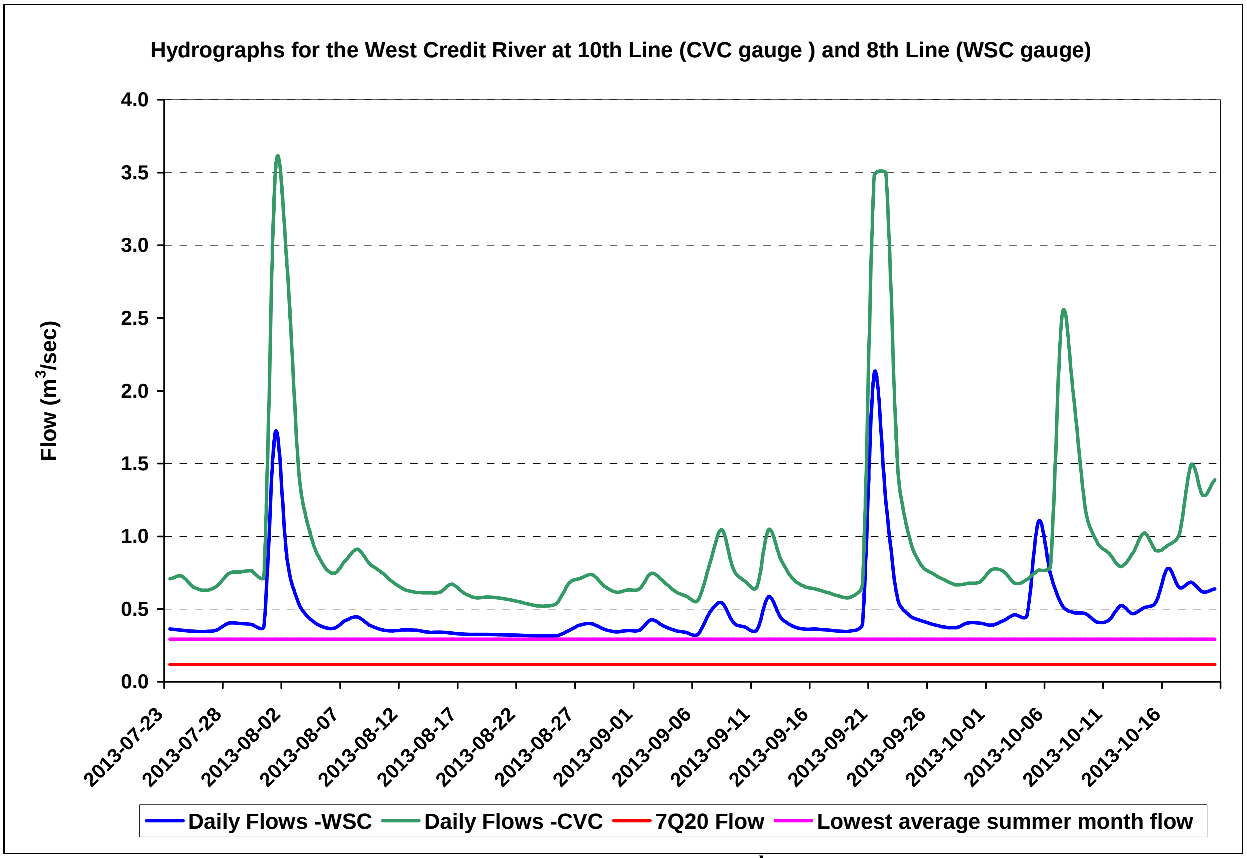


Figure 4: Hydrographs for the West Credit River at 10th Line (CVC Gauge) and 8th Line (WSC Gauge) during July-October 2013

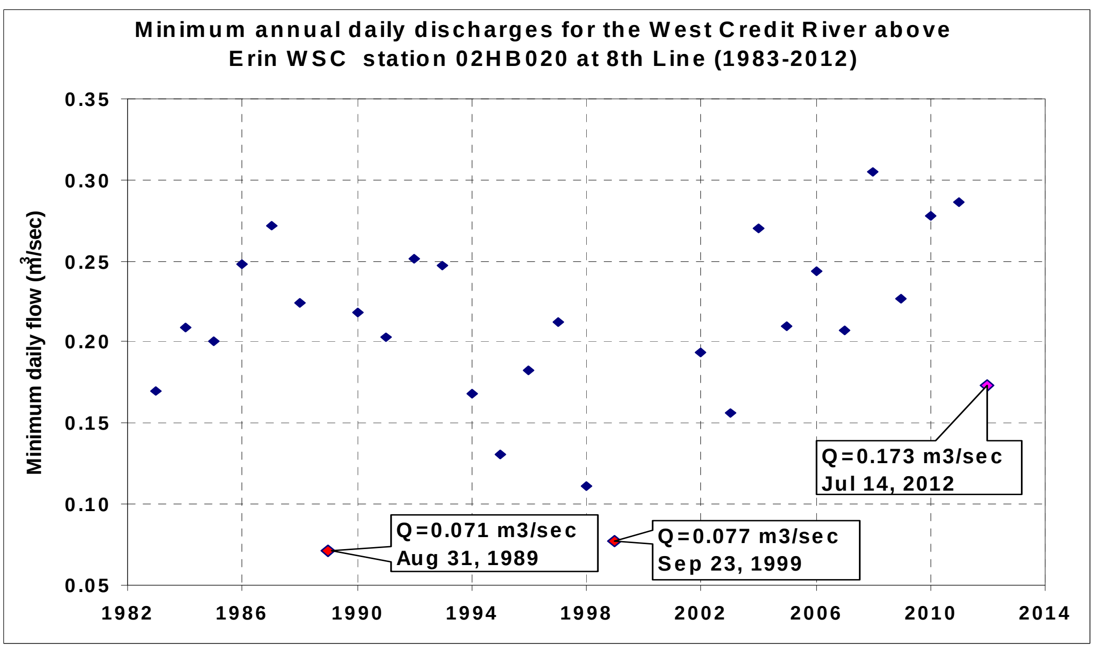


Figure 5: Minimum annual daily discharges for the West Credit River at 8th Line - WSC gauge (1983-2012)

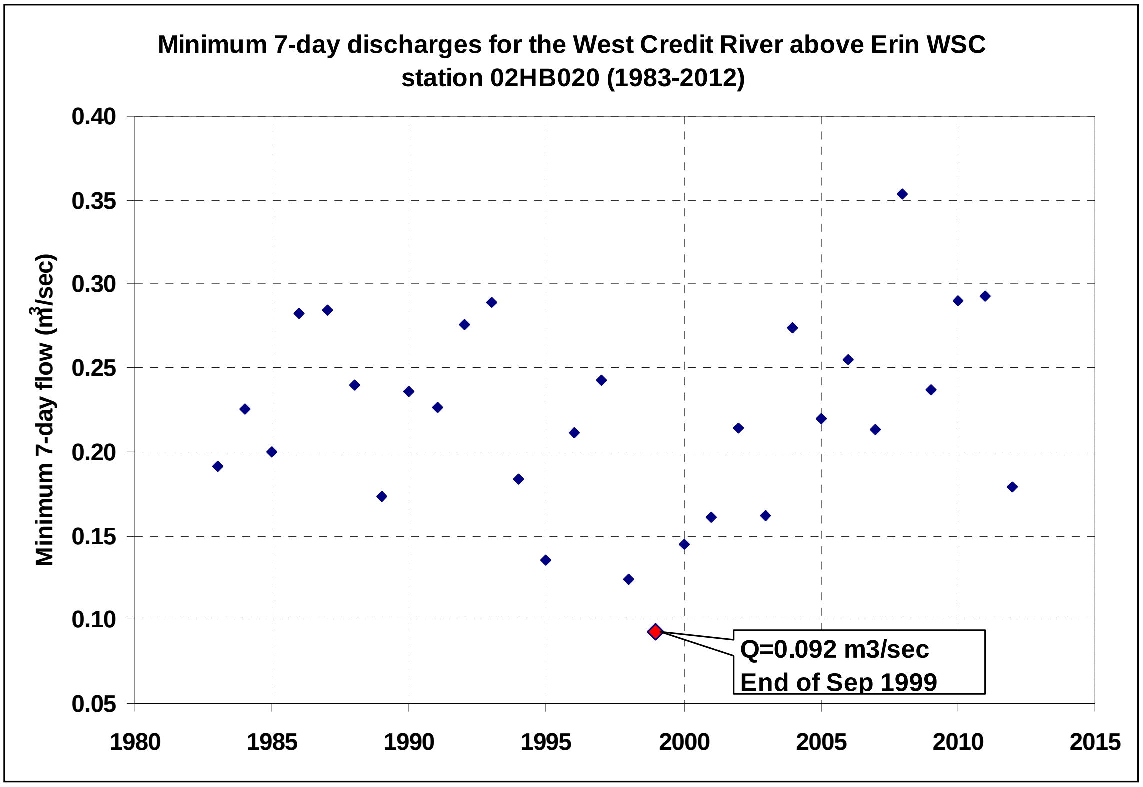


Figure 6: Minimum 7-day discharges for the West Credit River at 8th Line - WSC gauge (1983-2012)

Comparative results of the 7Q20 calculation for the West Credit River at 8th Line (WSC Gauge) and 10th Line are presented in the Table 2.

Table 2: Comparative results of the 7Q20 calculation for the West Credit River

Month / Year	7Q20 (m^3/sec) Observation period at 8th Line	8th Line - WSC gauge	10th Line	Ratio = Q_{10Line} / Q_{8Line}	Report (Agency / Consultant)
May-95	1983-1993	0.172			West Credit River Assimilative Capacity Report, Triton Engineering
1998	1983-1994	0.177			West Credit Subwatershed Study, CVC
May-11	1983-2008	0.12	0.271	2.26	Phase 1 - Environmental Component - Existing Conditions Report, CVC, Aquafor Beach, and Blackport Hydrology
Feb-13	1983-2008	0.12	0.313	2.61	Draft Assimilative Capacity Study, B. M. Ross
Oct-13	1983-2012	0.12	0.187	1.56	Memo - Low flow assessment for the Erin SSMP, CVC

Comparison to Groundwater Flow Modelling Results

As a mean of obtaining an independent alternative assessment of low flow conditions in the West Credit between the 8th Line WSC gauge and 10th Line, CVC contracted Matrix Solutions to undertake an analysis of the groundwater discharge rates simulated by the groundwater flow model for the Credit River. As summarized in their draft memo dated October 25, 2013, Matrix Solutions modified the existing watershed-scale groundwater flow model for the Credit River (which is an update of the model that was peer reviewed for the accepted Tier 2 Integrated Water Budget Report for Source Water Protection) to allow for a transient simulation of groundwater discharge to the West Credit. Historical climate data were used from nearby meteorological stations to develop a time series for monthly groundwater recharge rates for the period from 1960 to 2005, and the memo summarizes the simulated groundwater discharge rates for the period from 1965 to 2005 (the first five years of the simulated results were omitted from the analysis to avoid bias from the set initial groundwater levels). Matrix Solutions notes that the simulated groundwater discharge (or baseflow) at the 8th Line WSC gauge is a reasonable match for the observed baseflow rates at the gauge. Simulated groundwater discharge at the 8th Line WSC gauge ranges from less than 0.1 m^3/s to approximately 0.5 m^3/s, with lower flows corresponding to dry years and higher flows corresponding to wetter years. The simulated groundwater discharge at 10th Line ranges from approximately 0.1 m^3/s to more than 1 m^3/s, with annual and seasonal fluctuations generally matching conditions at 8th Line.

The simulated groundwater discharge data indicate that the ratio of groundwater discharge at 10th Line and 8th Line increases during wetter conditions and decreases during drought conditions. The Matrix Solutions memo notes that while the contributing catchment area for the West Credit at 10th Line is approximately 2.7 times the contributing catchment area for the 8th Line WSC gauge, the simulated average monthly groundwater discharge at 10th Line is approximately double the simulated groundwater discharge at 8th Line. This is in part due to the fact that recharge that occurs in the north-eastern part of the West Credit catchment appears to contribute to groundwater flow towards the main Credit River to the east rather than to the West Credit. Matrix Solutions notes that the difference in simulated groundwater discharge between the two locations could be as low as 0.02 m^3/s during very dry years, however, it is also noted that the groundwater flow model does not simulate interflow, which could contribute to a somewhat greater flow difference between the two locations.

Conclusions:

- The 7Q20 flow value at 10th Line that was derived from the regression equation with the 7Q20 flow at 8th Line (0.120 m^3/sec) is estimated to be 0.187 m^3/sec. This is a reasonable estimation based on the currently available data from the 10th Line gauge. Further refinement of the estimated 7Q20 would require longer term measurement of flows.
- The estimated 7Q20 flow value at 10th Line, and the ratio of low flows between 10th Line and 8th Line, is generally supported by the assessment of simulated groundwater discharge completed by Matrix Solutions.

Recommendations

- A climate change sensitivity assessment could be completed on the estimated 7Q20 values in order to determine if a more conservative value would be appropriate for future applications.
- Collection and processing of streamflow data for both sites (8th Line and 10th Line) should be continued in order to refine the rating curves and estimates of 7Q20 flows.
- The regression equation presented in this memo should be refined and confirmed based on new low flow data
- Historical series of daily streamflows at 10th Line should be created using the established regression equation
- The Low Flow Frequency Analysis of the historical flow series at 10th Line should be conducted based on the Gumbel III and Cunnane frequency distributions.

MEMO

CIVICA
Innovations For The City

DATE: October 16, 2013

TO: Credit Valley Conservation
1255 Old Derry Road
Mississauga, ON L5N 6R4

ATTN: Alexander Pluchik, P.Eng., P.Geo.
Water Resources Specialist

cc: Neelam Gupta, Tim Kuntz

FROM: Edward Graham, M.A.Sc.Eng., P.Eng.

RE: **Analysis – Development of Open Channel Rating Curve #6**

This memo summarizes the development of a open channel rating curve for West Credit River at 10th Line, north of Wellington Rd.

Attaining Calibration Points

Calibration points have been collected by CVC staff which relate depth measurements at the gauge at the bubbler line the approximate time the area velocity flow measurement. The results were as follows:

Date	Measured Depth (m)	Measured Flow (L/s)	Hec-RAS Input Flow (L/s)	Hec-RAS Predicted Depth (L/s)	% Diff. Measured vs Model
Jul 24, 2013 13:00	0.37	720	720	0.38	-2.7%
Jul 29, 2013 10:30	0.369	760	720	NA	NA
Aug 13, 2013 13:15	0.354	620	630	0.35	+1.1%
Aug 19, 2013 10:45	0.348	580	610	0.35	-0.6%
Sep 23, 2013 10:00	0.468	1550	1550	0.47	-0.43%
Oct 7, 2013 10:35	0.586	2630	2630	0.58	1.0%

Differences between measured depth and measured flow during the July 29 visit as compared with the July 24 visit suggest this may be an outlier. This measurement has been removed from the rating curve development. It is recommended that measurements be taken at two separate cross sections during each site visit. If the water level at the sensor does not vary during that time, the confidence will increase. This will increase the confidence in the rating curve values.

Hec-Ras Model

The Hec-Ras model has been developed and calibrated to match the measurements obtained within the range of depth captured during the field measurement periods. The updated calibrated Depth vs Flow relationship is shown in Figure 1.

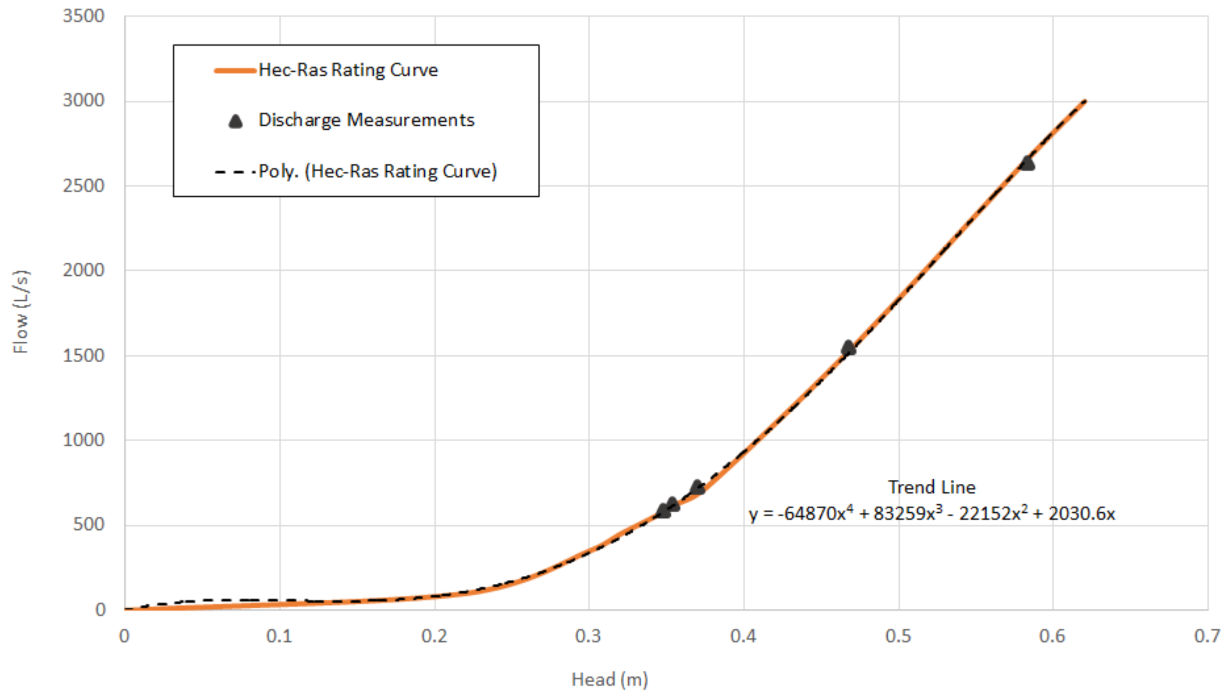


Figure 1: Oct 16 2013 Updated Rating Curve

Note that the polynomial Trend Line equation applies for the range of depth shown (0-0.8 m Head). For higher accuracy during higher flow events, it is recommended that future measurements continue with a 24, 48 and 72 hour interval following significant wet-weather event, particularly those during 'wet' antecedent moisture conditions such as those following consecutive events or during the fall or spring seasons.

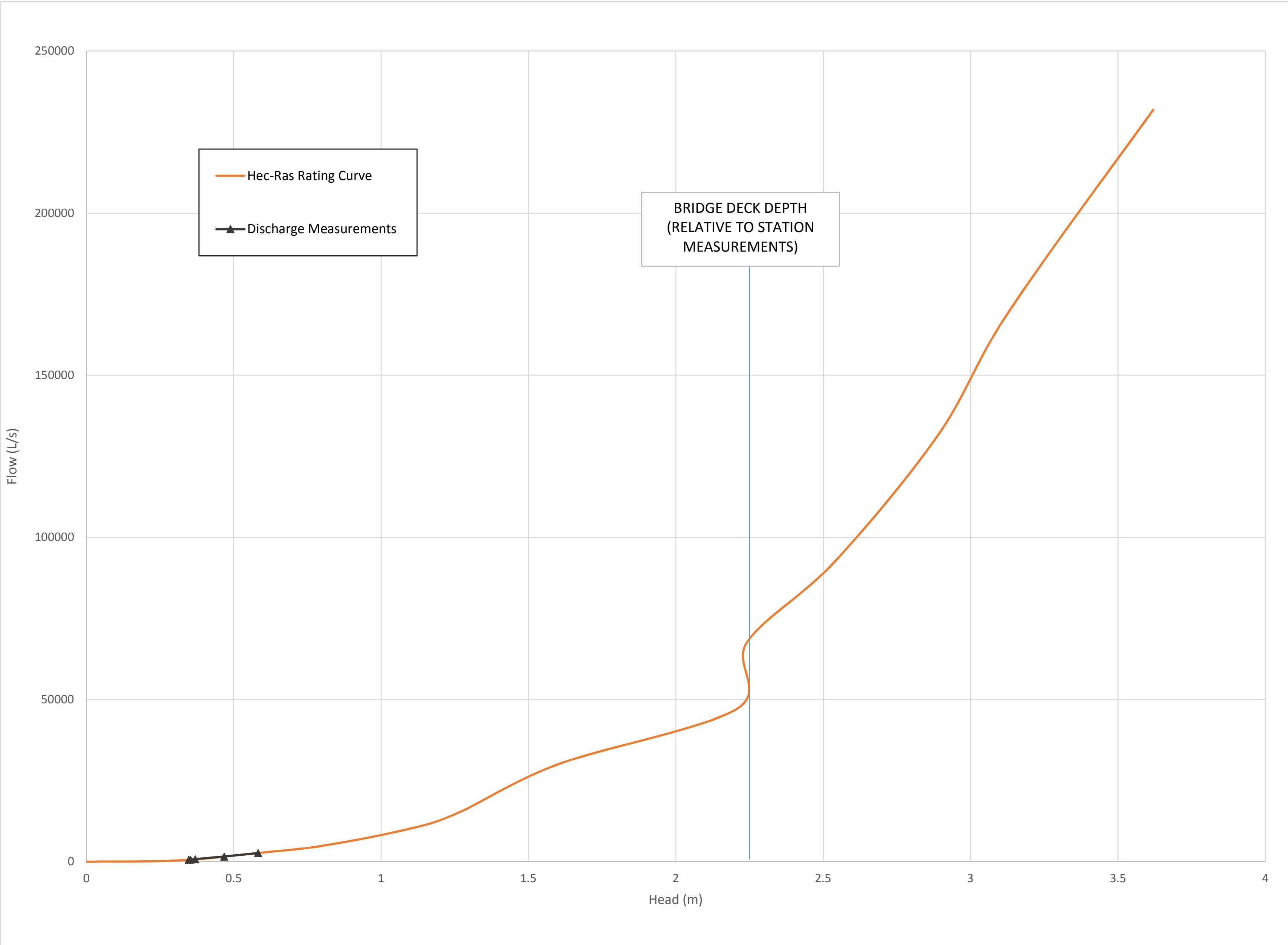
The rating curve is shown at different scales in **Appendix A**. The full rating curve provides the best flow estimate possible at the maximum extrapolated depth measurements. If you have any questions, please contact me at egraham@civicainfrastructure.com or Adrian Dieleman at adieleman@civicainfrastructure.com, or at our office telephone: (905) 532-9011.

Sincerely,

Civica Infrastructure Inc.

Edward Graham, M.A.Sc.Eng., P.Eng.
President

APPENDIX A



Hec-Ras Rating Curve
Discharge Measurements
BRIDGE DECK DEPTH
(RELATIVE TO STATION
MEASUREMENTS)
Flow (L/s)
Head (m)
250000
200000
150000
100000
50000
0
0
0.5
1
1.5
2
2.5
3
3.5
4

Date	Measurements		Hec-Ras	
	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)
Flow0			0	0
Flow100			0.22	100
Flow350			0.3	350
Flow450			0.32	450
19/08/2013	0.348	580	0.348	580
13/08/2013	0.354	620	0.354	620
24/07/2013	0.37	720	0.375	720
23/09/2013	0.468	1550	0.47	1550
07/10/2013	0.583	2630	0.58	2630
Flow3000			0.62	3000
Flow5000			0.81	5000
Flow10000			1.09	10000
Flow15000			1.26	15000
Flow30000			1.6	30000
2 Year			2.21	47300
5 Year			2.24	67500
10 Year			2.54	92600
25 Year			2.89	131600
50 Year			3.13	169700
100 Year			3.62	231900

APPENDIX B
WATER QUALITY DATA
PROVINCIAL MONITORING STATION
06007601502
DATA AND SUMMARY VALUES

Data analysis up to 2008 as prepared by the CVC
Updated by BMROSS to Include Data into 2013

Table: Annual and monthly 75th percentile values (Geomean values for E. coli and 25th Percentile for DO) of Parameters of Concern for the Erin SSMP Study

West Credit River @ Winston Churchill Blvd (data ranging from 1996 to 2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec [1.]
Total Phosphorus, mg/L (PWQO=0.03 mg/L)												
0.016	0.015	0.016	0.018	0.012	0.016	0.016	0.016	0.010	0.013	0.016	0.015	0.021
Nitrate Nitrogen, mg/L (PWQO=2.93 mg/L)												
2.10	2.65	2.70	1.90	1.68	1.71	1.80	1.75	1.74	1.79	2.08	2.18	2.52
Ammonia un-ionized, ug/L (2001-2008, PWQO=20 ug/L)												
0.347	0.578	0.370	0.232	0.310	0.379	0.479	0.413	0.344	0.216	0.154	0.240	0.240
Total Kjeldahl Nitrogen (TKN), mg/L												
0.420	0.375	0.530	0.423	0.383	0.448	0.470	0.405	0.350	0.450	0.448	0.445	0.410
Biochemical Oxygen Demand (BOD5), mg/L												
0.900	1.175	0.900	1.525	0.700	1.150	0.900	0.600	0.800	0.900	0.750	1.000	1.100
Escherichia coli (E. coli) Geomean concentrations, (PWQO=100 CFU/100mL)												
40	12	12	15	27	58	94	125	77	139	31	35	45
Total Ammonia, mg/L												
0.019	0.031	0.021	0.022	0.017	0.017	0.016	0.021	0.018	0.013	0.012	0.016	0.016
pH												
8.1	8.2	8.1	8.0	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.2
Temperature (^{o}C)												
15.3	2.2	1.0	3.7	8.0	13.6	20.2	18.4	17.0	14.1	8.7	3.3	2.7
DO (25th Percentile), mg/L (PWQO = >5 mg/L)												
10.8	13.6	14.2	12.7	11.2	10.6	10.0	9.6	10.8	10.5	11.6	11.5	12.5
Total Suspended Solids (TSS), mg/L (CWQG=25 mg/L)												
4	4	6	5	3	5	5	3	2	3	1	2	14

Notes: 1. December percentiles in most cases are only based on approximately 3 samples recorded over the sampling period from 1996 to 2013.

Raw Data		Monthly concentrations of Total Phosphorus in mg/L											
Sample	Total Phosphorus	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17-Sep-96	0.012									0.012			
15-Oct-96	0.004										0.004		
17-Dec-96	0.036												0.036
23-Jan-97	0.058	0.058											
18-Dec-97	0.002												0.002
24-Feb-98	0.008		0.008										
24-Mar-98	0.016			0.016									
23-Apr-98	0.018				0.018								
21-May-98	0.014					0.014							
17-Jun-98	0.016						0.016						
22-Jul-98	0.012							0.012					
20-Aug-98	0.004								0.004				
25-Sep-98	0.006									0.006			
27-Oct-98	0.014										0.014		
24-Nov-98	0.006											0.006	
18-Dec-98	0.006												0.006
25-Jan-99	0.026	0.026											
01-Mar-99	0.018			0.018									
29-Mar-99	0.008			0.008									
19-Apr-99	0.008				0.008								
27-May-99	0.008					0.008							
23-Jun-99	0.008						0.008						
23-Jul-99	0.006							0.006					
24-Aug-99	0.006								0.006				
30-Sep-99	0.016									0.016			
01-Nov-99	0.004											0.004	
25-Nov-99	0.022											0.022	
04-Jan-00	0.044	0.044											
03-Feb-00	0.016		0.016										
29-Feb-00	0.032		0.032										
30-Mar-00	0.006			0.006									
04-May-00	0.008					0.008							
30-May-00	0.008					0.008							
28-Jun-00	0.020						0.020						
26-Jul-00	0.010							0.010					
30-Aug-00	0.008								0.008				
28-Sep-00	0.004									0.004			
29-Nov-00	0.012											0.012	
03-Jan-01	0.006	0.006											
30-Jan-01	0.008	0.008											
27-Feb-01	0.014		0.014										
29-Mar-01	0.008			0.008									
30-Apr-01	0.008				0.008								
24-May-01	0.022					0.022							
26-Jun-01	0.008						0.008						
25-Jul-01	0.014							0.014					
29-Aug-01	0.008								0.008				
26-Sep-01	0.012									0.012			
25-Oct-01	0.018										0.018		
29-Nov-01	0.016											0.016	
03-Jan-02	0.016	0.016											
24-Jan-02	0.014	0.014											
04-Mar-02	0.016			0.016									
05-Jun-02	0.012						0.012						
26-Jun-02	0.028						0.028						
31-Jul-02	0.018							0.018					
28-Aug-02	0.010								0.010				
26-Sep-02	0.009									0.009			
30-Oct-02	0.008										0.008		
07-Jan-03	0.007	0.007											
30-Jan-03	0.012	0.012											
27-Mar-03	0.018			0.018									
01-May-03	0.016					0.016							
22-May-03	0.017					0.017							
26-Jun-03	0.013						0.013						
31-Jul-03	0.010							0.010					
28-Aug-03	0.006								0.006				
30-Sep-03	0.013									0.013			
30-Oct-03	0.007										0.007		
27-Nov-03	0.007											0.007	
08-Jan-04	0.008	0.008											
25-Feb-04	0.037		0.037										
30-Mar-04	0.029			0.029									
28-Apr-04	0.011				0.011								
26-May-04	0.015					0.015							
29-Jun-04	0.014						0.014						
28-Jul-04	0.010							0.010					
31-Aug-04	0.021								0.021				
23-Sep-04	0.008									0.008			
27-Oct-04	0.006										0.006		
30-Nov-04	0.008											0.008	
10-Jan-05	0.007	0.007											
27-Jan-05	0.015	0.015											
24-Feb-05	0.015		0.015										
31-Mar-05	0.025			0.025									
28-Apr-05	0.016				0.016								
26-May-05	0.014					0.014							
29-Jun-05	0.018						0.018						
28-Jul-05	0.010							0.010					
31-Aug-05	0.026								0.026				
29-Sep-05	0.013									0.013			
27-Oct-05	0.016										0.016		
30-Nov-05	0.024											0.024	
05-Jan-06	0.013	0.013											
26-Jan-06	0.015	0.015											
22-Feb-06	0.009		0.009										
30-Mar-06	0.004			0.004									
27-Apr-06	0.002				0.002								
25-May-06	0.006					0.006							
29-Jun-06	0.016						0.016						
27-Jul-06	0.013							0.013					
31-Aug-06	0.006								0.006				
28-Sep-06	0.023									0.023			
25-Oct-06	0.007										0.007		
28-Nov-06	0.006											0.006	
04-Jan-07	0.006	0.006											
31-Jan-07	0.009	0.009											
28-Feb-07	0.008		0.008										
28-Mar-07	0.024			0.024									
25-Apr-07	0.011				0.011								
30-May-07	0.011					0.011							

Raw Data		Monthly concentrations of Total Phosphorus in mg/L											
Sample	Total Phosphorus	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26-Jun-07	0.012						0.012						
25-Jul-07	0.012							0.012					
29-Aug-07	0.009								0.009				
26-Sep-07	0.011									0.011			
31-Oct-07	0.005										0.005		
26-Nov-07	0.005											0.005	
03-Jan-08	0.010	0.010											
31-Jan-08	0.008	0.008											
27-Feb-08	0.004		0.004										
26-Mar-08	0.007			0.007									
29-Apr-08	0.010				0.010								
28-May-08	0.007					0.007							
25-Jun-08	0.012						0.012						
30-Jul-08	0.019							0.019					
27-Aug-08	0.003								0.003				
30-Sep-08	0.012									0.012			
29-Oct-08	0.004										0.004		
26-Nov-08	0.011											0.011	
07-Jan-09	0.008	0.008											
29-Jan-09	0.013	0.013											
25-Feb-09	0.010		0.010										
25-Mar-09	0.007			0.007									
29-Apr-09	0.010				0.010								
27-May-09	0.022					0.022							
24-Jun-09	0.014						0.014						
29-Jul-09	0.020							0.020					
26-Aug-09	0.009								0.009				
30-Sep-09	0.013									0.013			
28-Oct-09	0.003										0.003		
25-Nov-09	0.010											0.010	
06-Jan-10	0.005	0.005											
24-Feb-10	0.006		0.006										
31-Mar-10	0.007			0.007									
28-Apr-10	0.008				0.008								
26-May-10	0.015					0.015							
30-Jun-10	0.016						0.016						
28-Jul-10	0.017							0.017					
25-Aug-10	0.007								0.007				
29-Sep-10	0.033									0.033			
27-Oct-10	0.033										0.033		
24-Nov-10	0.013											0.013	
05-Jan-11	0.009	0.009											
23-Feb-11	0.040		0.040										
30-Mar-11	0.008			0.008									
27-Apr-11	0.012				0.012								
25-May-11	0.014					0.014							
29-Jun-11	0.011						0.011						
27-Jul-11	0.006							0.006					
31-Aug-11	0.007								0.007				
28-Sep-11	0.009									0.009			
26-Oct-11	0.029										0.029		
30-Nov-11	0.033											0.033	
25-Jan-12	0.011	0.011											
29-Feb-12	0.007		0.007										
28-Mar-12	0.007			0.007									
25-Apr-12	0.015				0.015								
30-May-12	0.005					0.005							
27-Jun-12	0.013						0.013						
25-Jul-12	0.007							0.007					
29-Aug-12	0.007								0.007				
26-Sep-12	0.007									0.007			
31-Oct-12	0.002										0.002		
28-Nov-12	0.009											0.009	
30-Jan-13	0.039	0.039											
26-Feb-13	0.009		0.009										
27-Mar-13	0.008			0.008									
24-Apr-13	0.012				0.012								
29-May-13	0.032					0.032							
26-Jun-13	0.056						0.056						
07-Aug-13	0.012								0.012				
28-Aug-13	0.011								0.011				
25-Sep-13	0.005									0.005			

# of Samples	183	24	14	17	13	17	17	15	17	17	14	15	3
AVE	0.013	0.015	0.015	0.013	0.011	0.014	0.017	0.012	0.009	0.012	0.011	0.012	0.015
MIN	0.002	0.005	0.004	0.004	0.002	0.005	0.008	0.006	0.003	0.004	0.002	0.004	0.002
MAX	0.058	0.058	0.040	0.029	0.018	0.032	0.056	0.020	0.026	0.033	0.033	0.033	0.036
50th	**0.016**	**0.0105**	**0.0095**	**0.008**	**0.011**	**0.014**	**0.014**	**0.012**	**0.008**	**0.012**	**0.007**	**0.01**	**0.006**
10th	0.007	0.0063	0.0063	0.0066	0.008	0.0066	0.0098	0.0064	0.0052	0.0056	0.0033	0.0054	0.0028
25th	0.012	0.008	0.008	0.007	0.008	0.008	0.012	0.01	0.006	0.008	0.00425	0.0065	0.004
75th	**0.0160**	**0.0150**	**0.0158**	**0.0180**	**0.0120**	**0.0160**	**0.0160**	**0.0155**	**0.0100**	**0.0130**	**0.0155**	**0.0145**	**0.0210**
90th	0.03	0.0351	0.0355	0.0244	0.0158	0.022	0.0232	0.0186	0.0156	0.0188	0.0257	0.0232	0.03

Raw Data		Monthly concentrations of Nitrates in mg/L											
Sample Date	Nitrate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17-Sep-96	1.58									1.58			
15-Oct-96	0.95										0.95		
17-Dec-96	1.69												1.69
23-Jan-97	1.21	1.21											
18-Dec-97	2.66												2.66
24-Feb-98	2.23		2.23										
24-Mar-98	1.84			1.84									
23-Apr-98	1.66				1.66								
21-May-98	1.66					1.66							
17-Jun-98	1.59						1.59						
22-Jul-98	1.36							1.36					
20-Aug-98	1.49								1.49				
25-Sep-98	1.80									1.80			
27-Oct-98	1.88										1.88		
24-Nov-98	2.31											2.31	
18-Dec-98	2.37												2.37
25-Jan-99	2.14	2.14											
01-Mar-99	2.12			2.12									
29-Mar-99	1.54			1.54									
19-Apr-99	1.68				1.68								
27-May-99	1.21					1.21							
23-Jun-99	1.28						1.28						
23-Jul-99	1.39							1.39					
24-Aug-99	1.31								1.31				
30-Sep-99	1.21									1.21			
01-Nov-99	1.95											1.95	
25-Nov-99	1.84											1.84	
04-Jan-00	2.09	2.09											
03-Feb-00	2.98		2.98										
29-Feb-00	1.69		1.69										
30-Mar-00	1.56			1.56									
04-May-00	1.53					1.53							
30-May-00	1.59					1.59							
28-Jun-00	1.07						1.07						
26-Jul-00	1.81							1.81					
30-Aug-00	1.72								1.72				
28-Sep-00	1.79									1.79			
29-Nov-00	1.76											1.76	
03-Jan-01	2.66	2.66											
30-Jan-01	2.55	2.55											
27-Feb-01	1.56		1.56										
29-Mar-01	1.84			1.84									
30-Apr-01	1.98				1.98								
24-May-01	1.14					1.14							
26-Jun-01	1.64						1.64						
25-Jul-01	1.56							1.56					
29-Aug-01	1.74								1.74				
26-Sep-01	1.50									1.50			
25-Oct-01	1.42										1.42		
29-Nov-01	1.83											1.83	
03-Jan-02	2.68	2.68											
24-Jan-02	2.45	2.45											
04-Mar-02	1.72			1.72									
05-Jun-02	1.80						1.80						
26-Jun-02	0.87						0.87						
31-Jul-02	1.57							1.57					
28-Aug-02	2.03								2.03				
26-Sep-02	2.01									2.01			
30-Oct-02	2.34										2.34		
07-Jan-03	2.82	2.82											
30-Jan-03	3.38	3.38											
27-Mar-03	1.55			1.55									
01-May-03	1.71					1.71							
22-May-03	1.65					1.65							
26-Jun-03	1.83						1.83						
31-Jul-03	1.79							1.79					
28-Aug-03	1.80								1.80				
30-Sep-03	1.72									1.72			
30-Oct-03	1.85										1.85		
27-Nov-03	2.09											2.09	
08-Jan-04	2.43	2.43											
25-Feb-04	2.89		2.89										
30-Mar-04	1.46			1.46									
28-Apr-04	2.04				2.04								
26-May-04	1.25					1.25							
29-Jun-04	2.18						2.18						

Raw Data		Monthly concentrations of Nitrates in mg/L											
Sample Date	Nitrate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
28-Jul-04	1.82							1.82					
31-Aug-04	1.40								1.40				
23-Sep-04	2.16									2.16			
27-Oct-04	2.47										2.47		
30-Nov-04	2.17											2.17	
10-Jan-05	2.22	2.22											
27-Jan-05	3.02	3.02											
24-Feb-05	2.73		2.73										
31-Mar-05	1.22			1.22									
28-Apr-05	1.41				1.41								
26-May-05	2.06					2.06							
29-Jun-05	1.68						1.68						
28-Jul-05	1.78							1.78					
31-Aug-05	1.31								1.31				
29-Sep-05	1.33									1.33			
27-Oct-05	2.12										2.12		
30-Nov-05	0.94											0.94	
05-Jan-06	1.72	1.72											
26-Jan-06	2.10	2.10											
22-Feb-06	2.10		2.10										
30-Mar-06	1.90			1.90									
27-Apr-06	1.60				1.60								
25-May-06	1.80					1.80							
29-Jun-06	2.02						2.02						
27-Jul-06	1.65							1.65					
31-Aug-06	2.09								2.09				
28-Sep-06	1.14									1.14			
25-Oct-06	1.75										1.75		
28-Nov-06	2.18											2.18	
04-Jan-07	2.14	2.14											
31-Jan-07	2.97	2.97											
28-Feb-07	3.15		3.15										
28-Mar-07	1.11			1.11									
25-Apr-07	1.47				1.47								
30-May-07	1.88					1.88							
26-Jun-07	1.90						1.90						
25-Jul-07	1.63							1.63					
29-Aug-07	1.65								1.65				
26-Sep-07	1.50									1.50			
31-Oct-07	2.11										2.11		
26-Nov-07	2.37											2.37	
03-Jan-08	2.63	2.63											
31-Jan-08	2.33	2.33											
27-Feb-08	2.40		2.40										
26-Mar-08	2.31			2.31									
29-Apr-08	1.80				1.80								
28-May-08	2.07					2.07							
25-Jun-08	1.60						1.60						
30-Jul-08	1.71							1.71					
27-Aug-08	2.02								2.02				
30-Sep-08	1.82									1.82			
29-Oct-08	1.97										1.97		
26-Nov-08	2.17											2.17	
07-Jan-09	2.38	2.38											
29-Jan-09	2.65	2.65											
25-Feb-09	2.53		2.53										
25-Mar-09	2.11			2.11									
29-Apr-09	1.12				1.12								
27-May-09	1.66					1.66							
24-Jun-09	1.55						1.55						
29-Jul-09	1.19							1.19					
26-Aug-09	1.37								1.37				
30-Sep-09	1.04									1.04			
28-Oct-09	1.74										1.74		
25-Nov-09	2.00											2.00	
06-Jan-10	2.61	2.61											
24-Feb-10	2.59		2.59										
31-Mar-10	1.51			1.51									
28-Apr-10	1.35				1.35								
26-May-10	1.59					1.59							
30-Jun-10	1.07						1.07						
28-Jul-10	1.41							1.41					
25-Aug-10	1.57								1.57				
29-Sep-10	0.90									0.90			
27-Oct-10	1.13										1.13		
24-Nov-10	1.63											1.63	

Raw Data		Monthly concentrations of Nitrates in mg/L											
Sample Date	**Nitrate**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
05-Jan-11	2.00	2.00											
23-Feb-11	2.10		2.10										
30-Mar-11	1.91			1.91									
27-Apr-11	0.97				0.97								
25-May-11	1.25					1.25							
29-Jun-11	1.43						1.43						
27-Jul-11	1.54							1.54					
31-Aug-11	1.43								1.43				
28-Sep-11	1.41									1.41			
26-Oct-11	0.96										0.96		
30-Nov-11	0.71											0.71	
25-Jan-12	1.87	1.87											
29-Feb-12	2.32		2.32										
28-Mar-12	1.68			1.68									
25-Apr-12	1.18				1.18								
30-May-12	1.45					1.45							
27-Jun-12	1.32						1.32						
25-Jul-12	1.48							1.48					
29-Aug-12	1.22								1.22				
26-Sep-12	1.54									1.54			
31-Oct-12	1.04										1.04		
28-Nov-12	2.20											2.20	
30-Jan-13	1.62	1.62											
26-Feb-13	1.69		1.69										
27-Mar-13	1.86			1.86									
24-Apr-13	1.57				1.57								
29-May-13	0.77					0.77							
26-Jun-13	0.32						0.32						
07-Aug-13	1.39								1.39				
28-Aug-13	1.36								1.36				
25-Sep-13	1.36									1.36			

# of Samples	183	24	14	17	13	17	17	15	17	17	14	15	3
AVE	1.777	2.361	2.354	1.720	1.525	1.546	1.480	1.579	1.582	1.518	1.695	1.877	2.240
MIN	0.324	1.210	1.560	1.110	0.968	0.774	0.324	1.190	1.220	0.901	0.950	0.709	1.690
MAX	3.380	3.380	3.150	2.310	2.040	2.070	2.180	1.820	2.090	2.160	2.470	2.370	2.660
50th	1.720	2.405	2.360	1.720	1.570	1.590	1.590	1.570	1.490	1.500	1.800	2.000	2.370
10th	1.182	1.765	1.690	1.364	1.132	1.182	0.989	1.372	1.310	1.100	0.983	1.216	1.826
25th	1.440	2.098	2.100	1.540	1.350	1.250	1.280	1.445	1.370	1.330	1.203	1.795	2.030
75th	**2.095**	**2.653**	**2.695**	**1.900**	**1.680**	**1.710**	**1.800**	**1.745**	**1.740**	**1.790**	**2.075**	**2.175**	**2.515**
90th	2.930	2.757	2.400	2.034	1.898	1.960	1.955	2.028	2.170	2.316	2.367	2.370	2.602

Date	T. Ammonia NH_3+NH_4 (mg/L)	Field Water temperature	Field pH	pKa	f	NH3 (ug/L)	Monthly concentrations of NH3 in ug/L (PWQO = 20 ug/L)										
							Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
24-May-01	0.008	13.4	8.08	9.62	0.0279	0.223					0.223						
26-Jun-01	0.002	17.1	7.96	9.50	0.0280	0.056						0.056					
25-Jul-01	0.008	18.1	7.96	9.47	0.0301	0.241							0.241				
29-Aug-01	0.002	15.4	8.16	9.56	0.0386	0.077								0.077			
25-Oct-01	0.004	9.6	7.95	9.75	0.0156	0.062										0.062	
29-Nov-01	0.014	3.4	8.00	9.97	0.0107	0.149											0.149
03-Jan-02	0.012	0.9	8.17	10.06	0.0128	0.154	0.154										
24-Jan-02	0.008	1.7	8.12	10.03	0.0122	0.098	0.098										
04-Mar-02	0.002	3.9	8.13	9.95	0.0149	0.030			0.030								
05-Jun-02	0.002	12.6	7.80	9.65	0.0140	0.028						0.028					
26-Jun-02	0.009	20.2	8.20	9.40	0.0592	0.533						0.533					
31-Jul-02	0.002	20.2	7.88	9.40	0.0293	0.059							0.059				
28-Aug-02	0.006	16.8	8.01	9.51	0.0306	0.184								0.184			
26-Sep-02	0.002	14.4	8.00	9.59	0.0251	0.050									0.050		
30-Oct-02	0.002	4.5	8.15	9.93	0.0164	0.033										0.033	
27-Nov-02	0.007	1.3	8.16	10.04	0.0129	0.091											0.091
07-Jan-03	0.007	6.0	8.20	9.87	0.0207	0.145	0.145										
27-Mar-03	0.042	3.0	7.59	9.98	0.0040	0.170			0.170								
01-May-03	0.012	9.3	8.07	9.76	0.0200	0.240					0.240						
22-May-03	0.016	11.0	8.16	9.70	0.0279	0.446					0.446						
26-Jun-03	0.002	21.0	8.32	9.38	0.0809	0.162						0.162					
31-Jul-03	0.011	17.3	8.23	9.49	0.0516	0.568							0.568				
28-Aug-03	0.020	14.6	8.28	9.58	0.0475	0.950								0.950			
30-Sep-03	0.004	8.6	8.22	9.78	0.0265	0.106									0.106		
30-Oct-03	0.003	7.0	8.36	9.84	0.0321	0.096										0.096	
27-Nov-03	0.002	3.2	8.16	9.97	0.0151	0.030											0.030
08-Jan-04	0.009	6.1	8.14	9.87	0.0182	0.164	0.164										
25-Feb-04	0.013	0.4	8.19	10.08	0.0129	0.167		0.167									
30-Mar-04	0.022	5.1	8.02	9.91	0.0128	0.282			0.282								
28-Apr-04	0.010	5.7	8.08	9.89	0.0154	0.154				0.154							
26-May-04	0.009	12.9	7.96	9.64	0.0205	0.185					0.185						
29-Jun-04	0.003	13.8	8.17	9.61	0.0351	0.105						0.105					
28-Jul-04	0.002	15.5	8.13	9.55	0.0364	0.073							0.073				
31-Aug-04	0.003	15.3	8.12	9.56	0.0351	0.105								0.105			
23-Sep-04	0.004	13.7	8.18	9.61	0.0357	0.143									0.143		
27-Oct-04	0.002	9.1	8.09	9.77	0.0206	0.041										0.041	
30-Nov-04	0.002	2.7	8.11	9.99	0.0130	0.026											0.026
10-Jan-05	0.012	1.6	8.51	10.03	0.0292	0.350	0.350										
27-Jan-05	0.031	0.3	7.76	10.08	0.0048	0.148	0.148										
24-Feb-05	0.006	0.1	8.04	10.09	0.0089	0.053		0.053									
31-Mar-05	0.022	1.7	7.78	10.03	0.0056	0.124			0.124								
28-Apr-05	0.004	6.1	7.97	9.87	0.0124	0.050				0.050							
26-May-05	0.002	13.7	7.99	9.61	0.0233	0.047					0.047						
29-Jun-05	0.002	20.2	8.52	9.40	0.1162	0.232						0.232					
28-Jul-05	0.002	15.6	7.31	9.55	0.0057	0.011							0.011				
31-Aug-05	0.002	17.6	7.18	9.48	0.0049	0.010								0.010			
29-Sep-05	0.010	12.7	7.48	9.65	0.0068	0.068									0.068		
27-Oct-05	0.002	6.4	7.99	9.86	0.0133	0.027										0.027	
30-Nov-05	0.002	2.6	7.45	10.00	0.0028	0.006											0.006
05-Jan-06	0.020	1.6	7.76	10.03	0.0053	0.106	0.106										
29-Jun-06	0.004	16.3	7.68	9.53	0.0140	0.056						0.056					
27-Jul-06	0.011	19.2	7.34	9.43	0.0080	0.088							0.088				
31-Aug-06	0.002	14.0	7.57	9.60	0.0092	0.018								0.018			
28-Sep-06	0.013	12.2	7.75	9.66	0.0121	0.157									0.157		
25-Oct-06	0.002	5.8	7.88	9.88	0.0099	0.020										0.020	
28-Nov-06	0.016	6.9	7.79	9.84	0.0088	0.140											0.140
04-Jan-07	0.005	2.7	8.09	9.99	0.0124	0.062	0.062										
31-Jan-07	0.024	0.8	7.89	10.06	0.0067	0.161	0.161										
28-Feb-07	0.021	2.0	7.94	10.02	0.0083	0.174		0.174									
28-Mar-07	0.018	3.0	7.83	9.98	0.0070	0.126			0.126								
25-Apr-07	0.022	9.1	7.98	9.77	0.0161	0.353				0.353							
30-May-07	0.013	15.5	8.03	9.55	0.0291	0.379					0.379						
26-Jun-07	0.020	18.4	8.08	9.46	0.0402	0.803						0.803					
25-Jul-07	0.002	16.6	8.07	9.52	0.0345	0.069							0.069				
29-Aug-07	0.007	18.2	8.14	9.46	0.0452	0.316								0.316			
26-Sep-07	0.002	16.9	8.04	9.51	0.0330	0.066									0.066		
31-Oct-07	0.002	8.5	8.06	9.79	0.0184	0.037										0.037	
26-Nov-07	0.005	3.1	7.96	9.98	0.0095	0.048											0.048
03-Jan-08	0.012	0.1	8.88	10.09	0.0586	0.703	0.703										
31-Jan-08	0.005	0.7	7.59	10.06	0.0033	0.017	0.017										
27-Feb-08	0.002	0.7	7.79	10.06	0.0053	0.011		0.011									
26-Mar-08	0.002	2.1	7.70	10.01	0.0048	0.010			0.010								
29-Apr-08	0.003	7.6	7.43	9.82	0.0041	0.012				0.012							
28-May-08	0.002	10.8	7.76	9.71	0.0111	0.022					0.022						
25-Jun-08	0.002	15.2	7.88	9.56	0.0204	0.041						0.041					
30-Jul-08	0.010	16.5	7.44	9.52	0.0082	0.082							0.082				
27-Aug-08	0.010	13.4	7.82	9.62	0.0155	0.155								0.155			
30-Sep-08	0.013	12.6	7.71	9.65	0.0114	0.148									0.148		
29-Oct-08	0.010	4.4	7.76	9.93	0.0067	0.067										0.067	
26-Nov-08	0.011	2.5	8.08	10.00	0.0119	0.131											0.131
07-Jan-09	0.018	7.47	8.08	9.82	0.0177	0.319	0.319										
29-Jan-09	0.033	7.58	8.08	9.82	0.0179	0.590	0.590										
25-Feb-09	0.019	7.88	8.08	9.81	0.0183	0.348		0.348									
25-Mar-09	0.012	7.49	8.08	9.82	0.0178	0.213			0.213								
29-Apr-09	0.006	7.87	8.08	9.81	0.0183	0.110				0.110							
27-May-09	0.015	8	8.08	9.81	0.0185	0.277					0.277						
24-Jun-09	0.017	8.16	8.08	9.80	0.0187	0.318						0.318					
29-Jul-09	0.022	7.84	8.08	9.81	0.0183	0.402							0.402				
26-Aug-09	0.002	8.17	8.08	9.80	0.0187	0.037								0.037			
30-Sep-09	0.011	8.03	8.08	9.80	0.0185	0.204									0.204		
28-Oct-09	0.002	7.98	8.08	9.81	0.0185	0.037										0.037	
25-Nov-09	0.012	8.04	8.08	9.80	0.0185	0.222											0.222
06-Jan-10	0.026	7.93	8.08	9.81	0.0184	0.478	0.478										
24-Feb-10	0.020	8.01	8.08	9.80	0.0185	0.370		0.370									
31-Mar-10	0.014	7.65	8.08	9.82	0.0180	0.252			0.252								
28-Apr-10	0.010	8	8.08	9.81	0.0185	0.185				0.185							
26-May-10	0.018	8.13	8.08	9.80	0.0187	0.336					0.336						
30-Jun-10	0.037	8.04	8.08	9.80	0.0185	0.686						0.686					
28-Jul-10	0.025	8.2	8.08	9.80	0.0188	0.469							0.469				
25-Aug-10	0.019	8.09	8.08	9.80	0.0186	0.354								0.354			
29-Sep-10	0.014	7.8	8.08	9.81	0.0182	0.255									0.255		

Date	T. Ammonia NH_3+NH_4 (mg/L)	Field Water temperature	Field pH	pKa	f	NH3 (ug/L)	Monthly concentrations of NH3 in ug/L (PWQO = 20 ug/L)										
							Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
27-Oct-10	0.018	7.74	8.08	9.81	0.0181	0.326										0.326	
24-Nov-10	0.016	7.82	8.08	9.81	0.0182	0.292											0.292
05-Jan-11	0.032	8.27	8.08	9.80	0.0189	0.604	0.604										
23-Feb-11	0.037	8.18	8.08	9.80	0.0187	0.693		0.693									
30-Mar-11	0.025	8.09	8.08	9.80	0.0186	0.465			0.465								
27-Apr-11	0.030	8.06	8.08	9.80	0.0186	0.557				0.557							
25-May-11	0.019	12.38	8.08	9.66	0.0259	0.491					0.491						
29-Jun-11	0.013	8.14	8.08	9.80	0.0187	0.243						0.243					
27-Jul-11	0.024	8.07	8.08	9.80	0.0186	0.446							0.446				
31-Aug-11	0.016	8.19	8.08	9.80	0.0188	0.300								0.300			
28-Sep-11	0.002	8.16	8.08	9.80	0.0187	0.037									0.037		
26-Oct-11	0.020	7.95	8.08	9.81	0.0184	0.368										0.368	
30-Nov-11	0.017	7.85	8.08	9.81	0.0183	0.310											0.310
25-Jan-12	0.031	8.12	8.08	9.80	0.0187	0.578	0.578										
29-Feb-12	0.012	7.92	8.08	9.81	0.0184	0.220		0.220									
28-Mar-12	0.005	7.69	8.08	9.82	0.0180	0.090			0.090								
25-Apr-12	0.013	7.62	8.08	9.82	0.0179	0.233				0.233							
30-May-12	0.010	7.97	8.08	9.81	0.0184	0.184					0.184						
27-Jun-12	0.013	7.94	8.08	9.81	0.0184	0.239						0.239					
25-Jul-12	0.021	7.97	8.08	9.81	0.0184	0.387							0.387				
29-Aug-12	0.010	7.85	8.08	9.81	0.0183	0.183								0.183			
26-Sep-12	0.016	7.96	8.08	9.81	0.0184	0.295									0.295		
31-Oct-12	0.019	7.74	8.08	9.81	0.0181	0.344										0.344	
28-Nov-12	0.020	8.05	8.08	9.80	0.0186	0.371											0.371
30-Jan-13	0.097	7.76	8.08	9.81	0.0181	1.759	1.759										
26-Feb-13	0.070	7.85	8.08	9.81	0.0183	1.279		1.279									
27-Mar-13	0.011	7.95	8.08	9.81	0.0184	0.202			0.202								
24-Apr-13	0.017	7.85	8.08	9.81	0.0183	0.310				0.310							
29-May-13	0.021	7.7	8.08	9.82	0.0181	0.379					0.379						
26-Jun-13	0.117	7.94	8.08	9.81	0.0184	2.152						2.152					
07-Aug-13	0.035	7.96	8.08	9.81	0.0184	0.645								0.645			
28-Aug-13	0.030	8.01	8.08	9.80	0.0185	0.555								0.555			
25-Sep-13	0.023	8.12	8.08	9.80	0.0187	0.429									0.429		

# of Samples	134	134	134			134	17	9	11	9	12	14	12	14	12	12	12
AVE	0.014	8.836	8.011			0.258	0.379	0.368	0.179	0.218	0.267	0.404	0.241	0.278	0.163	0.121	0.151
MIN	0.002	0.1	7.18			0.006	0.017	0.011	0.010	0.012	0.022	0.028	0.011	0.010	0.037	0.020	0.006
MAX	0.117	21	8.88			2.152	1.759	1.279	0.465	0.557	0.491	2.152	0.568	0.950	0.429	0.368	0.371
50th	**0.011**	**7.99**	**8.08**			**0.172**	**0.164**	**0.220**	**0.170**	**0.185**	**0.259**	**0.236**	**0.164**	**0.183**	**0.145**	**0.052**	**0.136**
10th	0.002	2.03	7.753			0.030	0.083	0.045	0.030	0.042	0.060	0.045	0.060	0.024	0.052	0.027	0.026
25th	0.00325	6.525	7.963			0.067	0.145	0.167	0.107	0.110	0.185	0.068	0.072	0.084	0.067	0.036	0.043
75th	**0.019**	**12.545**	**8.080**			**0.347**	**0.578**	**0.370**	**0.232**	**0.310**	**0.379**	**0.479**	**0.413**	**0.344**	**0.216**	**0.154**	**0.240**
90th	0.0257	16.57	8.167			0.556	0.643	0.810	0.282	0.394	0.439	0.768	0.467	0.618	0.291	0.342	0.309

Raw Data		Monthly concentrations of TKN in mg/L											
Sample	Total Kjeldahl Nitrogen (TKN)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17-Sep-96	0.44									0.44			
15-Oct-96	0.30										0.30		
17-Dec-96	0.58												0.58
23-Jan-97	0.68	0.68											
18-Dec-97	0.18												0.18
24-Feb-98	0.32		0.32										
24-Mar-98	0.36			0.36									
23-Apr-98	0.38				0.38								
21-May-98	0.38					0.38							
17-Jun-98	0.38						0.38						
22-Jul-98	0.36							0.36					
20-Aug-98	0.30								0.30				
25-Sep-98	0.22									0.22			
27-Oct-98	0.28										0.28		
24-Nov-98	0.28											0.28	
18-Dec-98	0.24												0.24
25-Jan-99	0.52	0.52											
01-Mar-99	0.44			0.44									
29-Mar-99	0.40			0.40									
19-Apr-99	0.34				0.34								
27-May-99	0.36					0.36							
23-Jun-99	0.28						0.28						
23-Jul-99	0.32							0.32					
24-Aug-99	0.28								0.28				
30-Sep-99	0.42									0.42			
01-Nov-99	0.30											0.30	
25-Nov-99	0.32											0.32	
04-Jan-00	0.60	0.60											
03-Feb-00	0.28		0.28										
29-Feb-00	0.60		0.60										
30-Mar-00	0.32			0.32									
04-May-00	0.40					0.40							
30-May-00	0.40					0.40							
28-Jun-00	0.74						0.74						
26-Jul-00	0.34							0.34					
30-Aug-00	0.30								0.30				
28-Sep-00	0.28									0.28			
29-Nov-00	0.42											0.42	
03-Jan-01	0.24	0.24											
30-Jan-01	0.28	0.28											
27-Feb-01	0.44		0.44										
29-Mar-01	0.38			0.38									
30-Apr-01	0.28				0.28								
24-May-01	0.64					0.64							
26-Jun-01	0.40						0.40						
25-Jul-01	0.40							0.40					
29-Aug-01	0.30								0.30				
26-Sep-01	0.32									0.32			
25-Oct-01	0.44										0.44		
29-Nov-01	0.32											0.32	
03-Jan-02	0.30	0.30											
24-Jan-02	0.32	0.32											
04-Mar-02	0.36			0.36									
05-Jun-02	0.36						0.36						
26-Jun-02	0.50						0.50						
31-Jul-02	0.42							0.42					
28-Aug-02	0.28								0.28				
26-Sep-02	0.29									0.29			
30-Oct-02	0.27										0.27		
07-Jan-03	0.26	0.26											
30-Jan-03	0.26	0.26											
27-Mar-03	0.43			0.43									
01-May-03	0.41					0.41							
22-May-03	0.39					0.39							
26-Jun-03	0.35						0.35						
31-Jul-03	0.31							0.31					

Raw Data		Monthly concentrations of TKN in mg/L											
Sample	Total Kjeldahl Nitrogen (TKN)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
28-Aug-03	0.28								0.28				
30-Sep-03	0.38									0.38			
30-Oct-03	0.36										0.36		
27-Nov-03	0.36											0.36	
08-Jan-04	0.32	0.32											
25-Feb-04	0.53		0.53										
30-Mar-04	0.44			0.44									
28-Apr-04	0.37				0.37								
26-May-04	0.50					0.50							
29-Jun-04	0.29						0.29						
28-Jul-04	0.38							0.38					
31-Aug-04	0.43								0.43				
23-Sep-04	0.27									0.27			
27-Oct-04	0.21										0.21		
30-Nov-04	0.33											0.33	
10-Jan-05	0.33	0.33											
27-Jan-05	0.31	0.31											
24-Feb-05	0.32		0.32										
31-Mar-05	0.41			0.41									
28-Apr-05	0.35				0.35								
26-May-05	0.34					0.34							
29-Jun-05	0.44						0.44						
28-Jul-05	0.26							0.26					
31-Aug-05	0.37								0.37				
29-Sep-05	0.50									0.50			
27-Oct-05	0.49										0.49		
30-Nov-05	0.55											0.55	
05-Jan-06	0.36	0.36											
29-Jun-06	0.40						0.40						
27-Jul-06	0.41							0.41					
31-Aug-06	0.24								0.24				
28-Sep-06	0.62									0.62			
25-Oct-06	0.45										0.45		
28-Nov-06	0.32											0.32	
04-Jan-07	0.28	0.28											
31-Jan-07	0.31	0.31											
28-Feb-07	0.26		0.26										
28-Mar-07	0.42			0.42									
25-Apr-07	0.44				0.44								
30-May-07	0.34					0.34							
26-Jun-07	0.35						0.35						
25-Jul-07	0.37							0.37					
29-Aug-07	0.25								0.25				
26-Sep-07	0.33									0.33			
31-Oct-07	0.22										0.22		
26-Nov-07	0.30											0.30	
03-Jan-08	0.33	0.33											
31-Jan-08	0.39	0.39											
27-Feb-08	0.27		0.27										
26-Mar-08	0.37			0.37									
29-Apr-08	0.39				0.39								
28-May-08	0.31					0.31							
25-Jun-08	0.47						0.47						
30-Jul-08	0.41							0.41					
27-Aug-08	0.35								0.35				
30-Sep-08	0.37									0.37			
29-Oct-08	0.36										0.36		
26-Nov-08	0.33											0.33	
07-Jan-09	0.35	0.35											
29-Jan-09	0.36	0.36											
25-Feb-09	0.26		0.26										
25-Mar-09	0.29			0.29									
29-Apr-09	0.42				0.42								
27-May-09	0.56					0.56							
24-Jun-09	0.35						0.35						
29-Jul-09	0.49							0.49					
26-Aug-09	0.35								0.35				
30-Sep-09	0.45									0.45			
28-Oct-09	0.32										0.32		
25-Nov-09	0.31											0.31	

Raw Data		Monthly concentrations of TKN in mg/L											
Sample	**Total Kjeldahl Nitrogen (TKN)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
06-Jan-10	0.24	0.24											
24-Feb-10	0.22		0.22										
31-Mar-10	0.31			0.31									
28-Apr-10	0.30				0.30								
26-May-10	0.40					0.40							
30-Jun-10	0.50						0.50						
28-Jul-10	0.39							0.39					
25-Aug-10	0.30								0.30				
29-Sep-10	0.74									0.74			
27-Oct-10	0.50										0.50		
24-Nov-10	0.47											0.47	
05-Jan-11	0.33	0.33											
23-Feb-11	0.66		0.66										
30-Mar-11	0.29			0.29									
27-Apr-11	0.34				0.34								
25-May-11	0.43					0.43							
29-Jun-11	0.42						0.42						
27-Jul-11	0.32							0.32					
31-Aug-11	0.29								0.29				
28-Sep-11	0.32									0.32			
26-Oct-11	0.61										0.61		
30-Nov-11	0.54											0.54	
25-Jan-12	0.40	0.40											
29-Feb-12	0.31		0.31										
28-Mar-12	0.30			0.30									
25-Apr-12	0.36				0.36								
30-May-12	0.39					0.39							
27-Jun-12	0.38						0.38						
25-Jul-12	0.30							0.30					
29-Aug-12	0.28								0.28				
26-Sep-12	0.27									0.27			
31-Oct-12	0.26										0.26		
28-Nov-12	1.80											1.80	
30-Jan-13	0.58	0.58											
26-Feb-13	0.59		0.59										
27-Mar-13	0.58			0.58									
24-Apr-13	0.03				0.03								
29-May-13	0.62					0.62							
26-Jun-13	0.65						0.65						
07-Aug-13	0.16								0.16				
28-Aug-13	0.43								0.43				
25-Sep-13	0.63									0.63			

# of Samples	178	23	13	16	12	16	17	15	17	17	14	15	3
AVE	0.383	0.363	0.389	0.381	0.333	0.429	0.427	0.365	0.305	0.403	0.362	0.463	0.333
MIN	0.03	0.24	0.22	0.29	0.03	0.31	0.28	0.26	0.16	0.22	0.21	0.28	0.18
MAX	1.8	0.68	0.66	0.58	0.44	0.64	0.74	0.49	0.43	0.74	0.61	1.8	0.58
50th	**0.36**	**0.33**	**0.32**	**0.375**	**0.355**	**0.4**	**0.4**	**0.37**	**0.3**	**0.37**	**0.34**	**0.33**	**0.24**
10th	0.267	0.26	0.26	0.295	0.282	0.34	0.326	0.304	0.246	0.27	0.232	0.3	0.192
25th	0.3	0.29	0.27	0.3175	0.33	0.375	0.35	0.32	0.28	0.29	0.2725	0.315	0.21
75th	**0.420**	**0.375**	**0.530**	**0.423**	**0.383**	**0.448**	**0.470**	**0.405**	**0.350**	**0.450**	**0.448**	**0.445**	**0.410**
90th	0.553	0.568	0.598	0.44	0.417	0.59	0.56	0.416	0.394	0.624	0.497	0.546	0.512

Raw Data		Monthly concentrations of BOD5 in mg/L											
Sample	**BOD5**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
17-Sep-96	0.8									0.80			
15-Oct-96	0.4										0.40		
17-Dec-96	1.2												1.20
23-Jan-97	4.8	4.80											
18-Dec-97	1												1.00
24-Feb-98	0.2		0.20										
24-Mar-98	0.6			0.60									
23-Apr-98	0.4				0.40								
21-May-98	0.8					0.80							
17-Jun-98	0.4						0.40						
22-Jul-98	0.6							0.60					
20-Aug-98	0.6								0.60				
25-Sep-98	0.4									0.40			
27-Oct-98	0.6										0.60		
24-Nov-98	0.4											0.40	
18-Dec-98	0.2												0.20
25-Jan-99	1	1.00											
01-Mar-99	0.8			0.80									
29-Mar-99	1.6			1.60									
19-Apr-99	0.6				0.60								
27-May-99	1.4					1.40							
23-Jun-99	0.8						0.80						
23-Jul-99	0.6							0.60					
24-Aug-99	0.8								0.80				
30-Sep-99	1.4									1.40			
01-Nov-99	0.6											0.60	
25-Nov-99	1											1.00	
04-Jan-00	0.8	0.80											
03-Feb-00	3.2		3.20										
29-Feb-00	0.6		0.60										
30-Mar-00	1.6			1.60									
04-May-00	1.2					1.20							
30-May-00	0.2					0.20							
28-Jun-00	1						1.00						
26-Jul-00	0.6							0.60					
30-Aug-00	0.4								0.40				
28-Sep-00	0.6									0.60			
29-Nov-00	0.6											0.60	
03-Jan-01	0.4	0.40											
30-Jan-01	0.4	0.40											
27-Feb-01	0.2		0.20										
29-Mar-01	0.4			0.40									
30-Apr-01	0.2				0.20								
26-Jun-01	0.2						0.20						
29-Aug-01	0.4								0.40				
26-Sep-01	0.8									0.80			
25-Oct-01	0.6										0.60		
29-Nov-01	1											1.00	
03-Jan-02	0.6	0.60											
24-Jan-02	0.4	0.40											
04-Mar-02	1.6			1.60									
05-Jun-02	0.8						0.80						
26-Jun-02	0.2						0.20						
31-Jul-02	0.3							0.30					
28-Aug-02	0.2								0.20				
26-Sep-02	0.8									0.80			
30-Oct-02	0.3										0.30		
07-Jan-03	0.2	0.20											
30-Jan-03	1.2	1.20											
27-Mar-03	1.5			1.50									
22-May-03	0.6					0.60							
26-Jun-03	0.7						0.70						
31-Jul-03	0.6							0.60					
28-Aug-03	0.4								0.40				
30-Sep-03	0.3									0.30			
30-Oct-03	0.9										0.90		
27-Nov-03	1.1											1.10	

Raw Data		Monthly concentrations of BOD5 in mg/L											
Sample	BOD5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08-Jan-04	3.1	3.10											
25-Feb-04	0.2		0.20										
30-Mar-04	0.5			0.50									
28-Apr-04	0.2				0.20								
26-May-04	0.8					0.80							
29-Jun-04	0.6						0.60						
28-Jul-04	0.4							0.40					
31-Aug-04	0.4								0.40				
23-Sep-04	0.9									0.90			
27-Oct-04	0.4										0.40		
30-Nov-04	0.3											0.30	
10-Jan-05	0.3	0.30											
27-Jan-05	0.2	0.20											
24-Feb-05	0.7		0.70										
31-Mar-05	1.6			1.60									
28-Apr-05	0.7				0.70								
26-May-05	0.9					0.90							
29-Jun-05	1						1.00						
28-Jul-05	0.6							0.60					
31-Aug-05	0.9								0.90				
29-Sep-05	0.6									0.60			
27-Oct-05	0.4										0.40		
30-Nov-05	0.7											0.70	
05-Jan-06	0.8	0.80											
26-Jan-06	0.5	0.50											
22-Feb-06	0.5		0.50										
30-Mar-06	0.5			0.50									
27-Apr-06	0.5				0.50								
25-May-06	0.5					0.50							
29-Jun-06	0.7						0.70						
27-Jul-06	0.5							0.50					
31-Aug-06	0.5								0.50				
28-Sep-06	0.9									0.90			
25-Oct-06	0.3										0.30		
25-Apr-07	0.3				0.30								
30-May-07	0.6					0.60							
26-Jun-07	0.6						0.60						
25-Jul-07	0.9							0.90					
29-Aug-07	0.4								0.40				
26-Sep-07	0.4									0.40			
31-Oct-07	0.8										0.80		
26-Nov-07	0.4											0.40	
03-Jan-08	1.9	1.90											
31-Jan-08	0.5	0.50											
27-Feb-08	0.2		0.20										
26-Mar-08	0.5			0.50									
29-Apr-08	0.8				0.80								
28-May-08	0.7					0.70							
25-Jun-08	0.7						0.70						
30-Jul-08	0.2							0.20					
27-Aug-08	0.5								0.50				
30-Sep-08	0.5									0.50			
29-Oct-08	0.4										0.40		
26-Nov-08	0.2											0.20	
07-Jan-09	0.2	0.20											
29-Jan-09	0.2	0.20											
25-Feb-09	0.3		0.30										
25-Mar-09	0.5			0.50									
29-Apr-09	0.2				0.20								
27-May-09	1.1					1.10							
24-Jun-09	0.9						0.90						
29-Jul-09	0.6							0.60					
26-Aug-09	0.4								0.40				
30-Sep-09	0.7									0.70			
28-Oct-09	0.5										0.50		
25-Nov-09	1											1.00	
06-Jan-10	0.6	0.60											
24-Feb-10	0.7		0.70										
31-Mar-10	0.5			0.50									
28-Apr-10	0.8				0.80								

Raw Data		Monthly concentrations of BOD5 in mg/L											
Sample	**BOD5**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
26-May-10	3.2					3.20							
30-Jun-10	0.9						0.90						
28-Jul-10	0.2							0.20					
25-Aug-10	0.2								0.20				
29-Sep-10	1.5									1.50			
27-Oct-10	1										1.00		
24-Nov-10	1.5											1.50	
05-Jan-11	1.2	1.20											
23-Feb-11	0.9		0.90										
30-Mar-11	0.2			0.20									
27-Apr-11	0.6				0.60								
25-May-11	0.5					0.50							
29-Jun-11	0.3						0.30						
27-Jul-11	0.6							0.60					
31-Aug-11	1.8								1.80				
28-Sep-11	0.9									0.90			
26-Oct-11	1										1.00		
30-Nov-11	0.2											0.20	
25-Jan-12	1.1	1.10											
29-Feb-12	1.7		1.70										
28-Mar-12	1.5			1.50									
25-Apr-12	0.8				0.80								
30-May-12	1.1					1.10							
27-Jun-12	0.2						0.20						
25-Jul-12	0.4							0.40					
29-Aug-12	0.2								0.20				
26-Sep-12	0.3									0.30			
31-Oct-12	0.2										0.20		
28-Nov-12	1.4											1.40	
30-Jan-13	2.2	2.20											
26-Feb-13	1.1		1.10										
27-Mar-13	0.5			0.50									
24-Apr-13	0.4				0.40								
29-May-13	1.5					1.50							
26-Jun-13	1.2						1.20						
07-Aug-13	1.5								1.50				
28-Aug-13	1								1.00				
25-Sep-13	1.1									1.10			

# of Samples	175	22	13	16	13	15	17	14	17	17	14	14	3
AVE	0.751	1.027	0.808	0.900	0.500	1.007	0.659	0.507	0.624	0.759	0.557	0.743	0.800
MIN	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2
MAX	4.8	4.8	3.2	1.6	0.8	3.2	1.2	0.9	1.8	1.5	1	1.5	1.2
50th	**0.6**	**0.6**	**0.6**	**0.55**	**0.5**	**0.8**	**0.7**	**0.6**	**0.4**	**0.8**	**0.45**	**0.65**	**1**
10th	0.2	0.2	0.2	0.45	0.2	0.5	0.2	0.23	0.2	0.36	0.3	0.23	0.36
25th	0.4	0.4	0.2	0.5	0.3	0.6	0.4	0.4	0.4	0.5	0.4	0.4	0.6
75th	**0.900**	**1.175**	**0.900**	**1.525**	**0.700**	**1.150**	**0.900**	**0.600**	**0.800**	**0.900**	**0.750**	**1.000**	**1.100**
90th	1.46	2.17	1.58	1.6	0.8	1.46	1	0.6	1.2	1.22	0.97	1.31	1.16

Raw Data		Monthly concentrations of E. coli in cts/100mL											
Sample	E. coli	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17-Sep-96	108									108.00			
15-Oct-96	12										12.00		
17-Dec-96	128												128.00
23-Jan-97	124	124.00											
18-Dec-97	16												16.00
24-Feb-98	20		20.00										
24-Mar-98	4			4.00									
23-Apr-98	20				20.00								
21-May-98	32					32.00							
17-Jun-98	160						160.00						
22-Jul-98	92							92.00					
20-Aug-98	60								60.00				
25-Sep-98	56									56.00			
27-Oct-98	4										4.00		
24-Nov-98	4											4.00	
25-Jan-99	52	52.00											
01-Mar-99	40			40.00									
29-Mar-99	4			4.00									
19-Apr-99	20				20.00								
27-May-99	24					24.00							
23-Jun-99	48						48.00						
23-Jul-99	92							92.00					
24-Aug-99	28								28.00				
30-Sep-99	556									556.00			
01-Nov-99	8											8.00	
25-Nov-99	16											16.00	
04-Jan-00	168	168.00											
03-Feb-00	4		4.00										
29-Feb-00	4		4.00										
30-Mar-00	80			80.00									
04-May-00	24					24.00							
30-May-00	20					20.00							
28-Jun-00	16						16.00						
26-Jul-00	56							56.00					
30-Aug-00	32								32.00				
28-Sep-00	16									16.00			
29-Nov-00	8											8.00	
03-Jan-01	4	4.00											
30-Jan-01	10	10.00											
27-Feb-01	20		20.00										
29-Mar-01	12			12.00									
30-Apr-01	12				12.00								
24-May-01	110					110.00							
26-Jun-01	120						120.00						
25-Jul-01	100							100.00					
29-Aug-01	92								92.00				
26-Sep-01	160									160.00			
25-Oct-01	64										64.00		
29-Nov-01	300											300.00	
03-Jan-02	4	4.00											
24-Jan-02	8	8.00											
04-Mar-02	8			8.00									
05-Jun-02	160						160.00						
26-Jun-02	100						100.00						
31-Jul-02	140							140.00					
28-Aug-02	48								48.00				
26-Sep-02	40									40.00			
30-Oct-02	4										4.00		
07-Jan-03	4	4.00											
30-Jan-03	4	4.00											
27-Mar-03	4			4.00									
01-May-03	220					220.00							
22-May-03	4					4.00							
26-Jun-03	140						140.00						
31-Jul-03	36							36.00					
28-Aug-03	32								32.00				
30-Sep-03	52									52.00			
30-Oct-03	36										36.00		
27-Nov-03	12											12.00	
08-Jan-04	4	4.00											
25-Feb-04	190		190.00										
30-Mar-04	76			76.00									
28-Apr-04	16				16.00								
26-May-04	110					110.00							
29-Jun-04	110						110.00						
28-Jul-04	190							190.00					
31-Aug-04	230								230.00				
23-Sep-04	120									120.00			

Raw Data		Monthly concentrations of E. coli in cts/100mL											
Sample	E. coli	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
27-Oct-04	12										12.00		
30-Nov-04	20											20.00	
10-Jan-05	16	16.00											
27-Jan-05	4	4.00											
24-Feb-05	4		4.00										
31-Mar-05	80			80.00									
28-Apr-05	12				12.00								
26-May-05	48					48.00							
29-Jun-05	410						410.00						
28-Jul-05	100							100.00					
31-Aug-05	720								720.00				
29-Sep-05	210									210.00			
27-Oct-05	36										36.00		
30-Nov-05	300											300.00	
05-Jan-06	100	100.00											
26-Jan-06	10	10.00											
22-Feb-06	10		10.00										
30-Mar-06	10			10.00									
27-Apr-06	50				50.00								
25-May-06	20					20.00							
29-Jun-06	170						170.00						
27-Jul-06	240							240.00					
31-Aug-06	130								130.00				
28-Sep-06	450									450.00			
25-Oct-06	230										230.00		
28-Nov-06	100											100.00	
04-Jan-07	24	24.00											
31-Jan-07	4	4.00											
28-Feb-07	4		4.00										
28-Mar-07	4			4.00									
25-Apr-07	60				60.00								
30-May-07	56					56.00							
26-Jun-07	110						110.00						
25-Jul-07	120							120.00					
29-Aug-07	120								120.00				
26-Sep-07	760									760.00			
31-Oct-07	28										28.00		
26-Nov-07	52											52.00	
03-Jan-08	12	12.00											
31-Jan-08	8	8.00											
27-Feb-08	4		4.00										
26-Mar-08	32			32.00									
29-Apr-08	52				52.00								
28-May-08	32					32.00							
25-Jun-08	40						40.00						
30-Jul-08	820							820.00					
27-Aug-08	72								72.00				
30-Sep-08	500									500.00			
29-Oct-08	16										16.00		
26-Nov-08	12											12.00	
07-Jan-09	4	4.00											
29-Jan-09	20	20.00											
25-Feb-09	8		8.00										
25-Mar-09	24			24.00									
29-Apr-09	28				28.00								
27-May-09	280					280.00							
24-Jun-09	44						44.00						
29-Jul-09	140							140.00					
26-Aug-09	44								44.00				
30-Sep-09	300									300.00			
28-Oct-09	20										20.00		
25-Nov-09	52											52.00	
06-Jan-10	4	4.00											
24-Feb-10	4		4.00										
31-Mar-10	4			4.00									
28-Apr-10	32				32.00								
26-May-10	76					76.00							
30-Jun-10	60						60.00						
28-Jul-10	96							96.00					
25-Aug-10	64								64.00				
29-Sep-10	930									930.00			
27-Oct-10	60										60.00		
24-Nov-10	52											52.00	
05-Jan-11	4	4.00											
23-Feb-11	12		12.00										
30-Mar-11	4			4.00									
27-Apr-11	64				64.00								
25-May-11	76					76.00							

Raw Data		Monthly concentrations of E. coli in cts/100mL											
Sample	E. coli	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
29-Jun-11	150						150.00						
27-Jul-11	160							160.00					
31-Aug-11	48								48.00				
28-Sep-11	56									56.00			
26-Oct-11	240										240.00		
30-Nov-11	380											380.00	
25-Jan-12	28	28.00											
29-Feb-12	60		60.00										
28-Mar-12	28			28.00									
25-Apr-12	60				60.00								
30-May-12	56					56.00							
27-Jun-12	88						88.00						
25-Jul-12	130							130.00					
29-Aug-12	64								64.00				
26-Sep-12	32									32.00			
31-Oct-12	160										160.00		
28-Nov-12	24											24.00	
30-Jan-13	110	110.00											
26-Feb-13	56		56.00										
27-Mar-13	88			88.00									
24-Apr-13	8				8.00								
29-May-13	1400					1400.00							
26-Jun-13	96						96.00						
07-Aug-13	72								72.00				
28-Aug-13	130								130.00				
25-Sep-13	72									72.00			

# of Samples	182	24	14	17	13	17	17	15	17	17	14	15	2
Geomean	**39.69**	**12.49**	**11.79**	**15.34**	**26.95**	**57.64**	**94.36**	**125.44**	**76.88**	**139.23**	**31.40**	**34.86**	**45.25**
MIN	4.00	4.00	4.00	4.00	8.00	4.00	16.00	36.00	28.00	16.00	4.00	4.00	16.00
MAX	1400.00	168.00	190.00	88.00	64.00	1400.00	410.00	820.00	720.00	930.00	240.00	380.00	128.00
50th	49.00	9.00	9.00	12.00	28.00	56.00	110.00	120.00	64.00	120.00	32.00	24.00	72.00
10th	4.00	4.00	4.00	4.00	12.00	20.00	42.40	70.40	32.00	36.80	6.40	8.00	27.20
25th	13.00	4.00	4.00	4.00	16.00	24.00	60.00	94.00	48.00	56.00	13.00	12.00	44.00
75th	110.00	25.00	20.00	40.00	52.00	110.00	150.00	150.00	120.00	450.00	63.00	76.00	100.00
90th	219.00	107.00	58.80	80.00	60.00	244.00	164.00	220.00	170.00	637.60	209.00	300.00	116.80

Date	T. Ammonia NH_3+NH_4 (mg/L)	Monthly concentrations of T. Ammonia in mg/L										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
24-May-01	0.008					0.008						
26-Jun-01	0.002						0.002					
25-Jul-01	0.008							0.008				
29-Aug-01	0.002								0.002			
25-Oct-01	0.004										0.004	
29-Nov-01	0.014											0.014
03-Jan-02	0.012	0.012										
24-Jan-02	0.008	0.008										
04-Mar-02	0.002			0.002								
05-Jun-02	0.002						0.002					
26-Jun-02	0.009						0.009					
31-Jul-02	0.002							0.002				
28-Aug-02	0.006								0.006			
26-Sep-02	0.002									0.002		
30-Oct-02	0.002										0.002	
27-Nov-02	0.007											0.007
07-Jan-03	0.007	0.007										
27-Mar-03	0.042			0.042								
01-May-03	0.012					0.012						
22-May-03	0.016					0.016						
26-Jun-03	0.002						0.002					
31-Jul-03	0.011							0.011				
28-Aug-03	0.020								0.020			
30-Sep-03	0.004									0.004		
30-Oct-03	0.003										0.003	
27-Nov-03	0.002											0.002
08-Jan-04	0.009	0.009										
25-Feb-04	0.013		0.013									
30-Mar-04	0.022			0.022								
28-Apr-04	0.010				0.010							
26-May-04	0.009					0.009						
29-Jun-04	0.003						0.003					
28-Jul-04	0.002							0.002				
31-Aug-04	0.003								0.003			
23-Sep-04	0.004									0.004		
27-Oct-04	0.002										0.002	
30-Nov-04	0.002											0.002
10-Jan-05	0.012	0.012										
27-Jan-05	0.031	0.031										
24-Feb-05	0.006		0.006									
31-Mar-05	0.022			0.022								
28-Apr-05	0.004				0.004							
26-May-05	0.002					0.002						
29-Jun-05	0.002						0.002					
28-Jul-05	0.002							0.002				
31-Aug-05	0.002								0.002			
29-Sep-05	0.010									0.010		
27-Oct-05	0.002										0.002	
30-Nov-05	0.002											0.002
05-Jan-06	0.020	0.020										
29-Jun-06	0.004						0.004					
27-Jul-06	0.011							0.011				
31-Aug-06	0.002								0.002			
28-Sep-06	0.013									0.013		

Date	T. Ammonia NH_3+NH_4 (mg/L)	Monthly concentrations of T. Ammonia in mg/L										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
25-Oct-06	0.002										0.002	
28-Nov-06	0.016											0.016
04-Jan-07	0.005	0.005										
31-Jan-07	0.024	0.024										
28-Feb-07	0.021		0.021									
28-Mar-07	0.018			0.018								
25-Apr-07	0.022				0.022							
30-May-07	0.013					0.013						
26-Jun-07	0.020						0.020					
25-Jul-07	0.002							0.002				
29-Aug-07	0.007								0.007			
26-Sep-07	0.002									0.002		
31-Oct-07	0.002										0.002	
26-Nov-07	0.005											0.005
03-Jan-08	0.012	0.012										
31-Jan-08	0.005	0.005										
27-Feb-08	0.002		0.002									
26-Mar-08	0.002			0.002								
29-Apr-08	0.003				0.003							
28-May-08	0.002					0.002						
25-Jun-08	0.002						0.002					
30-Jul-08	0.010							0.010				
27-Aug-08	0.010								0.010			
30-Sep-08	0.013									0.013		
29-Oct-08	0.010										0.010	
26-Nov-08	0.011											0.011
07-Jan-09	0.018	0.018										
29-Jan-09	0.033	0.033										
25-Feb-09	0.019		0.019									
25-Mar-09	0.012			0.012								
29-Apr-09	0.006				0.006							
27-May-09	0.015					0.015						
24-Jun-09	0.017						0.017					
29-Jul-09	0.022							0.022				
26-Aug-09	0.002								0.002			
30-Sep-09	0.011									0.011		
28-Oct-09	0.002										0.002	
25-Nov-09	0.012											0.012
06-Jan-10	0.026	0.026										
24-Feb-10	0.020		0.020									
31-Mar-10	0.014			0.014								
28-Apr-10	0.010				0.010							
26-May-10	0.018					0.018						
30-Jun-10	0.037						0.037					
28-Jul-10	0.025							0.025				
25-Aug-10	0.019								0.019			
29-Sep-10	0.014									0.014		
27-Oct-10	0.018										0.018	
24-Nov-10	0.016											0.016
05-Jan-11	0.032	0.032										
23-Feb-11	0.037		0.037									
30-Mar-11	0.025			0.025								
27-Apr-11	0.030				0.030							
25-May-11	0.019					0.019						
29-Jun-11	0.013						0.013					
27-Jul-11	0.024							0.024				
31-Aug-11	0.016								0.016			
28-Sep-11	0.002									0.002		
26-Oct-11	0.020										0.020	
30-Nov-11	0.017											0.017
25-Jan-12	0.031	0.031										
29-Feb-12	0.012		0.012									
28-Mar-12	0.005			0.005								
25-Apr-12	0.013				0.013							
30-May-12	0.010					0.010						
27-Jun-12	0.013						0.013					
25-Jul-12	0.021							0.021				
29-Aug-12	0.010								0.010			
26-Sep-12	0.016									0.016		
31-Oct-12	0.019										0.019	
28-Nov-12	0.020											0.020

Date	T. Ammonia NH_3+NH_4 (mg/L)	Monthly concentrations of T. Ammonia in mg/L										
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
30-Jan-13	0.097	0.097										
26-Feb-13	0.070		0.070									
27-Mar-13	0.011			0.011								
24-Apr-13	0.017				0.017							
29-May-13	0.021					0.021						
26-Jun-13	0.117						0.117					
07-Aug-13	0.035								0.035			
28-Aug-13	0.030								0.030			
25-Sep-13	0.023									0.023		

# of Samples	134	17	9	11	9	12	14	12	14	12	12	12
AVE	0.014	0.022	0.022	0.016	0.013	0.012	0.017	0.012	0.012	0.010	0.007	0.010
MIN	0.002	0.005	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002
MAX	0.117	0.097	0.070	0.042	0.030	0.021	0.117	0.025	0.035	0.023	0.020	0.020
50th	0.011	0.018	0.019	0.014	0.010	0.013	0.007	0.011	0.009	0.011	0.003	0.012
10th	0.002	0.006	0.005	0.002	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.002
25th	0.003	0.009	0.012	0.008	0.006	0.009	0.002	0.002	0.002	0.004	0.002	0.004
75th	**0.019**	**0.031**	**0.021**	**0.022**	**0.017**	**0.017**	**0.016**	**0.021**	**0.018**	**0.013**	**0.012**	**0.016**
90th	0.026	0.032	0.044	0.025	0.024	0.019	0.032	0.024	0.027	0.016	0.019	0.017

Date	Field pH	Monthly concentrations of pH										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
24-May-01	8.08					8.080						
26-Jun-01	7.96						7.960					
25-Jul-01	7.96							7.960				
29-Aug-01	8.16								8.160			
25-Oct-01	7.95										7.950	
29-Nov-01	8											8.000
03-Jan-02	8.17	8.170										
24-Jan-02	8.12	8.120										
04-Mar-02	8.13			8.130								
05-Jun-02	7.8						7.800					
26-Jun-02	8.2						8.200					
31-Jul-02	7.88							7.880				
28-Aug-02	8.01								8.010			
26-Sep-02	8									8.000		
30-Oct-02	8.15										8.150	
27-Nov-02	8.16											8.160
07-Jan-03	8.2	8.200										
27-Mar-03	7.59			7.590								
01-May-03	8.07					8.070						
22-May-03	8.16					8.160						
26-Jun-03	8.32						8.320					
31-Jul-03	8.23							8.230				
28-Aug-03	8.28								8.280			
30-Sep-03	8.22									8.220		
30-Oct-03	8.36										8.360	
27-Nov-03	8.16											8.160
08-Jan-04	8.14	8.140										
25-Feb-04	8.19		8.190									
30-Mar-04	8.02			8.020								
28-Apr-04	8.08				8.080							
26-May-04	7.96					7.960						
29-Jun-04	8.17						8.170					
28-Jul-04	8.13							8.130				
31-Aug-04	8.12								8.120			
23-Sep-04	8.18									8.180		
27-Oct-04	8.09										8.090	
30-Nov-04	8.11											8.110
10-Jan-05	8.51	8.510										
27-Jan-05	7.76	7.760										
24-Feb-05	8.04		8.040									
31-Mar-05	7.78			7.780								
28-Apr-05	7.97				7.970							
26-May-05	7.99					7.990						
29-Jun-05	8.52						8.520					
28-Jul-05	7.31							7.310				
31-Aug-05	7.18								7.180			
29-Sep-05	7.48									7.480		
27-Oct-05	7.99										7.990	
30-Nov-05	7.45											7.450
05-Jan-06	7.76	7.760										
29-Jun-06	7.68						7.680					
27-Jul-06	7.34							7.340				
31-Aug-06	7.57								7.570			
28-Sep-06	7.75									7.750		
25-Oct-06	7.88										7.880	
28-Nov-06	7.79											7.790
04-Jan-07	8.09	8.090										
31-Jan-07	7.89	7.890										

Date	Field pH	Monthly concentrations of pH										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
28-Feb-07	7.94		7.940									
28-Mar-07	7.83			7.830								
25-Apr-07	7.98				7.980							
30-May-07	8.03					8.030						
26-Jun-07	8.08						8.080					
25-Jul-07	8.07							8.070				
29-Aug-07	8.14								8.140			
26-Sep-07	8.04									8.040		
31-Oct-07	8.06										8.060	
26-Nov-07	7.96											7.960
03-Jan-08	8.88	8.880										
31-Jan-08	7.59	7.590										
27-Feb-08	7.79		7.790									
26-Mar-08	7.7			7.700								
29-Apr-08	7.43				7.430							
28-May-08	7.76					7.760						
25-Jun-08	7.88						7.880					
30-Jul-08	7.44							7.440				
27-Aug-08	7.82								7.820			
30-Sep-08	7.71									7.710		
29-Oct-08	7.76										7.760	
26-Nov-08	8.08											8.080
07-Jan-09	7.47	7.470										
29-Jan-09	7.58	7.580										
25-Feb-09	7.88		7.880									
25-Mar-09	7.49			7.490								
29-Apr-09	7.87				7.870							
27-May-09	8					8.000						
24-Jun-09	8.16						8.160					
29-Jul-09	7.84							7.840				
26-Aug-09	8.17								8.170			
30-Sep-09	8.03									8.030		
28-Oct-09	7.98										7.980	
25-Nov-09	8.04											8.040
06-Jan-10	7.93	7.930										
24-Feb-10	8.01		8.010									
31-Mar-10	7.65			7.650								
28-Apr-10	8				8.000							
26-May-10	8.13					8.130						
30-Jun-10	8.04						8.040					
28-Jul-10	8.2							8.200				
25-Aug-10	8.09								8.090			
29-Sep-10	7.8									7.800		
27-Oct-10	7.74										7.740	
24-Nov-10	7.82											7.820
05-Jan-11	8.27	8.270										
23-Feb-11	8.18		8.180									
30-Mar-11	8.09			8.090								
27-Apr-11	8.06				8.060							
25-May-11	12.38					12.380						
29-Jun-11	8.14						8.140					
27-Jul-11	8.07							8.070				
31-Aug-11	8.19								8.190			
28-Sep-11	8.16									8.160		
26-Oct-11	7.95										7.950	
30-Nov-11	7.85											7.850
25-Jan-12	8.12	8.120										
29-Feb-12	7.92		7.920									
28-Mar-12	7.69			7.690								
25-Apr-12	7.62				7.620							
30-May-12	7.97					7.970						
27-Jun-12	7.94						7.940					
25-Jul-12	7.97							7.970				
29-Aug-12	7.85								7.850			
26-Sep-12	7.96									7.960		
31-Oct-12	7.74										7.740	
28-Nov-12	8.05											8.050
30-Jan-13	7.76	7.760										
26-Feb-13	7.85		7.850									
27-Mar-13	7.95			7.950								
24-Apr-13	7.85				7.850							

Date	Field pH	Monthly concentrations of pH										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
29-May-13	7.7					7.700						
07-Aug-13	7.96								7.960			
28-Aug-13	8.01								8.010			
25-Sep-13	8.12									8.120		

# of Samples	133	17	9	11	9	12	13	12	14	12	12	12
AVE	7.989	8.014	7.978	7.811	7.873	8.353	8.068	7.870	7.968	7.954	7.971	7.956
MIN	7.18	7.470	7.790	7.490	7.430	7.700	7.680	7.310	7.180	7.480	7.740	7.450
MAX	12.38	8.880	8.190	8.130	8.080	12.380	8.520	8.230	8.280	8.220	8.360	8.160
50th	**7.99**	**8.090**	**7.940**	**7.780**	**7.970**	**8.015**	**8.080**	**7.965**	**8.050**	**8.015**	**7.965**	**8.020**
10th	7.626	7.586	7.838	7.590	7.582	7.780	7.816	7.350	7.645	7.714	7.742	7.793
25th	7.820	7.760	7.880	7.670	7.850	7.968	7.940	7.740	7.878	7.788	7.850	7.843
75th	**8.120**	**8.170**	**8.040**	**7.985**	**8.000**	**8.093**	**8.170**	**8.085**	**8.155**	**8.130**	**8.068**	**8.088**
90th	8.19	8.366	8.182	8.090	8.064	8.157	8.296	8.193	8.184	8.178	8.144	8.155

Date	Field Water temperature	Monthly field water temperature (Celsius)										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
24-May-01	13.4					13.400						
26-Jun-01	17.1						17.100					
25-Jul-01	18.1							18.100				
29-Aug-01	15.4								15.400			
25-Oct-01	9.6										9.600	
29-Nov-01	3.4											3.400
03-Jan-02	0.9	0.900										
24-Jan-02	1.7	1.700										
04-Mar-02	3.9			3.900								
05-Jun-02	12.6						12.600					
26-Jun-02	20.2						20.200					
31-Jul-02	20.2							20.200				
28-Aug-02	16.8								16.800			
26-Sep-02	14.4									14.400		
30-Oct-02	4.5										4.500	
27-Nov-02	1.3											1.300
07-Jan-03	6	6.000										
27-Mar-03	3			3.000								
01-May-03	9.3					9.300						
22-May-03	11					11.000						
26-Jun-03	21						21.000					
31-Jul-03	17.3							17.300				
28-Aug-03	14.6								14.600			
30-Sep-03	8.6									8.600		
30-Oct-03	7										7.000	
27-Nov-03	3.2											3.200
08-Jan-04	6.1	6.100										
25-Feb-04	0.4		0.400									
30-Mar-04	5.1			5.100								
28-Apr-04	5.7				5.700							
26-May-04	12.9					12.900						
29-Jun-04	13.8						13.800					
28-Jul-04	15.5							15.500				
31-Aug-04	15.3								15.300			
23-Sep-04	13.7									13.700		
27-Oct-04	9.1										9.100	
30-Nov-04	2.7											2.700
10-Jan-05	1.6	1.600										
27-Jan-05	0.3	0.300										
24-Feb-05	0.1		0.100									
31-Mar-05	1.7			1.700								
28-Apr-05	6.1				6.100							
26-May-05	13.7					13.700						
29-Jun-05	20.2						20.200					
28-Jul-05	15.6							15.600				
31-Aug-05	17.6								17.600			
29-Sep-05	12.7									12.700		
27-Oct-05	6.4										6.400	
30-Nov-05	2.6											2.600
05-Jan-06	1.6	1.600										
29-Jun-06	16.3						16.300					
27-Jul-06	19.2							19.200				
31-Aug-06	14								14.000			
28-Sep-06	12.2									12.200		
25-Oct-06	5.8										5.800	
28-Nov-06	6.9											6.900

Date	Field Water temperature	Monthly field water temperature (Celsius)										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
04-Jan-07	2.7	2.700										
31-Jan-07	0.8	0.800										
28-Feb-07	2.0		2.000									
28-Mar-07	3.0			3.000								
25-Apr-07	9.1				9.100							
30-May-07	15.5					15.500						
26-Jun-07	18.4						18.400					
25-Jul-07	16.6							16.600				
29-Aug-07	18.2								18.200			
26-Sep-07	16.9									16.900		
31-Oct-07	8.5										8.500	
26-Nov-07	3.1											3.100
03-Jan-08	0.1	0.100										
31-Jan-08	0.7	0.700										
27-Feb-08	0.7		0.700									
26-Mar-08	2.1			2.100								
29-Apr-08	7.6				7.600							
28-May-08	10.8					10.800						
25-Jun-08	15.2						15.200					
30-Jul-08	16.5							16.500				
27-Aug-08	13.4								13.400			
30-Sep-08	12.6									12.600		
29-Oct-08	4.4										4.400	
26-Nov-08	2.5											2.500
07-Jan-09	1.5	1.500										
29-Jan-09	1.1	1.100										
25-Feb-09	1.4		1.400									
25-Mar-09	3.2			3.200								
29-Apr-09	5.5				5.500							
27-May-09	11.7					11.700						
24-Jun-09	17.2						17.200					
29-Jul-09	16.9							16.900				
26-Aug-09	16.7								16.700			
30-Sep-09	10.7									10.700		
28-Oct-09	9										9.000	
25-Nov-09	7.3											7.300
06-Jan-10	1	1.000										
24-Feb-10	1.8		1.800									
31-Mar-10	5.2			5.200								
28-Apr-10	8.1				8.100							
26-May-10	17.8					17.800						
30-Jun-10	14.4						14.400					
28-Jul-10	18.4							18.400				
25-Aug-10	15.5								15.500			
29-Sep-10	12.5									12.500		
27-Oct-10	10.4										10.400	
24-Nov-10	3.7											3.700
05-Jan-11	0.8	0.800										
23-Feb-11	0.1		0.100									
30-Mar-11	2.4			2.400								
27-Apr-11	8.3				8.300							
25-May-11	12.4					12.400						
29-Jun-11	14.4						14.400					
27-Jul-11	16.8							16.800				
31-Aug-11	15.1								15.100			
28-Sep-11	15.3									15.300		
26-Oct-11	7.4										7.400	
30-Nov-11	3.5											3.500
25-Jan-12	0.9	0.900										
29-Feb-12	1.5		1.500									
28-Mar-12	6.5			6.500								
25-Apr-12	4.9				4.900							
30-May-12	13.7					13.700						
27-Jun-12	14.5						14.500					
25-Jul-12	15.1							15.100				
29-Aug-12	14.1								14.100			
26-Sep-12	12.1									12.100		
31-Oct-12	6.7										6.700	
28-Nov-12	1.5											1.500
30-Jan-13	1.3	1.300										
26-Feb-13	1.2		1.200									

Date	Field Water temperature	Monthly field water temperature (Celsius)										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
27-Mar-13	2.1			2.100								
24-Apr-13	8.2				8.200							
29-May-13	12.7					12.700						
07-Aug-13	15.8								15.800			
28-Aug-13	17.5								17.500			
25-Sep-13	9									9.000		

# of Samples	133	17	9	11	9	12	13	12	14	12	12	12
AVE	9.155	1.712	1.022	3.473	7.056	12.908	16.562	17.183	15.714	12.558	7.400	3.475
MIN	0.1	0.100	0.100	1.700	4.900	9.300	12.600	15.100	13.400	8.600	4.400	1.300
MAX	21	6.100	2.000	6.500	9.100	17.800	21.000	20.200	18.200	16.900	10.400	7.300
50th	**9**	**1.100**	**1.200**	**3.000**	**7.600**	**12.800**	**16.300**	**16.850**	**15.450**	**12.550**	**7.200**	**3.150**
10th	1.22	0.540	0.100	2.100	5.380	10.820	13.920	15.510	14.030	9.170	4.630	1.600
25th	3	0.800	0.400	2.250	5.700	11.525	14.400	16.275	14.725	11.750	6.250	2.575
75th	**15.100**	**1.600**	**1.500**	**4.500**	**8.200**	**13.700**	**18.400**	**18.175**	**16.775**	**13.875**	**9.025**	**3.550**
90th	17.18	4.020	1.840	5.200	8.460	15.320	20.200	19.120	17.570	15.210	9.550	6.580

Raw Data		Monthly concentrations of DO in mg/L											
Sample	**DO**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2002-01-03	13.70	13.70											
2002-01-24	12.70	12.70											
2002-03-04	12.30			12.30									
2002-06-05	9.90						9.90						
2002-06-26	9.60						9.60						
2002-07-31	9.70							9.70					
2002-08-28	11.00								11.00				
2002-09-26	10.40									10.40			
2002-10-30	12.20										12.20		
2002-11-27	14.40											14.40	
2003-01-07	12.40	12.40											
2003-03-27	13.70			13.70									
2003-05-01	11.20					11.20							
2003-05-22	11.90					11.90							
2003-06-26	10.83						10.83						
2003-07-31	10.99							10.99					
2003-08-28	11.88								11.88				
2003-09-30	12.28									12.28			
2003-10-30	14.28										14.28		
2003-11-27	14.00											14.00	
2004-01-08	14.97	14.97											
2004-02-25	15.19		15.19										
2004-03-30	12.40			12.40									
2004-04-28	12.72				12.72								
2004-05-26	10.52					10.52							
2004-06-29	10.95						10.95						
2004-07-28	10.75							10.75					
2004-08-31	10.72								10.72				
2004-09-23	11.20									11.20			
2004-10-27	12.34										12.34		
2004-11-30	12.70											12.70	
2005-01-27	12.50	12.50											
2005-02-24	16.50		16.50										
2005-03-31	11.90			11.90									
2005-04-28	11.30				11.30								
2005-05-26	10.80					10.80							
2005-06-29	9.28						9.28						
2005-07-28	8.14							8.14					
2005-08-31	9.99								9.99				
2005-09-29	10.61									10.61			
2005-10-27	13.29										13.29		
2005-11-30	15.36											15.36	
2006-01-05	13.10	13.10											
2006-06-29	10.03						10.03						
2006-07-27	9.91							9.91					
2006-08-31	11.92								11.92				
2006-09-28	10.69									10.69			
2006-10-25	13.31										13.31		
2006-11-28	12.00											12.00	
2007-01-04	14.52	14.52											
2007-01-31	15.63	15.63											
2007-02-28	15.92		15.92										
2007-03-28	14.65			14.65									
2007-04-25	12.45				12.45								
2007-05-30	11.12					11.12							
2007-06-26	10.06						10.06						
2007-07-25	10.74							10.74					
2007-08-29	10.47								10.47				
2007-09-26	10.27									10.27			
2007-10-31	10.92										10.92		
2007-11-26	11.02											11.02	
2008-01-03	14.01	14.01											
2008-01-31	15.84	15.84											
2008-02-27	16.01		16.01										
2008-03-26	14.86			14.86									
2008-04-29	12.32				12.32								
2008-05-28	12.31					12.31							
2008-06-25	11.01						11.01						
2008-07-30	9.42							9.42					
2008-08-27	11.34								11.34				
2008-09-30	11.22									11.22			
2008-10-29	13.93										13.93		
2008-11-26	12.90											12.90	
2009-01-07	13.83	13.83											
2009-01-29	13.89	13.89											
2009-02-25	13.42		13.42										
2009-03-25	14.44			14.44									

Raw Data		Monthly concentrations of DO in mg/L											
Sample	DO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009-04-29	10.90				10.90								
2009-05-27	10.56					10.56							
2009-06-24	10.53						10.53						
2009-07-29	9.68							9.68					
2009-08-26	10.92								10.92				
2009-09-30	11.19									11.19			
2009-10-28	11.56										11.56		
2009-11-25	11.47											11.47	
2009-01-07	13.83	13.83											
2009-01-29	13.89	13.89											
2009-02-25	13.42		13.42										
2009-03-25	14.44			14.44									
2009-04-29	10.90				10.90								
2009-05-27	10.56					10.56							
2009-06-24	10.53						10.53						
2009-07-29	9.68							9.68					
2009-08-26	10.92								10.92				
2009-09-30	11.19									11.19			
2009-10-28	11.56										11.56		
2009-11-25	11.47											11.47	
2010-01-06	14.84	14.84											
2010-02-24	15.03		15.03										
2010-04-28	11.40				11.40								
2010-03-31	13.91			13.91									
2010-05-26	10.38					10.38							
2010-06-30	13.00						13.00						
2010-07-28	13.02							13.02					
2010-08-25	11.59								11.59				
2010-09-29	10.59									10.59			
2010-10-27	11.01										11.01		
2010-11-24	13.78											13.78	
2011-01-05	14.80	14.80											
2011-02-23	14.40		14.40										
2011-04-27	11.63				11.63								
2011-03-30	14.32			14.32									
2011-05-25	10.75					10.75							
2011-06-29	10.76						10.76						
2011-07-27	9.30							9.30					
2011-08-31	11.29								11.29				
2011-10-26	11.60										11.60		
2011-09-28	8.16									8.16			
2011-11-30	10.53											10.53	
2012-01-25	14.71	14.71											
2012-02-29	15.68		15.68										
2012-03-28	14.27			14.27									
2012-04-25	12.96				12.96								
2012-05-30	9.64					9.64							
2012-06-27	9.76						9.76						
2012-07-25	9.54							9.54					
2012-08-29	9.11								9.11				
2012-09-26	9.73									9.73			
2012-10-31	11.15										11.15		
2012-11-28	12.70											12.70	
2013-01-30	12.73	12.73											
2013-02-26	13.01		13.01										
2013-03-27	12.95			12.95									
2013-04-24	10.61				10.61								
2013-05-29	9.70					9.70							
2013-08-07	9.23								9.23				
2013-08-28	8.35								8.35				
2013-09-25	10.48									10.48			

# of Samples	138	18	10	12	10	12	13	12	14	13	12	12	
AVE	11.99	13.99	14.86	13.68	11.72	10.79	10.48	10.07	10.62	10.62	12.26	12.69	
MIN	8.14	12.40	13.01	11.90	10.61	9.64	9.28	8.14	8.35	8.16	10.92	10.53	
MAX	16.50	15.84	16.50	14.86	12.96	12.31	13.00	13.02	11.92	12.28	14.28	15.36	
50th	11.56	13.89	15.11	14.09	11.52	10.66	10.53	9.69	10.92	10.61	11.90	12.70	
10th	9.70	12.64	13.38	12.31	10.87	9.77	9.63	9.31	9.15	9.84	11.02	11.07	
25th	**10.61**	**13.25**	**13.67**	**12.81**	**11.00**	**10.49**	**9.90**	**9.51**	**10.11**	**10.40**	**11.46**	**11.47**	
75th	13.42	14.78	15.86	14.44	12.42	11.14	10.83	10.74	11.33	11.19	13.30	13.84	
90th	14.67	15.17	16.06	14.63	12.74	11.83	11.00	10.97	11.79	11.22	13.87	14.36	

Raw Data		Monthly concentrations of TSS in mg/L											
Sample	TSS / RSP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17-Sep-96	3									3.00			
15-Oct-96	2										2.00		
17-Dec-96	26												26.00
23-Jan-97	24	24.00											
18-Dec-97	1.5												1.50
24-Feb-98	1.5		1.50										
24-Mar-98	3.5			3.50									
23-Apr-98	2.5				2.50								
21-May-98	3					3.00							
17-Jun-98	5						5.00						
22-Jul-98	2							2.00					
20-Aug-98	1.5								1.50				
25-Sep-98	0.5									0.50			
27-Oct-98	1.5										1.50		
24-Nov-98	1.5											1.50	
18-Dec-98	1.5												1.50
25-Jan-99	14	14.00											
01-Mar-99	10.5			10.50									
29-Mar-99	2			2.00									
19-Apr-99	2				2.00								
27-May-99	7					7.00							
23-Jun-99	2.5						2.50						
23-Jul-99	2							2.00					
24-Aug-99	1.5								1.50				
30-Sep-99	3									3.00			
01-Nov-99	1											1.00	
25-Nov-99	1											1.00	
04-Jan-00	10	10.00											
03-Feb-00	9		9.00										
29-Feb-00	5.5		5.50										
30-Mar-00	2			2.00									
04-May-00	2.5					2.50							
30-May-00	2					2.00							
28-Jun-00	4						4.00						
26-Jul-00	1.5							1.50					
30-Aug-00	1.5								1.50				
28-Sep-00	1									1.00			
29-Nov-00	1.5											1.50	
03-Jan-01	2.5	2.50											
30-Jan-01	3	3.00											
27-Feb-01	3.5		3.50										
29-Mar-01	2			2.00									
30-Apr-01	3				3.00								
24-May-01	5.5					5.50							
26-Jun-01	2.5						2.50						
25-Jul-01	2.5							2.50					
29-Aug-01	3								3.00				
26-Sep-01	2									2.00			
25-Oct-01	2										2.00		
29-Nov-01	3											3.00	
03-Jan-02	2.5	2.50											
24-Jan-02	1	1.00											
04-Mar-02	4.5			4.50									
05-Jun-02	5.2						5.20						
26-Jun-02	13.5						13.50						
31-Jul-02	3.5							3.50					
28-Aug-02	1.1								1.10				
26-Sep-02	0.5									0.50			
30-Oct-02	1										1.00		
07-Jan-03	2	2.00											
30-Jan-03	3.3	3.30											
27-Mar-03	4			4.00									
01-May-03	6.3					6.30							
22-May-03	2.3					2.30							
26-Jun-03	2.3						2.30						
31-Jul-03	2.1							2.10					
28-Aug-03	0.8								0.80				
30-Sep-03	1.8									1.80			
30-Oct-03	1.2										1.20		
27-Nov-03	1.3											1.30	
08-Jan-04	2.1	2.10											
25-Feb-04	18.1		18.10										

Raw Data		Monthly concentrations of TSS in mg/L											
Sample	TSS / RSP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
30-Mar-04	9.9			9.90									
28-Apr-04	2.2				2.20								
26-May-04	4.5					4.50							
29-Jun-04	1.8						1.80						
28-Jul-04	1.7							1.70					
31-Aug-04	4.8								4.80				
23-Sep-04	0.5									0.50			
27-Oct-04	0.6										0.60		
30-Nov-04	1.6											1.60	
10-Jan-05	1.9	1.90											
27-Jan-05	5.6	5.60											
24-Feb-05	5.8		5.80										
31-Mar-05	6.9			6.90									
28-Apr-05	3.2				3.20								
26-May-05	2.9					2.90							
29-Jun-05	7.4						7.40						
28-Jul-05	1.7							1.70					
31-Aug-05	5.9								5.90				
29-Sep-05	3.5									3.50			
27-Oct-05	0.6										0.60		
30-Nov-05	9.9											9.90	
26-Jan-06	3	3.00											
22-Feb-06	1		1.00										
30-Mar-06	1			1.00									
27-Apr-06	3				3.00								
25-May-06	1					1.00							
29-Jun-06	2.8						2.80						
27-Jul-06	5.8							5.80					
31-Aug-06	1.1								1.10				
28-Sep-06	8.2									8.20			
25-Oct-06	1.1										1.10		
28-Nov-06	1.2											1.20	
04-Jan-07	1.4	1.40											
31-Jan-07	2.3	2.30											
28-Feb-07	2.1		2.10										
28-Mar-07	3.6			3.60									
25-Apr-07	3.1				3.10								
30-May-07	3.2					3.20							
26-Jun-07	3.3						3.30						
25-Jul-07	2.2							2.20					
29-Aug-07	1.3								1.30				
26-Sep-07	2.1									2.10			
31-Oct-07	0.6										0.60		
26-Nov-07	0.9											0.90	
03-Jan-08	3.9	3.90											
31-Jan-08	3.7	3.70											
27-Feb-08	1.8		1.80										
26-Mar-08	1.7			1.70									
29-Apr-08	2.2				2.20								
28-May-08	2.2					2.20							
25-Jun-08	3.6						3.60						
30-Jul-08	7.0							7.00					
27-Aug-08	1.3								1.30				
30-Sep-08	2.2									2.20			
29-Oct-08	0.7										0.70		
26-Nov-08	3.4											3.40	
07-Jan-09	1.1	1.10											
29-Jan-09	5.0	5.00											
25-Feb-09	2.3		2.30										
25-Mar-09	1.2			1.20									
29-Apr-09	3.5				3.50								
27-May-09	6.4					6.40							
24-Jun-09	4.2						4.20						
29-Jul-09	4.4							4.40					
26-Aug-09	1.1								1.10				
30-Sep-09	2.1									2.10			
28-Oct-09	1.0										1.00		
25-Nov-09	1.6											1.60	
06-Jan-10	2.1	2.10											
24-Feb-10	1.3		1.30										
31-Mar-10	2.5			2.50									
28-Apr-10	2.1				2.10								

Raw Data		Monthly concentrations of TSS in mg/L											
Sample	TSS / RSP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26-May-10	5.1					5.10							
30-Jun-10	4.4						4.40						
28-Jul-10	2.7							2.70					
25-Aug-10	0.9								0.90				
29-Sep-10	8.8									8.80			
27-Oct-10	3.8										3.80		
24-Nov-10	2.1											2.10	
05-Jan-11	1.5	1.50											
23-Feb-11	12.8		12.80										
30-Mar-11	1.9			1.90									
27-Apr-11	4.3				4.30								
25-May-11	5.0					5.00							
29-Jun-11	3.9						3.90						
27-Jul-11	2.9							2.90					
31-Aug-11	1.1								1.10				
28-Sep-11	2.0									2.00			
26-Oct-11	8.1										8.10		
30-Nov-11	8.0											8.00	
25-Jan-12	7.3	7.30											
29-Feb-12	2.0		2.00										
28-Mar-12	3.2			3.20									
25-Apr-12	4.8				4.80								
30-May-12	2.7					2.70							
27-Jun-12	2.0						2.00						
25-Jul-12	2.3							2.30					
29-Aug-12	1.5								1.50				
26-Sep-12	1.4									1.40			
31-Oct-12	7.0										7.00		
28-Nov-12	0.7											0.70	
30-Jan-13	29.9	29.90											
26-Feb-13	5.8		5.80										
27-Mar-13	3.0			3.00									
24-Apr-13	2.3				2.30								
29-May-13	30.3					30.30							
26-Jun-13	5.1						5.10						
07-Aug-13	1.1								1.10				
28-Aug-13	1.8								1.80				
25-Sep-13	0.8									0.80			

# of Samples	182	23	14	17	13	17	17	15	17	17	14	15	3
AVE	3.794	5.787	5.179	3.729	2.938	5.406	4.324	2.953	1.841	2.553	2.229	2.580	9.667
MIN	0.500	1.000	1.000	1.000	2.000	1.000	1.800	1.500	0.800	0.500	0.600	0.700	1.500
MAX	30.300	29.900	18.100	10.500	4.800	30.300	13.500	7.000	5.900	8.800	8.100	9.900	26.000
50th	**2.300**	**3.000**	**2.900**	**3.000**	**3.000**	**3.200**	**3.900**	**2.300**	**1.300**	**2.000**	**1.150**	**1.500**	**1.500**
10th	1.000	1.420	1.360	1.500	2.120	2.120	2.180	1.700	1.020	0.500	0.600	0.940	1.500
25th	1.500	2.050	1.850	2.000	2.200	2.500	2.500	2.000	1.100	1.000	0.775	1.100	1.500
75th	**4.150**	**5.300**	**5.800**	**4.000**	**3.200**	**5.500**	**5.000**	**3.200**	**1.500**	**3.000**	**2.000**	**2.550**	**13.750**
90th	7.270	13.200	11.660	8.100	4.140	6.640	6.080	5.240	3.720	5.380	6.040	6.160	21.100

APPENDIX C
MODEL CALCULATIONS
FINAL MIXED CONCENTRATIONS

APPENDIX C - IMPACT CALCULATIONS

Concentration Model - Objective Values - Appendix Information

Mass Balance calculations were completed based on updated 7Q20 flows and various population development scenarios including existing and possible projected growth numbers.

Dev.	**Population (people)**		**Avgerage Sewage Flow**		
Scenario	**Incremental**	**Cumulative**	(m^3/d)	(m^3/sec)	(L/s)
Scenario 1	3,087	3,087	1343	0.016	15.5
Scenario 2	1,394	4,481	1949	0.023	22.6
Scenario 3	1,519	6,000	2610	0.030	30.2

Total Phosphorus (mg/L)		0.1 mg/L	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Overall**
PWQO=0.03 mg/L	**River Data**	TP	0.015	0.016	0.018	0.012	0.016	0.016	0.016	0.010	0.013	0.016	0.015	0.021	0.016
Scenario 1	Population = 3,087		0.019	0.020	0.021	0.015	0.020	0.021	0.020	0.016	0.019	0.020	0.018	0.024	0.022
Scenario 2	Population = 4,481		0.021	0.021	0.022	0.016	0.021	0.023	0.022	0.018	0.022	0.021	0.019	0.025	0.024
Scenario 3	Population = 6,000		0.023	0.023	0.024	0.017	0.023	0.025	0.024	0.020	0.024	0.023	0.020	0.026	0.026
Nitrate Nitrogen		5 mg/L													
CCME=2.93 mg/L	**River Data**	N03-N	2.65	2.70	1.90	1.68	1.71	1.80	1.75	1.74	1.79	2.08	2.18	2.52	2.10
Scenario 1	Population = 3,087		2.76	2.80	2.01	1.78	1.85	1.98	1.92	1.94	2.02	2.22	2.28	2.60	2.29
Scenario 2	Population = 4,481		2.80	2.85	2.06	1.82	1.91	2.05	1.99	2.03	2.11	2.28	2.32	2.64	2.37
Scenario 3	Population = 6,000		2.85	2.90	2.11	1.87	1.97	2.13	2.07	2.11	2.21	2.34	2.37	2.68	2.45
Biochemial Oxygen Demand		3.6 mg/L													
PWQO=5 mg/L	**River Data**	BOD5	1.175	0.900	1.525	0.700	1.150	0.900	0.600	0.800	0.900	0.750	1.000	1.100	0.900
Scenario 1	Population = 3,087		1.284	1.028	1.599	0.785	1.253	1.050	0.761	0.973	1.092	0.890	1.094	1.190	1.081
Scenario 2	Population = 4,481		1.331	1.082	1.631	0.823	1.297	1.113	0.829	1.046	1.172	0.949	1.135	1.229	1.156
Scenario 3	Population = 6,000		1.379	1.138	1.665	0.862	1.342	1.177	0.898	1.119	1.251	1.010	1.178	1.269	1.231
Escherichia coli		100 mg/L													
PWQO=100 mg/L	**River Data**	E-Coli	12	10	15	25	37	101	124	84	144	21	27	45	39.690207
Scenario 1	Population = 3,087		16	14	18	27	40	101	123	85	141	25	30	47	44
Scenario 2	Population = 4,481		18	16	19	28	41	101	122	85	140	27	31	48	45
Scenario 3	Population = 6,000		20	18	21	29	42	101	122	86	138	28	32	49	47
Total Suspended Solids		3 mg/L													
CCME=25 mg/L	**River Data**	TSS	3.9	5.8	5.1	3.0	4.8	5.1	3.0	2.3	3.0	1.4	2.3	13.8	3.6
Scenario 1	Population = 3,087		3.9	5.7	5.0	3.0	4.7	4.9	3.0	2.3	3.0	1.5	2.3	13.4	3.6
Scenario 2	Population = 4,481		3.8	5.6	5.0	3.0	4.6	4.9	3.0	2.3	3.0	1.5	2.3	13.2	3.5
Scenario 3	Population = 6,000		3.8	5.6	5.0	3.0	4.6	4.8	3.0	2.3	3.0	1.6	2.3	13.0	3.5
Total Kjeldahl Nitrogen (TKN)		2 mg/L													
N/A	**River Data**	TKN	0.375	0.530	0.423	0.383	0.448	0.470	0.405	0.350	0.450	0.448	0.445	0.410	0.420
Scenario 1	Population = 3,087		0.448	0.600	0.479	0.430	0.512	0.555	0.490	0.452	0.561	0.524	0.501	0.467	0.526
Scenario 2	Population = 4,481		0.480	0.629	0.503	0.451	0.540	0.591	0.527	0.495	0.606	0.556	0.526	0.492	0.570
Scenario 3	Population = 6,000		0.512	0.660	0.529	0.473	0.569	0.627	0.563	0.538	0.652	0.589	0.551	0.518	0.614

Concentration Model - Objective Values - Appendix Information

Mass Balance calculations were completed based on updated 7Q20 flows and various population development scenarios including existing and possible projected growth numbers.

Dev.	Population (people)		Avgerage Sewage Flow		
Scenario	**Incremental**	**Cumulative**	(m^3/d)	(m^3/sec)	(L/s)
Scenario 1	3,087	3,087	1343	0.016	15.5
Scenario 2	1,394	4,481	1949	0.023	22.6
Scenario 3	1,519	6,000	2610	0.030	30.2

Temperature	**Plant Data**	°C	9.9	9.5	10.1	11.2	13.2	16.3	18.5	18.6	18.0	16.3	14.5	11.6	18.3
N/A	**River Data**	°C	2.2	1.0	3.7	8.0	13.6	20.2	18.4	17.0	14.1	8.7	3.3	2.7	15.3
Scenario 1	Population = 3,087		2.5	1.4	3.9	8.1	13.5	20.0	18.4	17.1	14.3	9.0	3.7	3.0	15.5
Scenario 2	Population = 4,481		2.7	1.6	4.0	8.1	13.5	19.9	18.4	17.1	14.4	9.2	3.8	3.2	15.6
Scenario 3	Population = 6,000		2.8	1.8	4.1	8.2	13.5	19.8	18.4	17.2	14.6	9.3	4.0	3.3	15.7
Dissolved Oxygen	5 mg/L														
DO>5 mg/L	**River Data**	DO	13.6	14.2	12.7	11.2	10.6	10.0	9.6	10.8	10.5	11.6	11.5	12.5	10.8
Scenario 1	Population = 3,087		13.2	13.7	12.4	11.0	10.3	9.7	9.3	10.5	10.1	11.2	11.2	12.2	10.4
Scenario 2	Population = 4,481		13.0	13.5	12.3	10.9	10.2	9.6	9.2	10.3	9.9	11.1	11.1	12.1	10.2
Scenario 3	Population = 6,000		12.8	13.3	12.2	10.9	10.1	9.5	9.1	10.2	9.8	11.0	11.0	12.0	10.0
Total Ammonia	0.4 mg/L														
N/A	**River Data**	NH4-N	0.031	0.021	0.022	0.017	0.017	0.016	0.021	0.018	0.013	0.012	0.016	0.016	0.019
Scenario 1	Population = 3,087		0.048	0.039	0.036	0.028	0.033	0.037	0.042	0.042	0.041	0.031	0.030	0.030	0.045
Scenario 2	Population = 4,481		0.055	0.047	0.041	0.033	0.040	0.046	0.050	0.052	0.052	0.039	0.036	0.036	0.055
Scenario 3	Population = 6,000		0.062	0.054	0.048	0.038	0.047	0.055	0.059	0.062	0.064	0.047	0.042	0.042	0.066
Required Total Ammonia	**River Temp**	°C	2.2	1.0	3.7	8.0	13.6	20.2	18.4	17.0	14.1	8.7	3.3	2.7	15.3
N/A	**River pH**		8.1	8.2	8.1	8.0	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1
		pka	10.005	10.047	9.952	9.801	9.612	9.396	9.454	9.499	9.595	9.778	9.967	9.986	9.553
		f	0.0135	0.0136	0.0132	0.0146	0.0241	0.0456	0.0527	0.0371	0.0342	0.0210	0.0136	0.0135	0.0372
Total River Ammonia to produce 20 ug/L un-ionized ammonia			1.48	1.48	1.52	1.37	0.83	0.44	0.38	0.54	0.58	0.95	1.48	1.48	0.54
	River Unionized Ammonia (ug/L)		1796	1786	1836	1654	1003	531	459	652	707	1150	1785	1790	651
	River Ammonia (ug/L)		31	21	22	17	17	16	21	18	13	12	16	16	19
			39255	37305	50747	55630	23606	9306	8197	10256	9748	23248	48805	49408	
			27487	26146	35381	38673	16505	6550	5766	7239	6908	16306	34033	34448	
			21021	20016	26939	29357	12604	5035	4430	5581	5347	12492	25918	26230	
			32.4	30.8	41.9	46.0	19.5	7.7	6.8	8.5	8.1	19.2	40.3	40.8	
			22.7	21.6	29.2	32.0	13.6	5.4	4.8	6.0	5.7	13.5	28.1	28.5	
			17.4	16.5	22.3	24.3	10.4	4.2	3.7	4.6	4.4	10.3	21.4	21.7	
Un-ionized Ammonia (NH3)	20 ug/L														
PWQO=20 ug/L	**River Data**	NH3	0.578	0.370	0.232	0.310	0.379	0.479	0.413	0.344	0.216	0.154	0.240	0.240	0.019
Calculation of Plant NH3		PH	8.1	8.2	8.1	8.0	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1
Required to produce 20 ug/L in River.															
							Plant NH3 required to exceed PWQO								
Scenario 1	Population = 3,087	NH3	432	415	553	669	469	352	366	318	278	405	545	550	298
Scenario 2	Population = 4,481		303	291	386	465	328	248	257	224	197	284	380	384	211
Scenario 3	Population = 6,000		232	223	294	353	251	191	198	173	152	218	290	292	163
							Required NH3 expressed in mg/L								
Scenario 1	Population = 3,087	NH3	0.432	0.415	0.553	0.669	0.469	0.352	0.366	0.318	0.278	0.405	0.545	0.550	0.298
Scenario 2	Population = 4,481		0.303	0.291	0.386	0.465	0.328	0.248	0.257	0.224	0.197	0.284	0.380	0.384	0.211
Scenario 3	Population = 6,000		0.232	0.223	0.294	0.353	0.251	0.191	0.198	0.173	0.152	0.218	0.290	0.292	0.163
pka based on est. effluent temperature		pka	10.005	10.047	9.952	9.801	9.612	9.396	9.454	9.499	9.595	9.778	9.967	9.986	9.553
f, based on river PH		f	0.0135	0.0136	0.0132	0.0146	0.0241	0.0456	0.0527	0.0371	0.0342	0.0210	0.0136	0.0135	0.0372
							Conversion to Total Ammonia required from Plant to exceed PWQO for NH3 (mg/L) in River								
Scenario 1	Population = 3,087	NH4-N	32.07	30.63	41.95	45.74	19.46	7.74	6.95	8.56	8.12	19.26	40.22	40.71	8.03
Scenario 2	Population = 4,481		22.46	21.47	29.25	31.80	13.61	5.44	4.88	6.04	5.75	13.51	28.05	28.39	5.68
Scenario 3	Population = 6,000		17.18	16.44	22.27	24.14	10.39	4.18	3.75	4.66	4.45	10.35	21.36	21.62	4.38

APPENDIX C - IMPACT CALCULATIONS

Concentration Model - Non-Compliance Values - Appendix Information

Mass Balance calculations were completed based on updated 7Q20 flows and various population development scenarios including existing and possible projected growth numbers.

Dev. Scenario	**Population (people)**		**Avgerage Sewage Flow**		
	Incremental	**Cumulative**	(m^3/d)	(m^3/sec)	(L/s)
Scenario 1	3,087	3,087	1343	0.016	15.5
Scenario 2	1,394	4,481	1949	0.023	22.6
Scenario 3	1,519	6,000	2610	0.030	30.2

			Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Overall**
Total Phosphorus (mg/L)		0.15 mg/L													
PWQO=0.03 mg/L	**River Data**	TP	0.015	0.016	0.018	0.012	0.016	0.016	0.016	0.010	0.013	0.016	0.015	0.021	0.016
Scenario 1	Population = 3,087		0.021	0.022	0.023	0.016	0.022	0.023	0.023	0.019	0.023	0.022	0.019	0.026	0.025
Scenario 2	Population = 4,481		0.024	0.025	0.025	0.018	0.024	0.027	0.026	0.022	0.027	0.025	0.022	0.028	0.029
Scenario 3	Population = 6,000		0.028	0.028	0.027	0.020	0.027	0.030	0.029	0.026	0.031	0.028	0.024	0.030	0.032
Nitrate Nitrogen		6 mg/L													
CCME=2.93 mg/L	**River Data**	N03-N	2.65	2.70	1.90	1.68	1.71	1.80	1.75	1.74	1.79	2.08	2.18	2.52	2.10
Scenario 1	Population = 3,087		2.80	2.85	2.05	1.81	1.89	2.03	1.97	2.00	2.09	2.27	2.31	2.64	2.36
Scenario 2	Population = 4,481		2.87	2.92	2.11	1.86	1.97	2.13	2.07	2.11	2.21	2.35	2.37	2.69	2.46
Scenario 3	Population = 6,000		2.93	2.99	2.18	1.92	2.05	2.23	2.17	2.23	2.34	2.43	2.44	2.75	2.57
Biochemial Oxygen Demand		7.5 mg/L													
PWQO=5 mg/L	**River Data**	BOD5	1.175	0.900	1.525	0.700	1.150	0.900	0.600	0.800	0.900	0.750	1.000	1.100	0.900
Scenario 1	Population = 3,087		1.460	1.212	1.739	0.900	1.416	1.266	0.969	1.215	1.370	1.081	1.236	1.330	1.342
Scenario 2	Population = 4,481		1.582	1.346	1.832	0.988	1.530	1.420	1.126	1.388	1.564	1.221	1.338	1.430	1.525
Scenario 3	Population = 6,000		1.707	1.483	1.928	1.080	1.648	1.578	1.285	1.563	1.758	1.366	1.444	1.533	1.710
Escherichia coli		100 mg/L													
PWQO=100 mg/L	**River Data**	E-Coli	12	10	15	25	37	101	124	84	144	21	27	45	40
Scenario 1	Population = 3,087		16	14	18	27	40	101	123	85	141	25	30	47	44
Scenario 2	Population = 4,481		18	16	19	28	41	101	122	85	140	27	31	48	45
Scenario 3	Population = 6,000		20	18	21	29	42	101	122	86	138	28	32	49	47
Total Suspended Solids		10 mg/L													
CCME=25 mg/L	**River Data**	TSS	3.9	5.8	5.1	3.0	4.8	5.1	3.0	2.3	3.0	1.4	2.3	13.8	4
Scenario 1	Population = 3,087		4.2	6.0	5.3	3.2	5.0	5.3	3.4	2.7	3.5	1.8	2.6	13.6	4.0
Scenario 2	Population = 4,481		4.3	6.1	5.4	3.3	5.1	5.4	3.5	2.9	3.7	2.0	2.7	13.6	4.2
Scenario 3	Population = 6,000		4.4	6.2	5.4	3.4	5.2	5.6	3.7	3.1	3.9	2.2	2.8	13.5	4.4
Total Kjeldahl Nitrogen (TKN)		3 mg/L													
N/A	**River Data**	TKN	0.375	0.530	0.423	0.383	0.448	0.470	0.405	0.350	0.450	0.448	0.445	0.410	0.420
Scenario 1	Population = 3,087		0.493	0.647	0.515	0.460	0.554	0.610	0.544	0.514	0.632	0.573	0.538	0.503	0.593
Scenario 2	Population = 4,481		0.544	0.697	0.555	0.493	0.600	0.670	0.603	0.583	0.707	0.626	0.578	0.544	0.664
Scenario 3	Population = 6,000		0.596	0.748	0.596	0.529	0.648	0.730	0.663	0.652	0.782	0.680	0.620	0.585	0.737

Concentration Model - Non-Compliance Values - Appendix Information

Mass Balance calculations were completed based on updated 7Q20 flows and various population development scenarios including existing and possible projected growth numbers.

Dev.	Population (people)		Avgerage Sewage Flow		
Scenario	Incremental	Cumulative	(m^3/d)	(m^3/sec)	(L/s)
Scenario 1	3,087	3,087	1343	0.016	15.5
Scenario 2	1,394	4,481	1949	0.023	22.6
Scenario 3	1,519	6,000	2610	0.030	30.2

			Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec	Overall
Temperature	**Plant Data**	°C	9.9	9.5	10.1	11.2	13.2	16.3	18.5	18.6	18.0	16.3	14.5	11.6	18.3
N/A	**River Data**	°C	2.2	1.0	3.7	8.0	13.6	20.2	18.4	17.0	14.1	8.7	3.3	2.7	15.3
Scenario 1	Population = 3,087		2.5	1.4	3.9	8.1	13.5	20.0	18.4	17.1	14.3	9.0	3.7	3.0	15.5
Scenario 2	Population = 4,481		2.7	1.6	4.0	8.1	13.5	19.9	18.4	17.1	14.4	9.2	3.8	3.2	15.6
Scenario 3	Population = 6,000		2.8	1.8	4.1	8.2	13.5	19.8	18.4	17.2	14.6	9.3	4.0	3.3	15.7
Dissolved Oxygen		4 mg/L													
DO>5 mg/L	**River Data**	DO	13.6	14.2	12.7	11.2	10.6	10.0	9.6	10.8	10.5	11.6	11.5	12.5	10.8
Scenario 1	Population = 3,087		13.1	13.7	12.4	11.0	10.3	9.7	9.3	10.4	10.0	11.2	11.2	12.2	10.3
Scenario 2	Population = 4,481		12.9	13.5	12.3	10.9	10.2	9.5	9.1	10.2	9.8	11.0	11.1	12.1	10.1
Scenario 3	Population = 6,000		12.7	13.3	12.1	10.8	10.0	9.4	9.0	10.0	9.7	10.9	11.0	11.9	9.9
Total Ammonia		2 mg/L													
N/A	**River Data**	NH4-N	0.031	0.021	0.022	0.017	0.017	0.016	0.021	0.018	0.013	0.012	0.016	0.016	0.019
Scenario 1	Population = 3,087		0.12	0.11	0.09	0.08	0.10	0.13	0.13	0.14	0.15	0.11	0.09	0.09	0.15
Scenario 2	Population = 4,481		0.16	0.15	0.12	0.10	0.14	0.17	0.17	0.19	0.21	0.15	0.12	0.12	0.21
Scenario 3	Population = 6,000		0.20	0.20	0.16	0.13	0.17	0.22	0.22	0.24	0.27	0.19	0.15	0.15	0.26
Required Total Ammonia	**River Temp**	°C	2.2	1.0	3.7	8.0	13.6	20.2	18.4	17.0	14.1	8.7	3.3	2.7	15.3
N/A	**River pH**		8.1	8.2	8.1	8.0	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1
		pka	10.005	10.047	9.952	9.801	9.612	9.396	9.454	9.499	9.595	9.778	9.967	9.986	9.553
		f	0.0135	0.0136	0.0132	0.0146	0.0241	0.0456	0.0527	0.0371	0.0342	0.0210	0.0136	0.0135	0.0372
Total River Ammonia to produce 20 ug/L un-ionized ammonia			1.48	1.48	1.52	1.37	0.83	0.44	0.38	0.54	0.58	0.95	1.48	1.48	0.54
	River Unionized Ammonia (ug/L)		1796	1786	1836	1654	1003	531	459	652	707	1150	1785	1790	651
	River Ammonia (ug/L)		31	21	22	17	17	16	21	18	13	12	16	16	19
			39255	37305	50747	55630	23606	9306	8197	10256	9748	23248	48805	49408	
			27487	26146	35381	38673	16505	6550	5766	7239	6908	16306	34033	34448	
			21021	20016	26939	29357	12604	5035	4430	5581	5347	12492	25918	26230	
			32.4	30.8	41.9	46.0	19.5	7.7	6.8	8.5	8.1	19.2	40.3	40.8	
			22.7	21.6	29.2	32.0	13.6	5.4	4.8	6.0	5.7	13.5	28.1	28.5	
			17.4	16.5	22.3	24.3	10.4	4.2	3.7	4.6	4.4	10.3	21.4	21.7	
Un-ionized Ammonia (NH3)		20 ug/L													
PWQO=20 ug/L	**River Data**	NH3	0.578	0.370	0.232	0.310	0.379	0.479	0.413	0.344	0.216	0.154	0.240	0.240	0.019
Calculation of Plant NH3		PH	8.1	8.2	8.1	8.0	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1
Required to produce 20 ug/L in River.															
								Plant NH3 required to exceed PWQO							
Scenario 1	Population = 3,087	NH3	432	415	553	669	469	352	366	318	278	405	545	550	298
Scenario 2	Population = 4,481		303	291	386	465	328	248	257	224	197	284	380	384	211
Scenario 3	Population = 6,000		232	223	294	353	251	191	198	173	152	218	290	292	163
								Required NH3 expressed in mg/L							
Scenario 1	Population = 3,087	NH3	0.432	0.415	0.553	0.669	0.469	0.352	0.366	0.318	0.278	0.405	0.545	0.550	0.298
Scenario 2	Population = 4,481		0.303	0.291	0.386	0.465	0.328	0.248	0.257	0.224	0.197	0.284	0.380	0.384	0.211
Scenario 3	Population = 6,000		0.232	0.223	0.294	0.353	0.251	0.191	0.198	0.173	0.152	0.218	0.290	0.292	0.163
pka based on est. effluent temperature		pka	10.005	10.047	9.952	9.801	9.612	9.396	9.454	9.499	9.595	9.778	9.967	9.986	9.553
f, based on river PH		f	0.0135	0.0136	0.0132	0.0146	0.0241	0.0456	0.0527	0.0371	0.0342	0.0210	0.0136	0.0135	0.0372
								Conversion to Total Ammonia required from Plant to exceed PWQO for NH3 (mg/L) in River							
Scenario 1	Population = 3,087	NH4-N	32.1	30.6	42.0	45.7	19.5	7.7	6.9	8.6	8.1	19.3	40.2	40.7	8.0
Scenario 2	Population = 4,481		22.5	21.5	29.3	31.8	13.6	5.4	4.9	6.0	5.8	13.5	28.0	28.4	5.7
Scenario 3	Population = 6,000		17.2	16.4	22.3	24.1	10.4	4.2	3.7	4.7	4.5	10.3	21.4	21.6	4.4

APPENDIX D
MIXING ZONE ANALYSIS

Review of Mixing Zone:

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 8.0E
                       HYDRO1:Version-8.0.0.0  April,2012
SITE NAME/LABEL:                WWTP Discharge - West Credit River - Winston Churchill
  DESIGN CASE:                  July 7Q20 Flow - 75th Conc. - Population Scenario 3
  FILE NAME:                    C:\Program Files (x86)\CORMIX 8.0\Sample Files\Sample1.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             04/24/2014--21:20:30
******************************************************************************
SUMMARY OF INPUT DATA:
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AMBIENT PARAMETERS:
  Cross-section                              = bounded
  Width                             BS       = 9.5 m
  Channel regularity                ICHREG = 1
  Ambient flowrate                  QA       = 0.27 m^3/s
  Average depth                     HA       = 0.3 m
  Depth at discharge                HD       = 0.3 m
  Ambient velocity                  UA       = 0.0961 m/s
  Darcy-Weisbach friction factor    F        = 0.1435
    Calculated from Manning's n              = 0.035
  Wind velocity                     UW       = 2 m/s
  Stratification Type               STRCND = U
  Surface temperature                        = 18.40 degC
  Bottom temperature                         = 18.40 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                   RHOAS  = 998.5218 kg/m^3
  Bottom density                    RHOAB  = 998.5218 kg/m^3
------------------------------------------------------------------------------
DISCHARGE PARAMETERS:               Single Port Discharge
  Nearest bank                               = right
  Distance to bank                  DISTB  = 4.5 m
  Port diameter                     D0       = 0.1 m
  Port cross-sectional area         A0       = 0.0079 m^2
  Discharge velocity                U0       = 3.95 m/s
  Discharge flowrate                Q0       = 0.031 m^3/s
  Discharge port height             H0       = 0 m
  Vertical discharge angle          THETA  = 0 deg
  Horizontal discharge angle        SIGMA  = 0 deg
  Discharge temperature (freshwater)       = 18.5 degC
  Corresponding density             RHO0   = 998.5028 kg/m^3
  Density difference                DRHO   = 0.0190 kg/m^3
  Buoyant acceleration              GP0    = 0.0002 m/s^2
  Discharge concentration           C0     = 0.1054 mg/l
  Surface heat exchange coeff.      KS     = 0 m/s
  Coefficient of decay              KD     = 0 /s
------------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.09 m          Lm  = 3.64 m          Lb  = 0.01 m
  LM  = 86.04 m          Lm' = 99999 m          Lb' = 99999 m
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NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 913.99
  Velocity ratio                  R      = 41.06
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MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                              = yes
  CMC concentration                 CMC        = 0.02 mg/l
  CCC concentration                 CCC        = 0.002 mg/l
  Water quality standard specified             = given by CCC value
  Regulatory mixing zone                       = yes
  Regulatory mixing zone specification         = distance
  Regulatory mixing zone value                 = 50 m (m^2 if area)
  Region of interest                           = 200 m
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H5-0 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 0.3 m
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MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

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X-Y-Z Coordinate system:
  Origin is located at the bottom below the port center:
    4.5 m from the right bank/shore.
  Number of display steps NSTEP = 20 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0051 mg/l
  Dilution at edge of NFR              s = 20.6
  NFR Location:                        x = 35.63 m
    (centerline coordinates)           y = 0 m
                                       z = 0.3 m
  NFR plume dimensions:  half-width (bh) = 2.95 m
                          thickness (bv) = 0.3 m
Cumulative travel time:       388.7434 sec.

WARNING:
 The LIMITING DILUTION (given by ambient flow/discharge ratio) is = 9.84
 This value is below the computed dilution of 20.63 at the end of the
 Near Field Region (NFR). Mixing for this discharge configuration is
 constrained by the ambient flow.
 Please carefully review the prediction file for additional warnings and information.
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Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
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Near-field instability behavior:
  The discharge flow will experience instabilities with full vertical mixing
  in the near-field.
  There may be benthic impact of high pollutant concentrations.
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FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 0 m
  downstream and continues as vertically mixed into the far-field.
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PLUME BANK CONTACT SUMMARY:
  Plume in bounded section contacts nearest bank at 0 m downstream.
  Plume contacts second bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 0.02  mg/l
Corresponding dilution                   = 5.27
The CMC was encountered at the following plume position:
  Plume location:                      x = 2.71 m
    (centerline coordinates)           y = 0 m
                                       z = 0.3 m
  Plume dimension:       half-width (bh) = 0.24 m
                          thickness (bv) = 0.3 m

 Computed distance from port opening to CMC location = 2.72 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
              Lq = 0.09 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.71 m.
 CRITERION 2: This location is beyond 5 times the ambient water depth of
              HD = 0.3 m.
 ++++++++++ The ambient depth TEST for the TDZ has FAILED. ++++++++++

 CRITERION 3: An RMZ was specified but its boundary was not encountered
              within the predicted plume region. Therefore, the Regulatory Mixing
              zone test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.95 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.
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