Cornwall
ONTARIO CANADA

CORNWALL WASTEWATER TREATMENT PLANT
ENVIRONMENTAL ASSESSMENT UPDATE

TECHNICAL MEMORANDUM NO. 2
RAW WASTEWATER CHARACTERIZATION

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1.0 INTRODUCTION

The Cornwall Wastewater Treatment Plant (WWTP) is owned and operated by the City of Cornwall. The plant provides primary treatment with chemical addition for enhanced treatment and phosphorus removal as well as disinfection. The existing WWTP has a Certificate of Approval (C of A) average day flow (ADF) capacity of 54,432 m^3/d and a peak design capacity of 108,900 m^3/d. Biosolids are treated on-site in an anaerobic digestion process and dewatered using centrifuges, prior to disposal in the City's landfill.

The Cornwall WWTP was originally constructed in 1968 and has undergone several expansions since then. The WWTP serves approximately 46,000 people, services commercial and industrial properties, and receives leachate from five waste disposal sites. Plant ownership was transferred to the MOE in 1970, and then to the City of Cornwall in 2000. Plant expansion in 1988 resulted in the current plant layout.

Figure 1 presents an aerial image of the Cornwall WWTP.

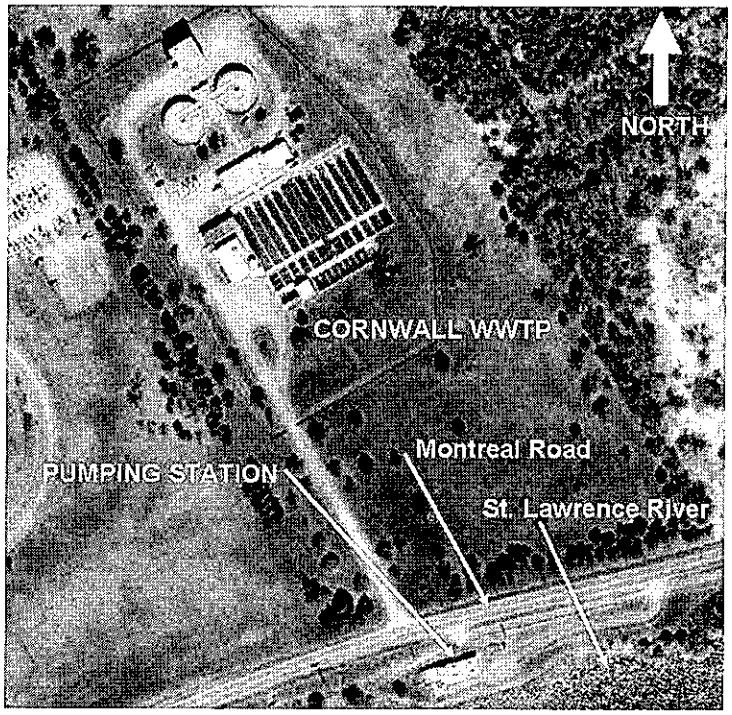

Figure 1 - Satellite Photograph of the Cornwall WWTP (courtesy of GoogleMaps)

A Pollution Control Planning (PCP) study was undertaken in 1995 to address concerns raised as part of the Remedial Action Plan (RAP), which stemmed from the designation of the St. Lawrence River (Cornwall area) as an Area of Concern (AOC) by the Water Quality Board and the International Joint Commission. The PCP has recently been updated to include a hydraulic assessment of critical sewer infrastructure and determine compliance with MOE Procedure F-5-5. In addition to other recommendations, the RAP recommended the following for the Cornwall WWTP:

- Upgrading the existing primary treatment plant to the equivalent of secondary treatment
- Achieve phosphorous removal to a compliance limit of 1.0 mg/L, with an objective of 0.5 mg/L
- Increase removal efficiency of other toxic contaminants
- Reduce bacteria levels

Following a plant-wide evaluation for required upgrades in 2003, a Schedule C Class Environmental Assessment (Class EA) for these upgrades was completed in 2005. As a result of the Class EA, a Biological Aerated Filter (BAF) system was recommended for the secondary treatment process upgrade and Ultraviolet (UV) irradiation was recommended for the disinfection system.

In May 2009, the City retained J.L. Richards & Associates Limited, in association with XCG Consultants Ltd. and CH2M HILL Canada Limited to update the 2005 Class EA and to update the budget for capital-required upgrades as well as life-cycle costing over the 20 year EA planning period. The update is to revisit the preferred treatment technologies identified in the EA based on existing conditions and constraints and to provide updated construction and life-cycle cost estimates.

The purpose of Technical Memorandum No. 2 (TM2) is to confirm the projected flows and raw wastewater characteristics for the expanded plant. Other technical memoranda will be prepared to summarize various elements of the overall project. These technical memoranda will form part of the Environmental Study Report Addenda (ESR Addenda), which is anticipated to be the main project deliverable for this project.

2.0 DESIGN WASTEWATER FLOWS

2.1 Historical Raw Wastewater Flows

Wastewater is conveyed to the Cornwall WWTP by a combination of separated and combined sewers. Flow is conveyed to a main sewage pumping station located on-site, which pumps wastewater to the Cornwall WWTP for treatment.

According to the 2005 ESR, the ADF over the period from 2001 – 2003 was approximately 47,500 m^3/d. Over the review period of this ESR Update (2006 to 2008), the ADF to the plant was approximately 48,071 m^3/d, or 88 percent of the rated capacity. Therefore, historical average day flows to the plant do not appear to have changed significantly since the time of the 2005 ESR.

Table 1 presents the ADF, maximum day flow (MDF) and the peak flows recorded at the WWTP over the three year period from January 1, 2006 to December 31, 2008.

Table 1 – Historic Raw Wastewater Flows (2006 – 2008)

Parameter	2006	2007	2008	Overall
ADF	50,449	45,437	48,333	48,071
MDF	113,000	108,000	109,000	113,000
MDF Factor	2.24	2.38	2.26	2.35
Peak Instantaneous Flow	115,000	110,000	116,000	116,000
Peak Flow Factor	2.28	2.42	2.40	2.41

Notes:
ADF – Average Day Flow
MDF – Maximum Day Flow
Peak instantaneous flow and maximum day flow are limited via the PLC. Actual peaking factors are therefore unknown.

Based on the 2006 Cornwall population of 45,965 (Statistics Canada, 2009), the average per capita flow was 1,046 L/cap·d. This value is significantly higher than the typical range of 315 – 540 L/cap·d (MOE, 2008). This may be due to the additional flow from industrial contributors, landfill leachate, inflow/infiltration (I/I) into the collection system and from the combined sewers.

Figure 2 presents the daily flows and peak flows recorded at the Cornwall WWTP from 2006 – 2008, which receives pumped flow directly from the main sewage pumping station.

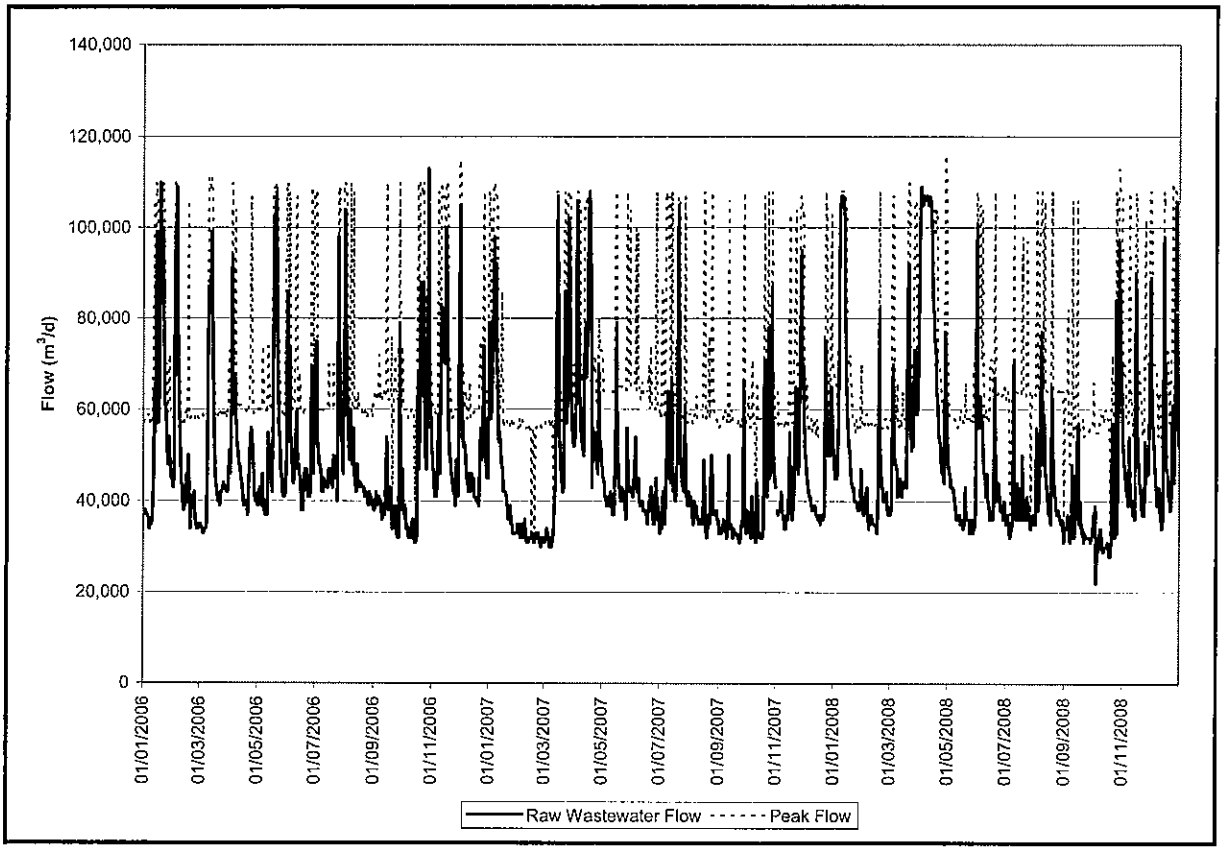

Figure 2 - Daily and Peak Flows Recorded at the Cornwall WWTP (2006 – 2008)

Maximum Day Flows (MDF) ranged from 108,000 m^3/d in 2007 to 113,000 m^3/d in 2006, exceeding the design peak flow capacity of the plant. In **Figure 2**, there were several instances when the daily flow approached the value of the peak flow, potentially indicating sustained peak flows. The sustained peak flows may be indicative of inflow/infiltration (I/I) into the collection system during wet weather flow events. It is important to note that the pumping station peak pumping capacity is controlled and limited, which in turn, limits the peak flow rate to the plant.

Figure 3 presents the monthly average day flows to the Cornwall WWTP from 2006 – 2008.

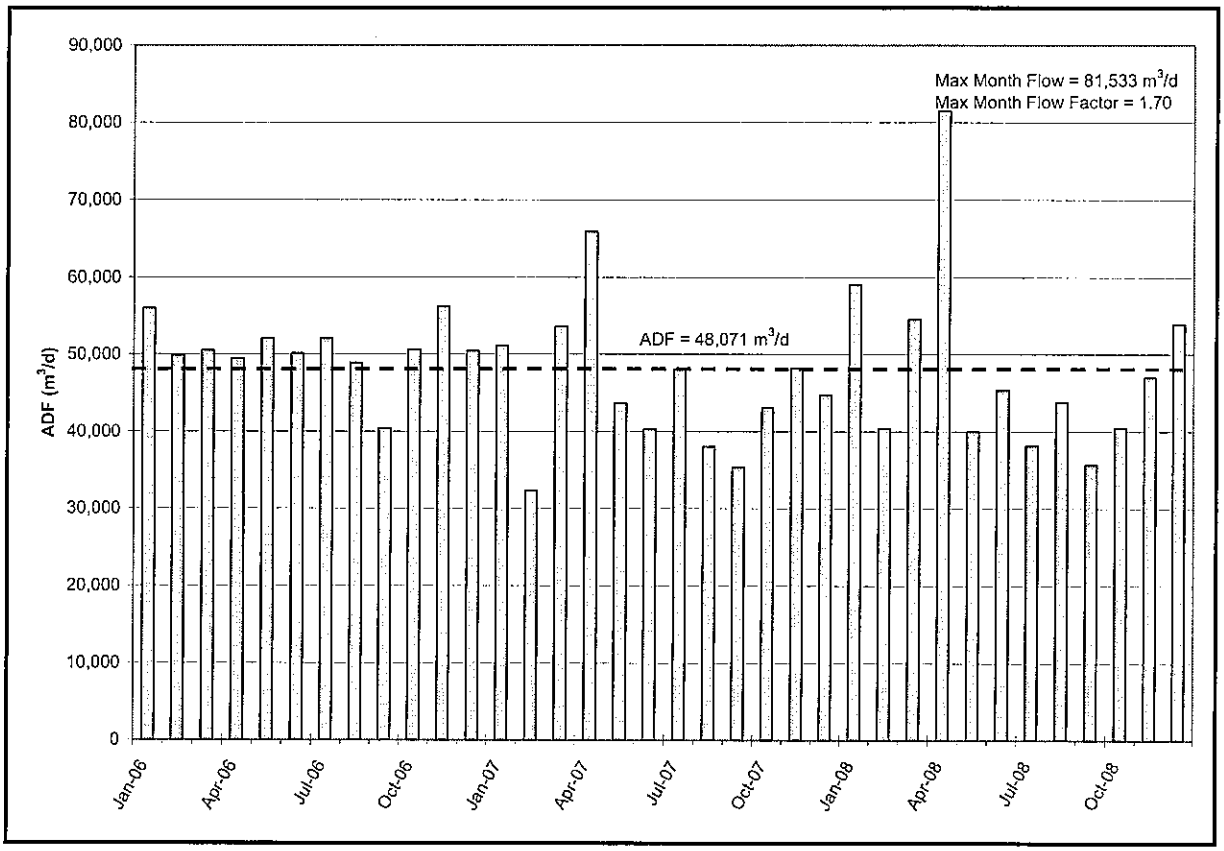

Figure 3 - Monthly Average Day Flows to the Cornwall WWTP (2006 – 2008)

Based on **Figure 3**, the Cornwall WWTP receives a wide variation in monthly flows. Monthly average flows have ranged from 32,321 m^3/d (February 2007) to 81,533 m^3/d (April 2008). The maximum month flow (MMF) may be attributed primarily to an extended period of sustained high flows from April 1 – 13, 2008. During this period, the ADF was 105,539 m^3/d, resulting in a maximum month flow factor of 1.70 for the month of April 2008. This result was higher than typical maximum month peaking factors of about 1.3 to 1.5 for municipal WPCPs (Metcalf & Eddy, 2003). The high maximum month peak factor at the Cornwall WWTP may be attributed to I/I in the existing collection system, as well as contribution from the combined sewers. However, other maximum month flow factors fall within the typical range.

2.1 2005 Environmental Study Report

The 2005 ESR recommended expanding the Cornwall WWTP to an ADF capacity of 65,318 m^3/d. This represents a 20 percent increase in plant capacity relative to the plant's existing rated capacity of 54,432 m^3/d.

According to the 2005 ESR, the ADF over the period from 2001 – 2003 was 47,500 m^3/d, or approximately 87 percent of the C of A rated capacity of the Cornwall WWTP. The proposed expansion would have provided an additional treatment capacity of 17,818 m^3/d relative to the 2005 flows.

It is noted that no planning horizon was specified for the 20 percent growth allowance in the 2005 ESR.

The design peak flow was based on the peak flow capacity of the existing forcemain and pumping station. The 2005 ESR recommended a peak flow of 130,000 m^3/d, which is equivalent to a peak factor of approximately 2.0.

Table 2 presents the flow design basis used in the 2005 ESR.

Table 2 – Flow Design Basis – 2005 ESR

Constituent	Flow Design Basis - 2005 ESR[1]
Historical Average ADF	47,500 m^3/d
Design ADF	65,318 m^3/d
Design Peak Flow	130,000 m^3/d
Design Peak Flow Factor	2.0

Notes:
1. Hydromantis Inc. Cornwall Class EA. July 2005.

2.2 Proposed Design Flow Basis

A review of recent plant operating data (from January 1, 2006 to December 31, 2008) suggests that the average day flow capacity of 65,318 m^3/day recommended in the 2005 ESR remains appropriate. This will result in a 20% increase of the plant's current rated capacity.

As discussed in Technical Memorandum No. 3, it is possible to increase the pumping station capacity up to approximately 186,000 m^3/day while maintaining a forcemain velocity of 3.0 m/s or less. Upon preliminary review, it is also noted that the existing primary clarifiers can be used for co-thickening of waste activated sludge up to 169,500 m^3/day, based on the 2008 MOE Design Guidelines. As a result, and following discussions with City staff, it is recommended that consideration be given to increasing the peak flow for the upgraded plant up to 160,000 m^3/d. This will be reviewed further during the design phase based on value engineering and a comprehensive cost-benefit analysis. In any event, the peak flow design basis shall be 130,000 m^3/d, as a minimum, consistent with the 2005 ESR.

It should be noted that the collection system is such that peak flows can be sustained for extended periods during wet weather events. Given that all flows to the plant are pumped, the recommended peak day and peak instantaneous flow capacity are the same.

Table 3 presents the proposed design flow basis for the expanded Cornwall WWTP.

Table 3 – Proposed Cornwall WWTP Design Basis

Parameter	Proposed Design Basis	2005 ESR
Average Day Flow	65,318 m^3/d	65,318 m^3/d
Peak Flow[1]	up to160,000 m^3/d [2]	130,000 m^3/d
Peak Flow Factor[1]	2.45	2.0

Notes:

1. Peak Day and Peak Instantaneous
2. Peak Day and Peak Instantaneous shall be 130,000 m^3/d, as a minimum, consistent with the 2005 ESR.

2.3 2009 Pollution Control Plan

In 2009, a Pollution Control Plan (PCP) Update was conducted. The objectives of the PCP Update included:

- An assessment of the existing collection system capacity;
- An assessment of the existing system's compliance with MOE F-5-5 Guidelines; and
- Refinement of CSO abatement strategies identified in previous PCP Updates.

A model was created to simulate the existing conditions of the Cornwall collection system and to estimate the system performance under typical year rainfall conditions, under a 25-year storm event and under two different future growth scenarios. The results of the simulation indicated the following:

- No capacity issues were identified at existing conditions under a 25 year storm event.

- Under existing conditions and typical year rainfall, the Cornwall collection system captured and treated greater than 90 percent of wet weather flows. As a result, the PCP Update indicates the collection system currently meets MOE F-5-5 Guidelines.

- Under the two future growth scenarios identified, the existing system exhibited capacity limitations in most of the major trunk sewers.

Several CSO abatement strategies were identified in the 2009 PCP Update, including storage at several locations within the collection system, satellite treatment at various CSO chambers and maximizing treatment of wet weather flows at the Cornwall WWTP. Of these strategies, maximizing the treatment of wet weather flows (ideally to 100 percent of wet weather flows) at the WWTP was considered the most favourable.

It should be noted that the two future growth scenarios identified in the 2009 PCP Update are not consistent with the flow basis for the Class EA Update, and the flows defined in the Class EA were not simulated using the model developed in the PCP study. With recent improvements to calculated flow measurement at the Brookdale CSO and future continued monitoring, there may be opportunity to refine the collection system model and simulate the design basis flow conditions for the expanded Cornwall WWTP.

3.0 RAW WASTEWATER QUALITY

3.1 Historical Raw Wastewater Quality

The collection system is comprised of separated and combined sewers. The raw wastewater contributed to the Cornwall WWTP is primarily of domestic origin. There are two significant industrial contributors to the collection system. Leachate from five landfill sites (one only active site) is also conveyed to the Cornwall WWTP for treatment.

Daily raw wastewater sampling results were reviewed for the period of January 1, 2006, to December 31, 2008. **Table 4** summarizes the monthly average raw wastewater constituent

concentrations for BOD_5, Total Suspended Solids (TSS), and Total Phosphorus (TP). Historical Total Kjeldahl Nitrogen (TKN) raw wastewater concentrations were provided for 2008. It should be noted that raw wastewater samples include contributions from the complete sewershed area, which includes industrial users and landfill leachate.

Based on the results presented in **Table 4**, the historical average raw wastewater concentrations represent a very low strength wastewater with respect to BOD_5 and TP, and low strength wastewater with respect to TSS and TKN.

Table 4 – Historical Average Raw Wastewater Constituent Concentrations

Parameter	2006	2007	2008	Overall	Typical Raw Domestic Wastewater Concentrations	
					MOE, 2008	Metcalf & Eddy, 2003 [1]
BOD_5 (mg/L)	61	66	67	64	150 – 200 mg/L	110 mg/L (low) 190 mg/L (med) 350 mg/L (high)
TSS (mg/L)	100	121	108	110	150 – 200 mg/L	120 mg/L (low) 210 mg/L (med) 400 mg/L (high)
TP (mg/L)	2.3	2.7	2.1	2.4	6 – 8 mg/L	4 mg/L (low) 7 mg/L (med) 12 mg/L (high)
TKN (mg/L)	n/a	n/a	16.4	16.4	n/a	20 mg/L (low) 40 mg/L (med) 70 mg/L (high)

Notes:
1. The "low", "med" and "high" refer to low, medium and high strength wastewaters. Low strength wastewaters based on approximate flowrate of 750 L/cap·d, medium strength on 460 L/cap·d, and high strength on 240 L/cap·d.

Table 5 summarizes the historical average loading and per capita loading to the WWTP for the key raw wastewater constituents. Maximum month loading factors were 1.7, 1.5, and 1.7 for BOD_5, TSS and TP, respectively. Based on the 2006 Cornwall population of 45,965 (Statistics

Canada, 2009), the average per capita BOD_5 and TP loadings is 67 g/cap·d and 2.3 g/cap·d, respectively. This is lower than the typical values for domestic wastewater of 75 g/cap·d (MOE, 2008) and 3.3 g/cap·d (Metcalf & Eddy, 2003), respectively. The per capita TSS and TKN loadings of 112 g/cap·d and 17.2 g/cap·d are higher than the typical values of 90 g/cap·d and 13.3 g/cap·d (MOE, 2008), respectively. The acceptance of leachate into the collection system, coupled with the presence of industrial contributors, potentially could lead to significant variations in daily loading impacting the calculated per capita loadings observed at the plant however, there are no reported incidences of this occurring.

Table 5 – Historical Average Raw Wastewater Constituent Loadings

Parameter	2006	2007	2008	Overall	Average Per Capita Loading [1]	Typical Per Capita Loading
BOD_5	3,069 kg/d (4,431 kg/d)	2,991 kg/d (4,235 kg/d)	3,218 kg/d (5,218 kg/d)	3,097 kg/d (5,218 kg/d)	67 g/cap·d	75 g/cap·d [2]
TSS	4,878 kg/d (5,699 kg/d)	5,280 kg/d (6,745 kg/d)	5,260 kg/d (7,795 kg/d)	5,159 kg/d (7,795 kg/d)	112 g/cap·d	90 g/cap·d [2]
TP	111 kg/d (147 kg/d)	115 kg/d (137 kg/d)	98 kg/d (119 kg/d)	108 kg/d (147 kg/d)	2.3 g/cap·d	3.3 g/cap·d [3]
TKN	n/a	n/a	792 kg/d (1,264 kg/d)	792 kg/d (1,264 kg/d)	17.2 g/cap·d	13.3 g/cap·d [3]

Notes:
Values in parentheses represent maximum monthly loads.
1. Based on the 2006 Cornwall population of 45,965 (Statistics Canada, 2009).
2. MOE, 2009.
3. Metcalf & Eddy, 2003.

3.2 Select Industrial and Landfill Leachate Contributors

There are two identified major industries that contribute to the loading at the Cornwall WWTP, referred to as Industry A and Industry B. Both industries pre-treat their wastewater prior to discharge to the collection system.

Effluent from Industry A is generally representative of low strength domestic wastewater with respect to BOD_5 and TP, and medium strength with respect to TSS. Effluent from Industry B is typically comparable to medium strength domestic wastewater with respect to BOD_5, and high strength with respect to TSS and TP. As is typical with industry effluent, both Industry A and B wastewater effluents are subject to variation in strength.

Presently landfill leachate from five landfills (one active landfill, four closed landfills) is able to be conveyed to the Cornwall WWTP for co-treatment. Leachate from all of the sites drains to the sanitary sewer collection system. The City's active and old municipal landfill sites contribute the comparative majority of landfill leachate flow to the collection system, and it is also the relatively higher strength leachate. From a domestic wastewater perspective, based on monitoring results the City landfill leachate is typically comparable to low strength domestic wastewater with respect to BOD_5, TSS and TP, and high strength with respect to ammonia species (TKN). From a landfill leachate perspective, all of the leachates would be generally characterized as 'weak' or low strength landfill leachates.

Table 6 presents the calculated loading contributions from Industry A & B, City Active & Old Landfill and Other Closed Landfills as a percentage of the 2006-8 historic Cornwall WWTP flows and loadings.

Table 6 –Select Industrial and Landfill Leachate Contributions as a Percent of Cornwall WWTP Flows and Loadings

Parameter	Industry A&B	City Active & Old Landfill	Other Closed Landfills
Average Flow	1.1%	1.7%	0.6%
BOD_5 Loading	1.0%	3.8%	<0.1%
TSS Loading	1.7%	0.7%	<0.1%
TP Loading	3.2%	1.0%	<0.1%
TKN Loadings	na	13.2%	0.1%

Notes:
(1) Some of the above findings/information reference an in-progress City study in regard to the evaluation of landfill leachate potential impact to the Cornwall WWTP.

Based on the above presented percentage flows and loadings, the select industry effluents and landfill leachates (even if somewhat variable in nature) do not contribute a significant hydraulic or organic loading to the Cornwall WWTP. The highest loading contribution is with TKN (leachate ammonia), however this impact appears minimal as the historical overall TKN loading to the WWTP is "low." It is also noted that the current flows from the Active Landfill are not likely to increase, and it is expected that the leachate flows and loadings from the closed landfills will decrease with age.

3.3 Raw Wastewater Design Basis

Table 7 presents the proposed raw wastewater design basis. The projected concentrations are based on the application of historic concentrations and maximum month loading factors, except

in the case of TP where a higher typical "low" concentration has been adopted. The historical concentrations, the design basis proposed in the 2005 ESR and typical raw domestic wastewater concentrations are also provided for reference purposes.

Table 7 – Raw Wastewater Constituent Concentration Design Basis

Parameter	Updated Design Basis	Historical Concentrations	2005 ESR	Typical Raw Domestic Wastewater Concentrations	
				MOE, 2008	Metcalf & Eddy, 2003 (1)
BOD_5	110 mg/L	64 mg/L	180 mg/L	150 – 200 mg/L	110 mg/L (low) 190 mg/L (med) 350 mg/L (high)
TSS	165 mg/L	110 mg/L	200 mg/L	150 – 200 mg/L	120 mg/L (low) 210 mg/L (med) 400 mg/L (high)
TP	4 mg/L	2.4 mg/L	5.0 mg/L	6 – 8 mg/L	4 mg/L (low) 7 mg/L (med) 12 mg/L (high)
TKN	26 mg/L	16.4 mg/L	n/a	n/a	20 mg/L (low) 40 mg/L (med) 70 mg/L (high)

Notes:
n/a – not available
1. The "low", "med" and "high" refer to low, medium and high strength wastewaters. Low strength wastewaters based on approximate flowrate of 750 L/cap.d, medium strength on 460 L/cap·d, and high strength on 240 L/cap·d.

Based on **Table 7**, the historic and existing raw wastewater may be characterized as low strength with respect to BOD_5, TP and TKN, and low to medium strength with respect to TSS.

Based on the required provisions for 20 percent growth, and without further identification of growth specific to industry and population growth in Cornwall, the assumption of historic concentrations is considered to serve as an appropriate base. The future wastewater concentration projections were based on applying historic maximum month loading factors to historic concentrations. Adopting these values as the design basis is intended to provide some safety factor, and ensure that the design flows would include maximum month loadings.

The projected design basis concentrations for each constituent are lower than the design basis proposed in the ESR (Hydromantis, 2005). The design basis proposed in the ESR was based on typical medium strength domestic raw wastewater concentrations. However, based on historical values, the raw wastewater strength at the Cornwall WWTP is characteristic of a low strength domestic wastewater. It was assumed that the wastewater characteristics at the Cornwall WWTP will not change significantly in the future. Inherent in this assumption is that ratio of residential/institutional, commercial and industrial land uses will remain approximately the same.

4.0 SUMMARY OF DESIGN FLOWS AND LOADINGS

4.1 Updated Design Basis

The updated design basis proposed for the Cornwall WWTP is presented in **Table 8**.

A review of recent plant operating data (from January 1, 2006 to December 31, 2008) suggests that the average day flow capacity of 65,318 m^3/day recommended in the 2005 ESR remains appropriate. This will result in a 20% increase of the plant's current rated capacity.

The 2009 Pollution Control Plan Update demonstrates that the City of Cornwall is in compliance with MOE F-5-5 Guidelines; however, the 2009 PCP update suggests that it would be an effective strategy to maximize the treatment of wet-weather flows at the upgraded WWTP to reduce potential combined sewer overflows.

As discussed in Technical Memorandum No. 3, it is possible to increase the pumping station capacity up to approximately 186,000 m^3/day while maintaining a forcemain velocity of 3.0 m/s or less. Upon preliminary review, it is also noted that the existing primary clarifiers can be used for co-thickening of waste activated sludge up to 169,500 m^3/day, based on the 2008 MOE Design Guidelines. As a result, and following discussions with City staff, it is recommended that consideration be given to increasing the peak day and peak instantaneous flow for the upgraded plant up to 160,000 m^3/d. This will be reviewed further during the design phase based on value engineering and a comprehensive cost-benefit analysis. In any event, the peak flow design basis shall be 130,000 m^3/d, as a minimum, consistent with the 2005 ESR. We note that the collection system is such that peak flows can be sustained for extended periods during wet weather events. Given that all flows to the plant are pumped, the recommended peak day and peak instantaneous flow capacity are the same.

Table 8 – Proposed Cornwall WWTP Design Basis

Parameter	Updated Design Basis	2005 ESR
Average Day Flow	65,318 m^3/d	65,318 m^3/d
Peak Flow[1]	up to 160,000 m^3/d [2]	130,000 m^3/d
Peak Flow Factor[1]	2.45	2.0
BOD_5 Concentration	110 mg/L	180 mg/L
TSS Concentration	165 mg/L	200 mg/L
TP Concentration	4 mg/L	5.0 mg/L
TKN Concentration	26 mg/L	n/a

Notes:
n/a – not available
1. Peak Day and Peak Instantaneous
2. Peak Day and Peak Instantaneous shall be 130,000 m^3/d, as a minimum, consistent with the 2005 ESR.

REFERENCES

Hydromantis, 2005. Environmental Study Report: Cornwall Waste Water Treatment Plant.

Metcalf & Eddy, 2003. Wastewater Engineering – Treatment and Reuse.

MOE, 2008. Guidelines for the Design of Sewage Treatment Plants.

Statistics Canada, 2009. 2006 Cornwall Community Profile.