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BAY OF QUINTE REMEDIAL ACTION PLAN
ADVANCEMENT OF PPCPS FOR QUINTE MUNICIPALITIES: ANALYSIS OF PHOSPHORUS INPUTS TO THE BAY OF QUINTE FROM URBAN STORMWATER DISCHARGES FROM ON-BAY MUNICIPALITIES

DRAFT REPORT

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1. *INTRODUCTION*

This report describes progress to date in completing the work plan submitted to Quinte Conservation on February 3, 2009.

2. *PURPOSE*

The purpose of the proposed work tasks is to assist Quinte Conservation with making progress on the completion of Pollution Prevention and Control Plans (PPCPs) for municipalities in the Quinte RAP area, including Picton, Napanee and Deseronto; and with updating previous PPCPs that were completed for City of Belleville in 1997 and for Trenton in 1997. Completion of PPCPs is required by Recommendation #23 of the Bay of Quinte Remedial Action Plan Stage 2 Report (1993).

The RAP requirement for preparation of PPCPs was recommended as part of the RAP strategy for addressing bacteriological contamination of near-shore recreational waters. Investigations carried out during the RAP process showed that urban stormwater runoff was a primary cause of near-shore bacteriological contamination. As a result, the focus of PPCPs is on reducing the impact of urban stormwater discharges to waterfront areas.

There is also concern about the contribution that urban stormwater discharges may be making to nutrient enrichment of the Bay of Quinte; in particular, whether the phosphorus loadings from urban stormwater may by contributing to maintaining or increasing phosphorus concentrations in the Bay.

Mitigating the impact of urban stormwater discharges from existing built-up areas could require retrofit measures such as construction of end-of-pipe treatment facilities at existing storm outfalls along the waterfront. Such measures could potentially be relatively costly, in terms of initial construction cost and ongoing operational costs. As well, implementation opportunities along waterfront areas may be limited and may be at odds with other plans for waterfront improvement or redevelopment.

It is therefore important within the PPCP process to analyze the potential impact of existing urban stormwater discharges in relation to other known causes of water quality impairment in the Bay of Quinte. This analysis will help with evaluating the benefit-versus-cost of implementing retrofit outfall treatment or other stormwater management techniques that may be needed.

As important step forward, analysis of stormwater discharges relative contribution to phosphorus loadings to the Bay of Quinte is being undertaken. The results will help put the stormwater issue into perspective, and help confirm what the focus of PPCP efforts should be.

3. *INFORMATION AND DATA GATHERED*

3.1 *Sewage Treatment Plants:*

Quinte Conservation has supplied flowrate and influent/effluent quality data (monthly averages) for sewage treatment plants for Picton, Trenton, Napanee and Deseronto for the years 2001 – 2006 and the City of Belleville has supplied flowrate and influent/effluent quality data from 2005 – 2008 as indicated below in Table 1 below.

Table 1 Effluent Data for Sewage Treatment Plants: Coverage of Monthly Data for 2001-2008

	2001	2002	2003	2004	2005	2006	2007	2008
Picton	✓	✓	✓	✓	✓			
Trenton	✓		✓	✓	✓			
Belleville					✓	✓	✓	✓
Napanee	✓		✓	✓	✓			
Deseronto				✓	✓			

These data have been used to develop average monthly loadings of total phosphorus from each STP to the Bay.

3.2 *Tributary Rivers*

Quinte Conservation has provided the complete PWQMN dataset for the Prince Edward County watershed, the Napanee River watershed and the Moira River watershed.

XCG acquired additional PWQMN data directly from the Ontario Ministry of Environment for selected stations along the Trent River.

Data from the stations in Table 2 below have been used to characterize river flows in terms of average or typical monthly total phosphorus concentration at outlet to the Bay.

Table 2 Data Sources to Estimate Total Phosphorus Loads to the Bay of Quinte from Primary Tributary Rivers

River	PWQMN Station used to Characterize TP in Flow to Bay of Quinte	PWQMN Period of Record	WSC Streamflow Gauge to Estimate Monthly Streamflow Volume
Napanee River	17003500102 River Rd, County Rd 9, downstream of Napanee	• Data covers 1965-2006. • 40 samples in the period 2001-2006.	02HM007 Napanee River at Camden East: 694 km^2 out of approx 780 km^2 to Bay of Quinte. Data to 2007
Salmon River	17003100102 Dundas St, Hastings County Rd 2, Shannonville	• Data covers 1964-2006. • 45 samples in the period 2001-2006.	02HM003 Salmon R. near Shannonville: 891 km^2; data to 2007
Moira River	17002600102 Footbridge, end of Catharine St, Belleville	• Data covers 1964-2006. • 35 samples in the period 2001-2006.	02HL001 Moira R near Foxboro: 2,620 km^2 out of approx 2,735 km^2 to Bay of Quinte
Trent River	17002106802 Trent River at Dixon Drive in Trenton	• Data covers 2002-2006 with 33 samples in that period	Sum of flows at Trent River at Healey Falls (02HK002) and Crowe River at Marmora (02HK003) has been pro-rated based on land area

Appendix A provides plots (Figures A-1, A-2, A-3 and A-4) of monthly mean river flow versus observed TP concentrations in the Moira, Salmon, Napanee and Trent Rivers, for 2001-2006.

In the case of the Trent River outflow at Trenton to the Bay, it was necessary to estimate total flow at Trenton using the gauge on the Crowe River at Marmora (tributary area,990 sq. km), and the gauge on the Trent River at Healey Falls (9,090 sq. km). The flow at Trenton has been estimated by summing these two gauge flows (total tributary area 11,080 sq. km) and then pro-rating up to the total drainage area at Trenton of 12,400 sq. km. Also note that gauge flow at Healey Falls was not available for 2004, 2005 and 2006. For these years, the flow at Healey Falls has been estimated based on the flow at the Crowe River gauge, using a simple empirical function based on the historical flow record back to year 1970. Figure A-5 in Appendix A shows the results of this flow estimation method.

The PWQMN data and streamflow data have been used to develop estimates of average monthly TP loads delivered by these tributary rivers to the Bay, for the period 2001 – 2006.

3.3 Urban Drainage Areas

Figure 1 presents a map indicating the estimated boundary of the urban drainage area for Trenton, Belleville, Picton, Napanee and Deseronto.

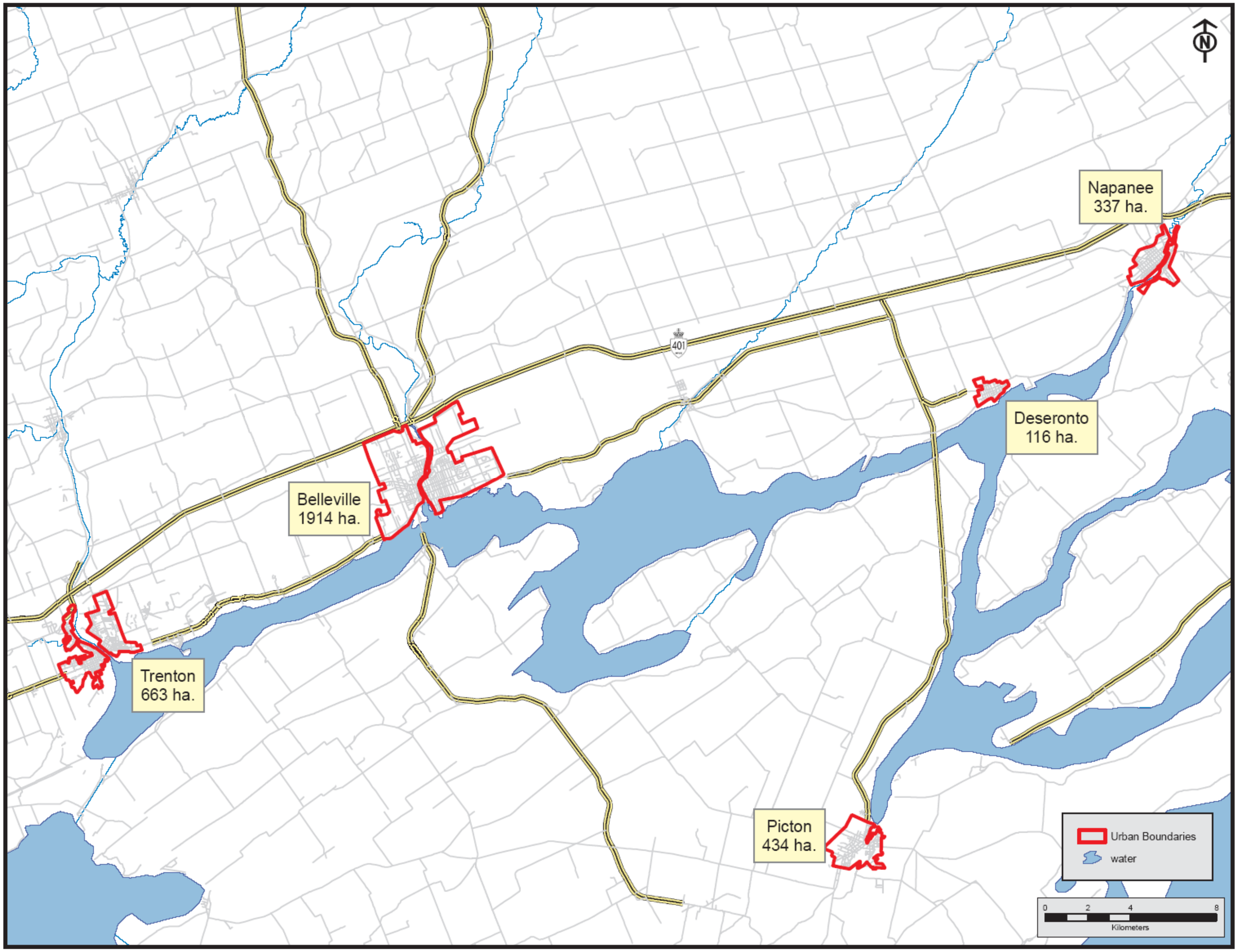


Figure 1 Urban Drainage Areas

The boundaries have been based on available mapping of urban drainage systems for each of the urban areas, including:

- The Storm Drainage System Plan for Belleville (paper copy) that had been prepared during the Belleville Pollution Control Plan (CH2M Gore & Storrie Limited, 1997).
- Drainage system plans that had previously been prepared for Picton, Napanee and Deseronto, as presented in an earlier report by XCG Consultants (XCG, 2005).
- Generalized mapping of storm sewer systems in Trenton per the 1997 Trenton PCP report (XCG, 1997).

Available digital aerial photography has also been reviewed to help with final estimation of the extent of urban area served by municipal drainage systems.

3.4 Phosphorus Levels in Urban Runoff

Sampling of selected number of storm drainage outfalls was carried out in 2008 by Quinte Conservation, in both dry weather and wet weather.

Results of the initial sampling rounds were provided by Quinte Conservation to XCG Consultants. Sample analysis included analysis for Total Phosphorus (TP), and these data therefore assist with determining average or representative phosphorus concentrations to assist with estimating monthly and annual loadings carried by urban runoff.

Additionally, XCG has reviewed a number of literature sources with respect to the range and typical values of TP concentration in urban runoff, particularly in southern Ontario. As well, some limited data were reported in the Trenton Pollution Control Planning Study (XCG Consultants, 1997).

See below for how this information has been applied to estimate monthly and annual TP loadings from urban runoff form Trenton, Belleville, Picton, Napanee and Deseronto.

4. *ESTIMATION OF URBAN RUNOFF TP LOADINGS*

4.1 Overview

Locations in Study Area: Urbanized areas of Trenton, Belleville, Napanee, Deseronto, and Picton.

Variable of Interest: Total phosphorus load (L, in kilograms) by calendar month or on an annual basis.

Method of Analysis: For a specified time interval (one month or one year), L was calculated as the product of concentration (C) and urban area runoff volume (V).

4.2 Urban Area Runoff Volume

Because there are no long-term streamflow records for storm sewer outfalls, long-term urban area runoff volume must be determined by simulation, using either (i) a calibrated, continuous urban runoff model and historical precipitation and temperature data, or (ii) an analysis of historical streamflow data for a gauged drainage basin that is and has been for some time almost completely urbanized.

For this study, the second simulation method was selected. It is more efficient and likely more accurate in that (i) a calibrated continuous urban runoff model for these outfalls does not exist. And (ii) data do not exist to develop one.

After a review of the long-term streamflow data for a number of urbanized basins on the north shore of Lake Ontario, two drainage basins in the Toronto area were selected as indicator basins for urban runoff simulation: Black Creek near Weston (02HC027) and Highland Creek near West Hill (02HC013).

- Time series of annual runoff volume were analyzed to determine the year in which annual streamflow stabilized at a constant value. The overall data set was censored so as to begin at this year.
- To allow for the difference in drainage basin area, monthly and annual runoff volumes were expressed in terms of depth of runoff (in mm).
- The effective connected impervious area was determined by assuming that, on a long-term basis, the summer month runoff was generated solely by rain falling on connected impervious surfaces, with a small abstraction due to depression storage.
- The urban area runoff depths, on a monthly basis, for Toronto rainfall conditions were taken as the average monthly runoff depths for Black Creek and Highland Creek.

A review of climate normals data for rainfall for Toronto Pearson, Trenton, Belleville and Napanee indicated that:

- there was no significant difference (for the purposes of this study) between any of the three eastern Ontario stations, and
- there was a significant difference between Toronto Pearson the three eastern Ontario stations, particularly in the summer month of July.

Accordingly, Belleville was selected as the climate station for this study.

Monthly values of urbanized area runoff depths for the five locations in the study area were determined by multiplying the Toronto area average depths by the ratio of Belleville rainfall to Toronto Pearson rainfall.

4.3 Monthly TP Concentration

Analysis of the technical literature on the subject of event-based TP concentrations reveals the following facts:

- The overall range is one order of magnitude – from about 0.1 mg/l to about 1 mg/l.
- The lower values correspond to large runoff events on clean pavement.
- The higher values correspond to winter and spring events in northern areas.
- Event values for sewer outfalls in Belleville are about 0.2 mg/l (based on 2008 sampling data provided by Quinte Conservation).
- Event values for parking lot runoff (June through October) in Kingston are about 0.2 mg/l.
- Values for Toronto reported by Heaney et al. (1999) range from 0.31 for streets to 0.56 for landscaped areas.
- Spring and winter values for northern U.S. states are up to 1 mg/l.
- The average value reported by NURP is 0.46 mg/l.

Following a review of the information given above, the following interim values for eastern Ontario sites are proposed:

Time of Year	Typical TP Concentration in Urban Runoff
June- October	0.2 mg/l
November	0.3 mg/l
December- February	0.5 mg/l
March and April	0.6 mg/l
May	0.4 mg/l

4.4 Results

The data provided in Tables 3 to 7 is more or less self-explanatory and follows the above discussion.

- The first row for all locations gives the Belleville rainfall (in mm). Different values for each location can be used later if so desired.
- The second row gives the depth of runoff for all locations, calculated by adjusting the Toronto runoff by the ratio of Belleville rainfall to Toronto rainfall.
- The third row transforms depth of runoff in 1000 cubic metres.
- The fourth row gives monthly average TP concentrations in mg/l, which can be updated.
- The fifth row gives the monthly and annual TP load in kg.

Table 3: Urban Stormwater TP Loadings for Trenton (Area = 663 ha)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Rainfall (mm)	33.2	28	47.9	67.7	73.9	70.9	52.7	80.7	86.4	75.4	75.7	43.4	735.9
Runoff (mm)	33	36	59	49	39	33	32	37	36	33	40	38	464
Runoff (1000 m^3)	216	238	391	325	257	216	214	243	238	220	268	251	3075
Concentration (mg/L)	0.5	0.5	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.5	
Loading (kg)	108	119	235	195	103	43	43	49	48	44	80	125	1191

Table 4: Urban Stormwater TP Loadings for Belleville (Area = 1914 ha)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Rainfall (mm)	33.2	28	47.9	67.7	73.9	70.9	52.7	80.7	86.4	75.4	75.7	43.4	735.9
Runoff (mm)	33	36	59	49	39	33	32	37	36	33	40	38	464
Runoff (1000 m^3)	624	686	1130	938	742	622	617	701	688	635	773	724	8878
Concentration (mg/L)	0.5	0.5	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.5	
Loading (kg)	312	343	678	563	297	124	123	140	138	127	232	362	3439

Table 5: Urban Stormwater TP Loadings for Napanee (Area = 337 ha)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Rainfall (mm)	33.2	28	47.9	67.7	73.9	70.9	52.7	80.7	86.4	75.4	75.7	43.4	735.9
Runoff (mm)	33	36	59	49	39	33	32	37	36	33	40	38	464
Runoff (1000 m^3)	110	121	199	165	131	110	109	123	121	112	136	127	1563
Concentration (mg/L)	0.5	0.5	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.5	
Loading (kg)	55	60	119	99	52	22	22	25	24	22	41	64	605

Table 6: Urban Stormwater TP Loadings for Deseronto (Area = 116 ha)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Rainfall (mm)	33.2	28	47.9	67.7	73.9	70.9	52.7	80.7	86.4	75.4	75.7	43.4	735.9
Runoff (mm)	33	36	59	49	39	33	32	37	36	33	40	38	464
Runoff (1000 m^3)	38	42	68	57	45	38	37	42	42	38	47	44	538
Concentration (mg/L)	0.5	0.5	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.5	
Loading (kg)	19	21	41	34	18	8	7	8	8	8	14	22	208

Table 7: Urban Stormwater TP Loadings for Picton (Area = 434 ha)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Rainfall (mm)	33.2	28	47.9	67.7	73.9	70.9	52.7	80.7	86.4	75.4	75.7	43.4	735.9
Runoff (mm)	33	36	59	49	39	33	32	37	36	33	40	38	464
Runoff (1000 m^3)	141	155	256	213	168	141	140	159	156	144	175	164	2013
Concentration (mg/L)	0.5	0.5	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0.5	
Loading (kg)	71	78	154	128	67	28	28	32	31	29	53	82	780

5. ESTIMATION OF TP LOADS FROM OTHER SOURCES

5.1 Loads from Tributary Rivers

The Total Phosphorus sampling data from the Provincial Water Quality Monitoring Network (PWQMN stations per Table 2 above) has been used to develop average in-river TP concentrations for each calendar month, for 2001 to 2006. The results are listed in Table 8.

The streamflow data from Water Survey of Canada gauges (per Table 2 above) has been used to estimate average monthly mean flowrate for the same period. Results are provided in Table 9.

Table 10 then provides the resulting estimates of average monthly and annual TP loads to the Bay of Quinte from the Trent, Moira, Salmon and Napanee Rivers.

5.2 Loads from Municipal Sewage Treatment Plants

The available data on sewage plant effluent for the municipal plants in Trenton, Belleville, Picton, Napanee and Deseronto have been used to estimate average monthly effluent discharge to the Bay of Quinte. Table 11 presents the results.

Table 8: Tributary Rivers - MONTHLY MEAN TP CONCENTRATIONS based on PWQMN data fro 2001-2006

MONTH	Trent River Trent River-Dixon Dr, Trenton PWQMN 17002106802 # values	 Average mg/L	Moira River Footbridge, end of Catharine St, Belleville (PWQMN data) # values	 Average mg/L	Salmon River Dundas St, Hastings Cnty Rd 2, Shannonville (PWQMN data) # values	 Average mg/L	Napanee River River Rd, Cnty Rd 9, dwnstrm Napanee (Source: PWQMN) # values	 Average mg/L
Jan	0	na	0	na	1	0.012	0	na
Feb	0	na	0	na	2	0.020	0	na
Mar	0	na	0	na	2	0.020	0	na
Apr	1	0.023	3	0.019	4	0.017	4	0.027
May	4	0.018	3	0.024	3	0.016	3	0.034
Jun	8	0.037	5	0.018	5	0.025	5	0.043
Jul	7	0.028	5	0.015	6	0.022	6	0.063
Aug	7	0.026	5	0.021	4	0.020	4	0.061
Sep	1	0.019	4	0.020	6	0.022	6	0.050
Oct	3	0.016	5	0.015	6	0.016	6	0.029
Nov	1	0.018	5	0.019	4	0.014	4	0.035
Dec	1	0.025	0	na	2	0.015	2	0.022
ALL	33	0.027	35	0.019	45	0.019	40	0.043

Table 9: Tributary Rivers - MONTHLY MEAN FLOW based on Water Survey of Canada data for 2001-2006

MONTH	Trent River # values	 Mean flow m^3/s	Moira River # values	 Mean flow m^3/s	Salmon River # values	 Mean flow m^3/s	Napanee River # values	 Mean flow m^3/s
Jan	6	148.2	6	39.7	6	15.3	5	10.9
Feb	6	107.9	6	31.2	6	12.1	5	7.8
Mar	6	132.7	6	48.6	6	18.8	5	13.8
Apr	6	279.1	6	83.9	6	29.4	5	24.5
May	6	162.2	6	39.2	6	15.2	5	11.2
Jun	6	99.6	6	26.0	6	10.7	5	7.9
Jul	6	48.2	6	7.8	6	3.7	5	2.6
Aug	6	40.4	6	2.7	6	1.3	5	1.5
Sep	6	39.0	6	4.7	6	1.9	5	2.0
Oct	6	54.5	6	10.0	6	4.3	5	2.0
Nov	6	96.3	6	31.9	6	12.3	5	5.9
Dec	6	132.7	6	51.0	6	20.2	5	13.0
ALL	72	111.7	72	31.4	72	12.1	60	8.6

Table 10: Tributary Rivers - ESTIMATED MONTHLY AVERAGE TP LOADS

MONTH	Trent River TP conc.	 TP load kg	Moira River TP conc.	 TP load kg	Salmon River TP conc.	 TP load kg	Napanee River TP conc.	 TP load kg
Jan	0.027	10,600	0.019	2,000	0.012	500	0.043	1,200
Feb	0.027	7,000	0.019	1,400	0.020	600	0.043	800
Mar	0.027	9,500	0.019	2,400	0.020	1,000	0.043	1,600
Apr	0.023	16,600	0.019	4,200	0.017	1,300	0.027	1,700
May	0.018	7,700	0.024	2,500	0.016	600	0.034	1,000
Jun	0.037	9,600	0.018	1,200	0.025	700	0.043	900
Jul	0.028	3,600	0.015	300	0.022	200	0.063	400
Aug	0.026	2,900	0.021	100	0.020	100	0.061	200
Sep	0.019	1,900	0.020	200	0.022	100	0.050	300
Oct	0.016	2,400	0.015	400	0.016	200	0.029	200
Nov	0.018	4,500	0.019	1,600	0.014	400	0.035	500
Dec	0.025	8,900	0.019	2,500	0.015	800	0.022	700
ALL		85,200		18,800		6,500		9,500

Note: TP concentration used to estimate monthly river loads is based on the PWQMN average for the calendar month (2001-2006) as listed above; or for months with no PWQMN observations, the average of all 2001-2006 data has been applied.

Table 11

Average monthly load (kg) of Total Phosphorus discharged from municipal sewage treatment plants

based on available data for 2001 to 2008

	Napanee		Trenton		Picton		Deseronto		Belleville	
	Number of years with data	TP load (kg)	Number of years with data	TP load (kg)	Number of years with data	TP load (kg)	Number of years with data	TP load (kg)	Number of years with data	TP load (kg)
January	4	42	4	85	5	47	2	6.6	4	216
February	4	32	3	48	5	132	2	4.8	4	133
March	4	55	4	61	5	71	2	11.8	4	296
April	4	43	4	62	5	48	2	5.9	4	330
May	4	40	4	67	5	54	2	13.1	4	110
June	4	42	4	63	5	17	2	3.2	4	117
July	4	35	4	92	5	15	2	1.7	4	166
August	4	35	4	60	5	25	2	4.7	4	132
September	4	28	4	65	5	20	2	3.2	4	111
October	4	24	4	73	5	18	2	6.2	4	144
November	4	48	4	90	5	30	2	7.5	4	131
December	4	58	4	92	5	46	2	5.9	4	186
Year		482		857		522		74.5		2071

6. COMPARISON OF LOADS FROM THREE SOURCES

Previous examinations of the Bay of Quinte phosphorus budget have generally been based on the considering or describing the total external phosphorous input into the Bay of Quinte as originating primarily from municipal sewage treatment plants, the major tributary rivers (Trent, Moira, Salmon and Napanee Rivers) and atmospheric deposition processes.

Comparing estimates of the load carried by urban runoff directly into the Bay is therefore useful for the purpose of providing a more complete examination or description of other sources of external TP input.

First of all, it is useful to compare the urban runoff load from each urban area with the load from the corresponding municipal sewage treatment plant.

Figures 2 to 6 provide this comparison on the basis of the estimated average monthly load from each of these two municipal sources.

It is noteworthy that:

- The urban runoff TP load is generally of the same magnitude as load from the sewage treatment plant (WPCP).
- During the summer months, the estimated urban runoff TP load may equal or exceed that from the sewage plants.

Figure 7 shows how all three source types vary by month. This graph shows that while the tributary river inputs decline through the summer months, they nonetheless remain much larger than the other two sources combined.

Figure 8 compares estimated TP loadings into the Bay of Quinte from the three source types, for the June-September summer period, which is generally considered to be the critical period with respect to excessive growth of algae and resulting impacts on water quality especially dissolved oxygen levels. Figure 8 clearly shows that, as expected from previous studies, the tributary rivers are the overwhelming source.

Figure 8 also shows that over the summer period, the estimated load from urban runoff is nearly equal that from the municipal sewage plants. This is noteworthy finding, inasmuch as considerable effort has been made over recent years to improve treatment process at each of the STPs and thereby reduce their role in maintaining sum TP levels in the Bay. The finding here may point to the fact that it may make sense to now turn some attention and resources to reducing the TP load from urban runoff directly into the Bay.

Some questions that will need to be answered include the following.

1. What specific measures or techniques can be used to reduce TP levels in urban runoff, and what is the cost per kilogram reduction in phosphorus loadings? Previous review of available information on the efficacy of

conventional end-of-pipe stormwater treatment ponds (summarized in XCG, 2006) indicated that long-term phosphorus removal by such ponds may be 50% of incoming load. What other removal measures can be considered, what are their costs, and how do those costs (considering full life-cycle costing) compare with costs of further process improvements at the STPs?

2. What is the bio-availability of phosphorus carried in urban stormwater, versus that originating from sewage treatment plants? This will depend on the specific phosphorus compounds that constitute the TP load from each source.

3. Does the intermittent nature of stormwater discharges and the fact that they are restricted to near-shore areas limit their impact on the Bay as a whole?

Answering these questions will require further effort and analysis. Further advancement of the PPCP process for each of Belleville, Trenton, Picton and Napanee will assist, by identifying specific opportunities and associated costs to retrofit improvement to municipal storm drainage systems to reduce runoff volumes and/or TP loadings to the Bay.

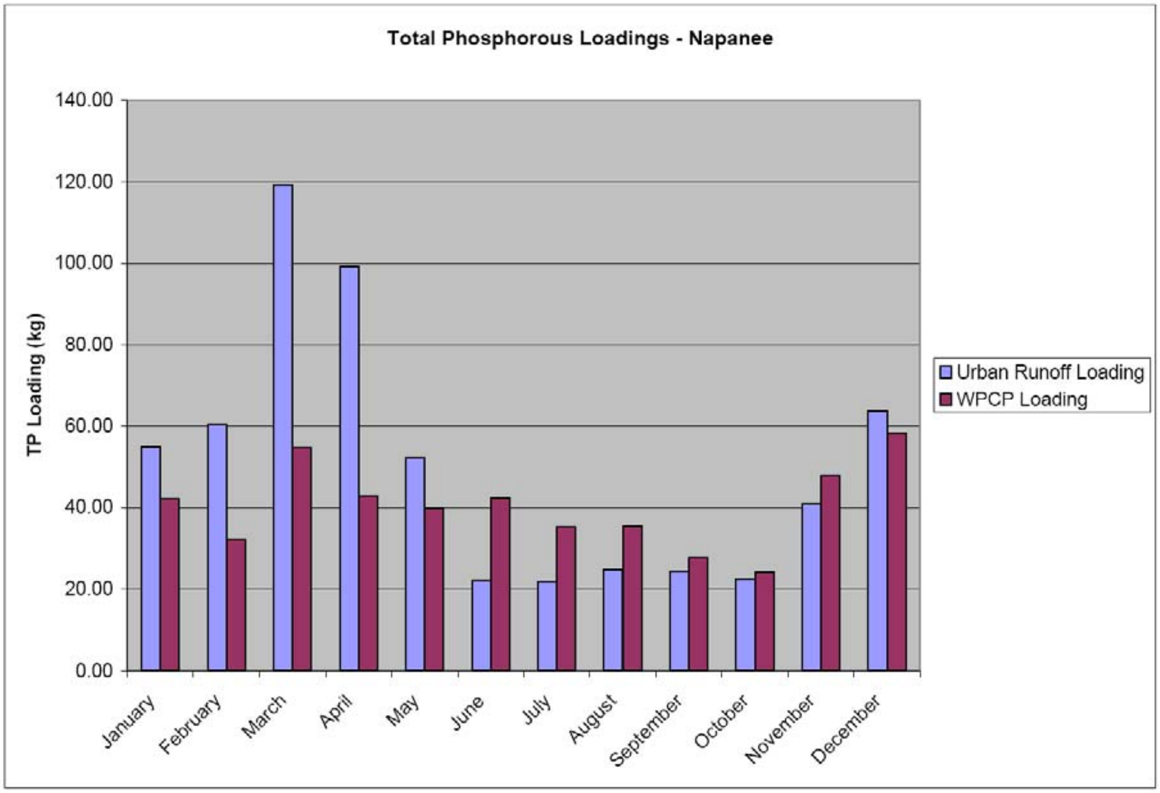


Figure 2 Total Phosphorous Loadings – Napanee

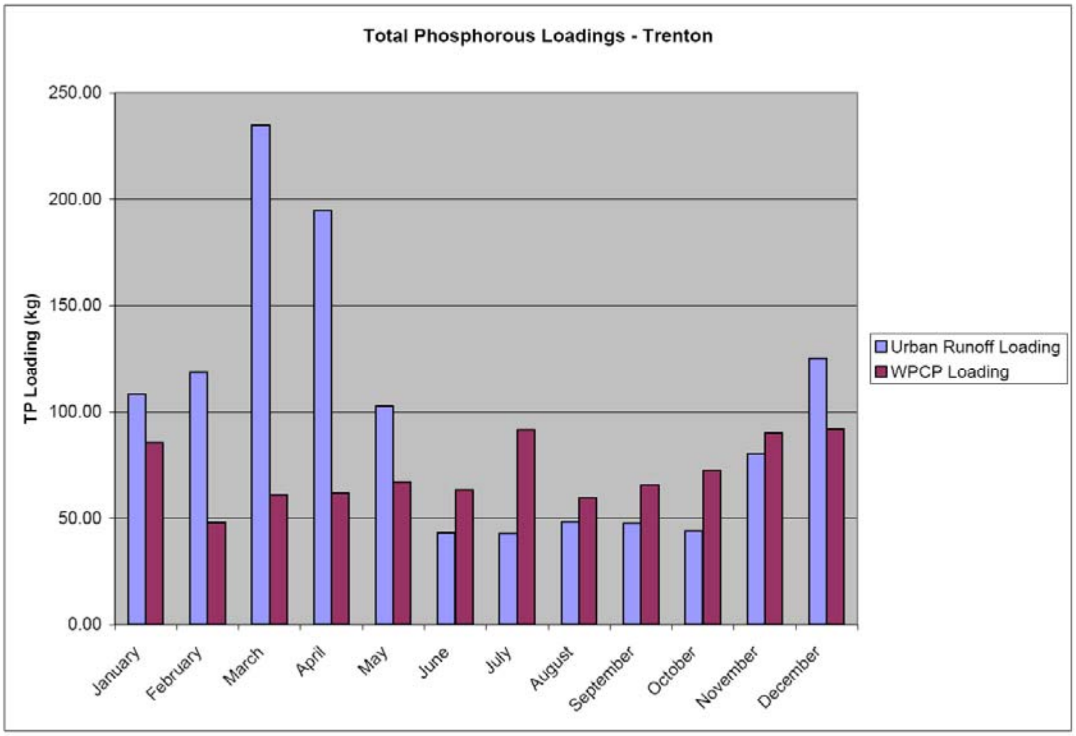


Figure 3 Total Phosphorous Loadings – Trenton

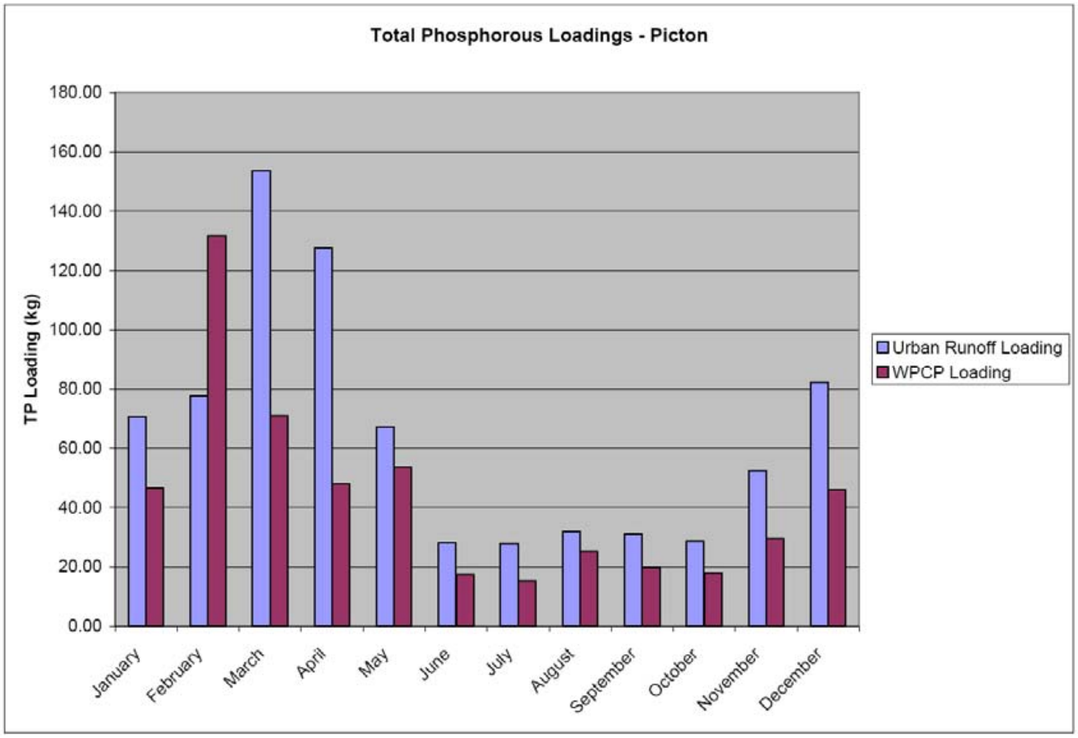


Figure 4 Total Phosphorous Loadings – Picton

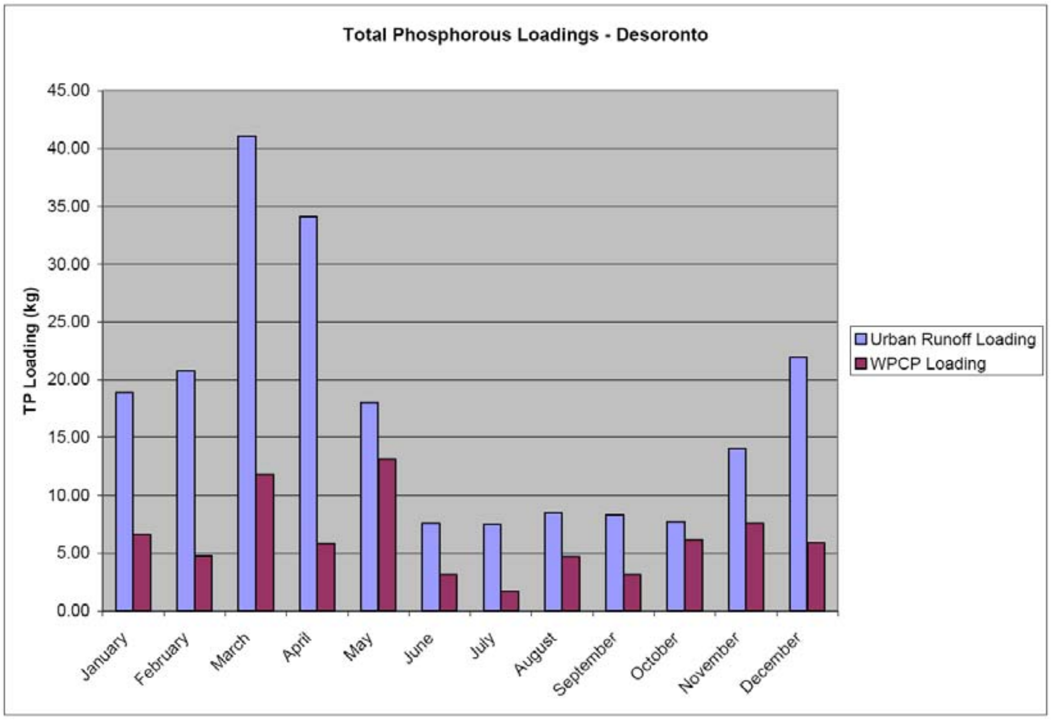


Figure 5 Total Phosphorous Loadings – Deseronto

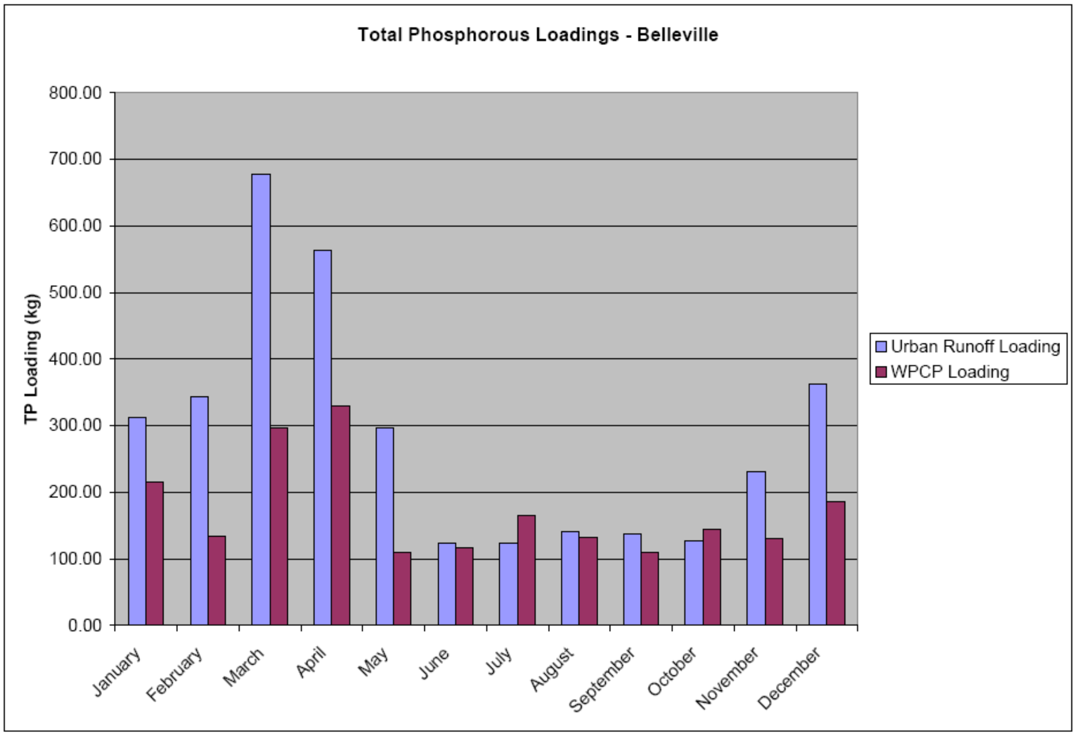


Figure 6 Total Phosphorous Loadings – Belleville

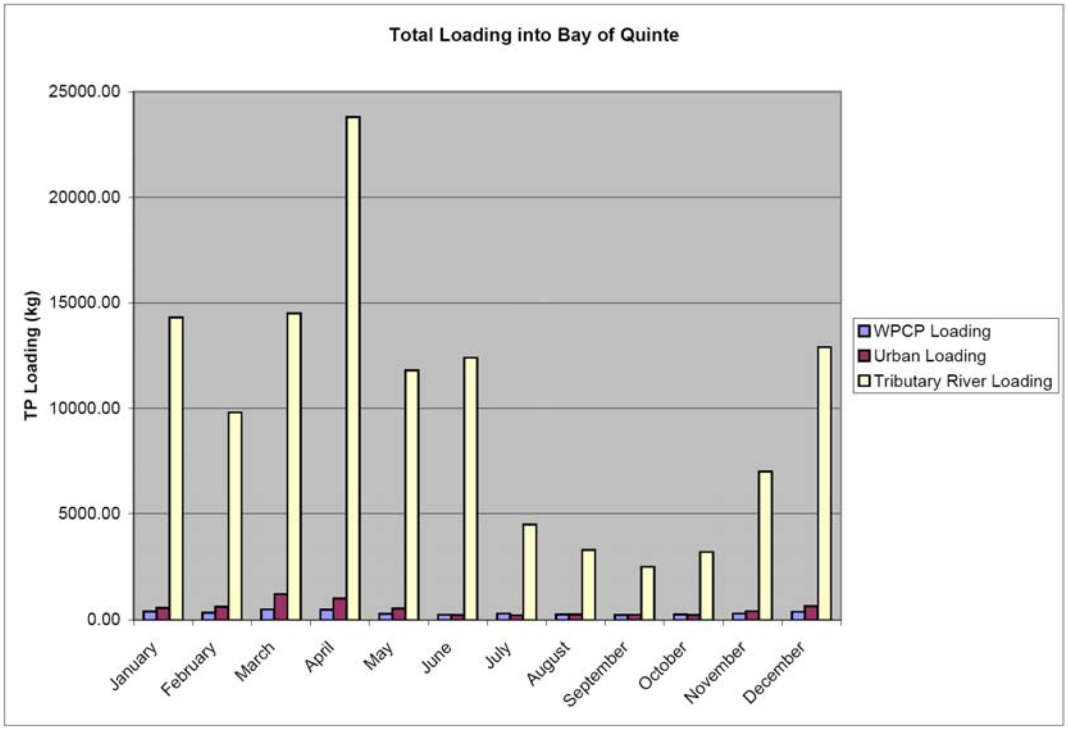
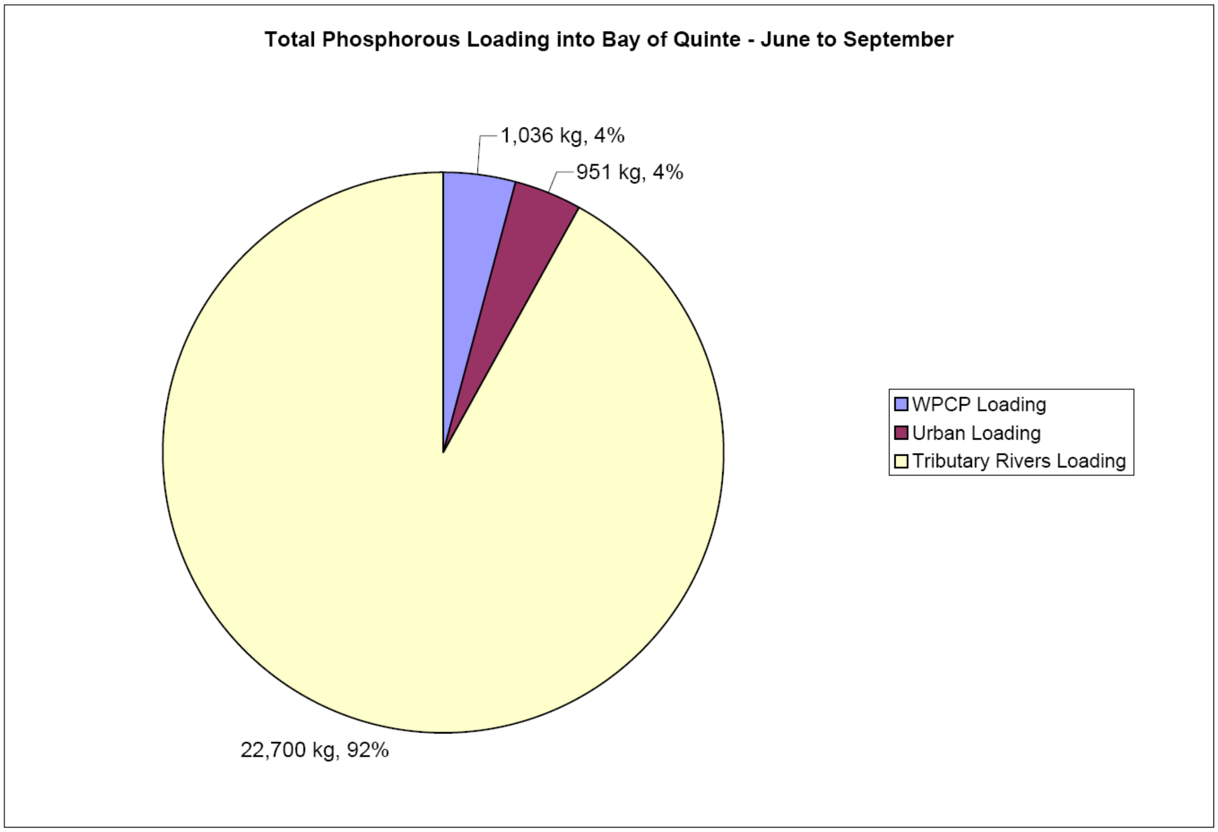


Figure 7 Comparison of Estimated Monthly TP Load from the Three Sources to The Bay

Figure 8 Estimated Loading into Bay of Quinte from the Three Sources, for June - September



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<u>Literature sources for data on typical urban runoff phosphorus concentration</u>

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Van Buren, M.A. 1994. Constituent mass balance for an urban stormwater detention pond in Kingston Township. Unpublished MSc Thesis, Department civil Engineering, Queen's University, Kingston, Ontario. (Kingston value)

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APPENDIX A

PLOTS OF MONTHLY MEAN FLOWRATE AND PWQMN TP CONCENTRATION IN TRIBUTARY RIVERS

Figure A-1

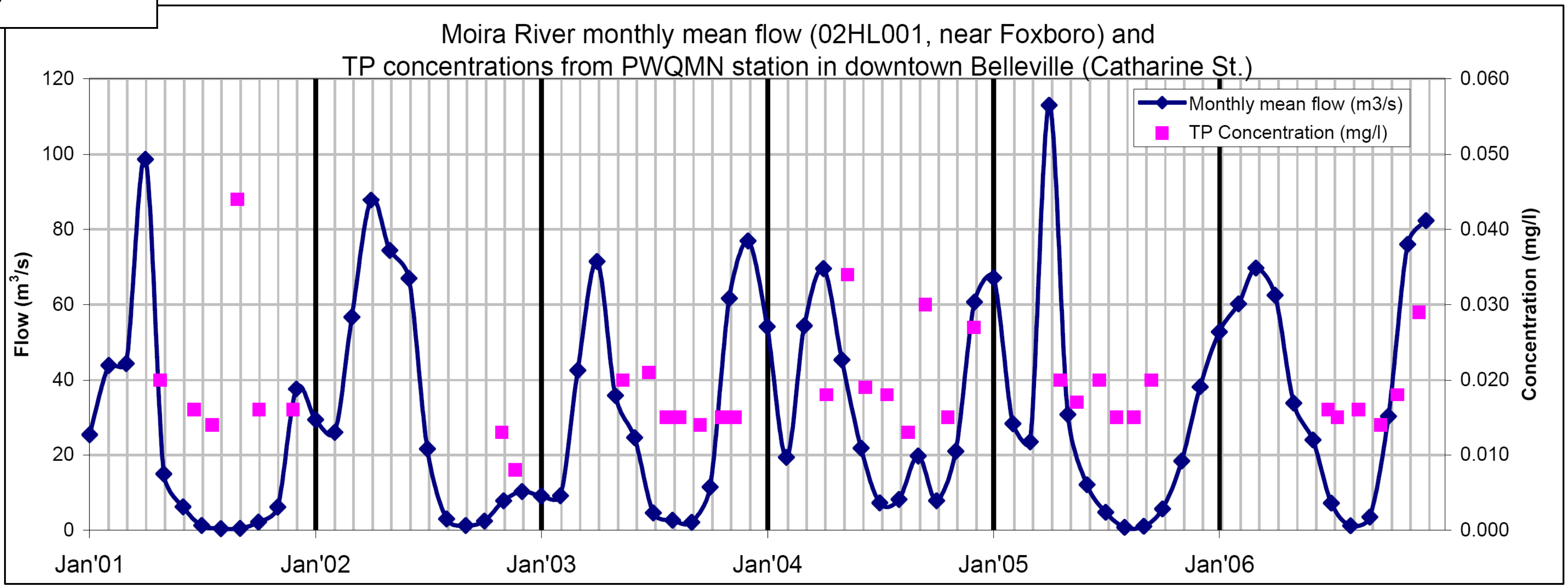


Figure A-2

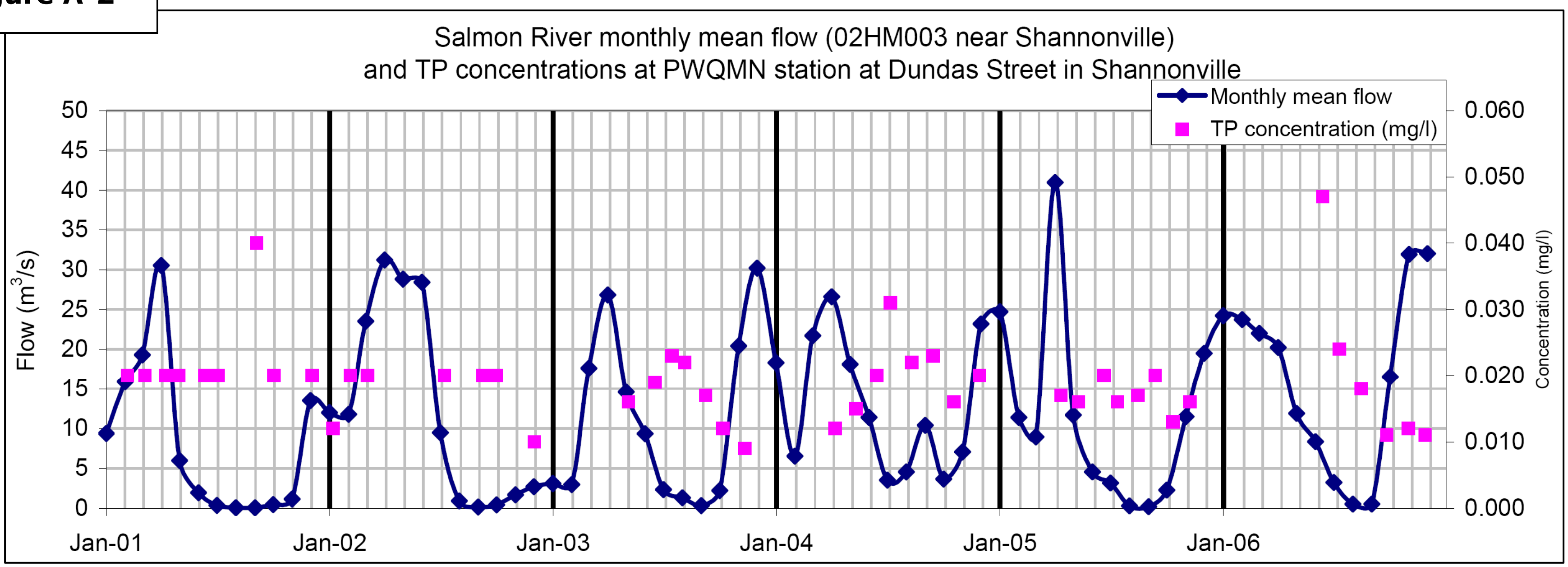
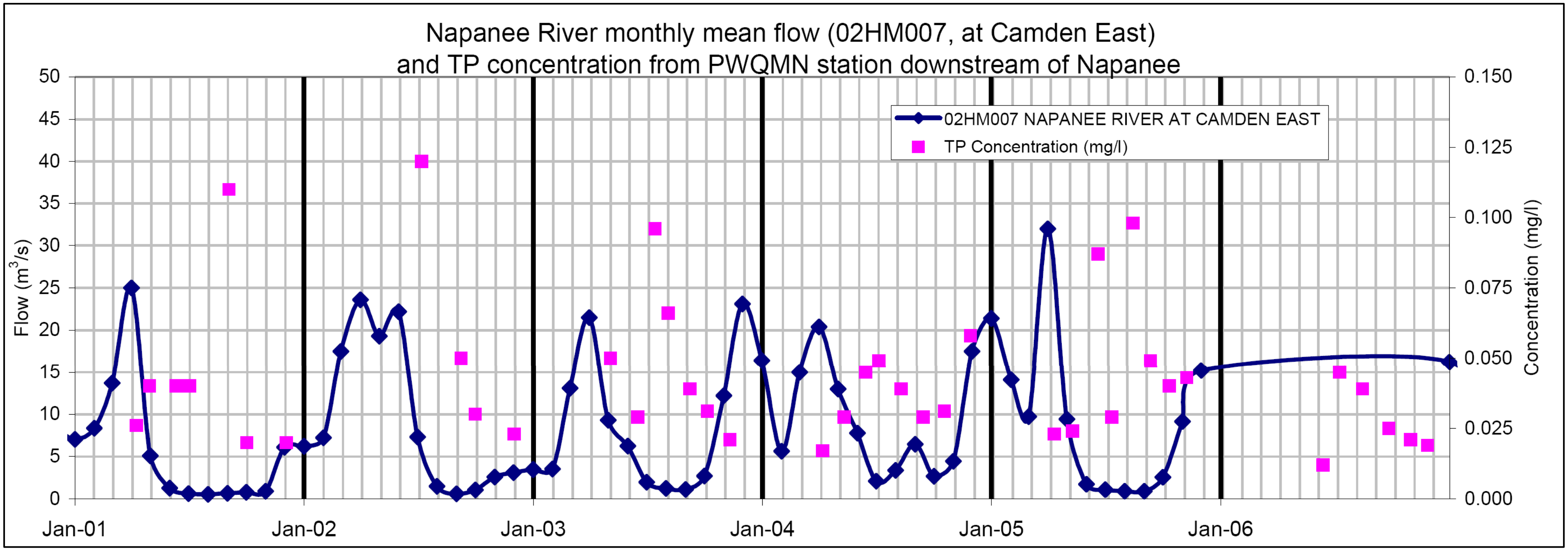
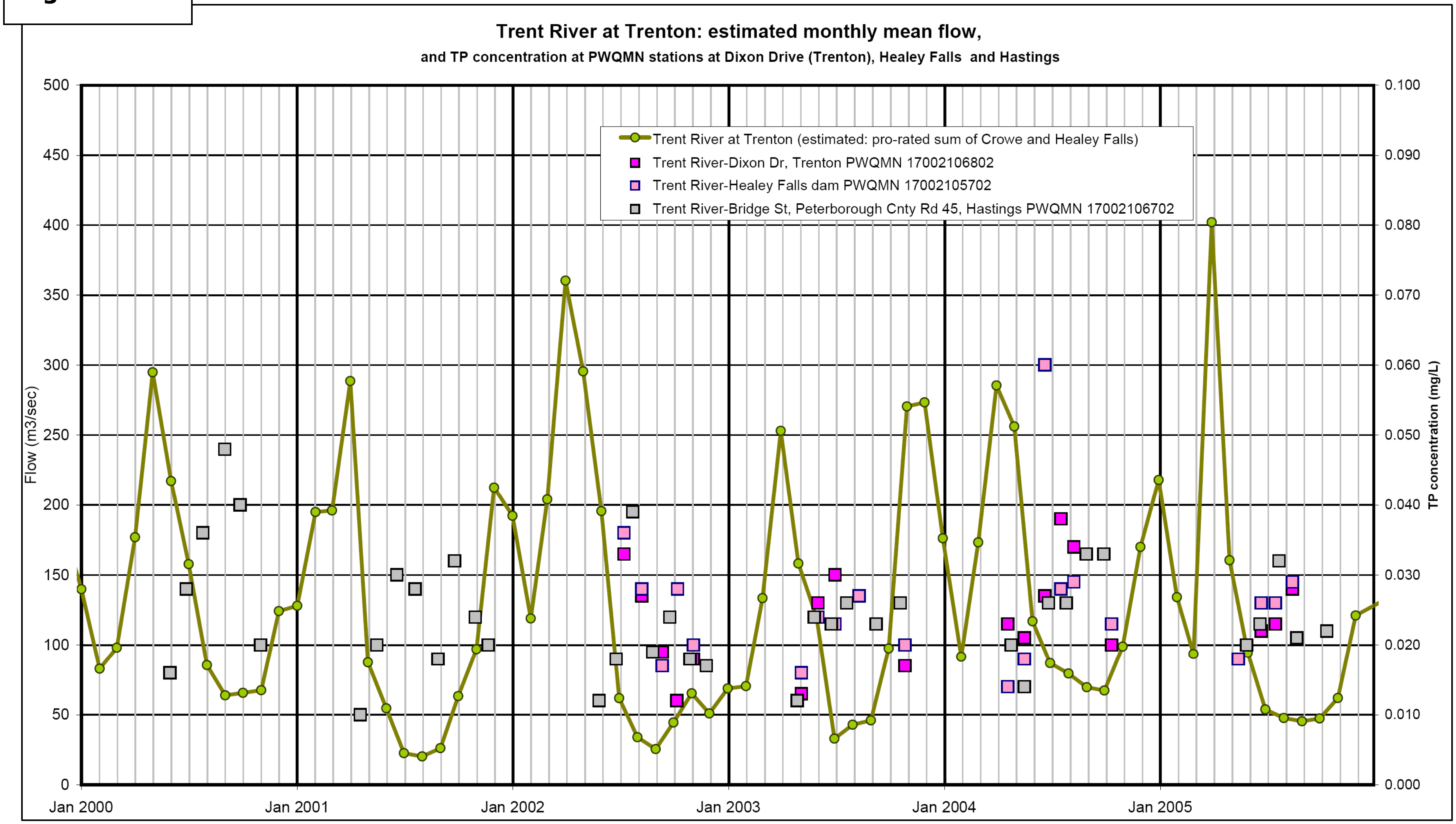


Figure A-3



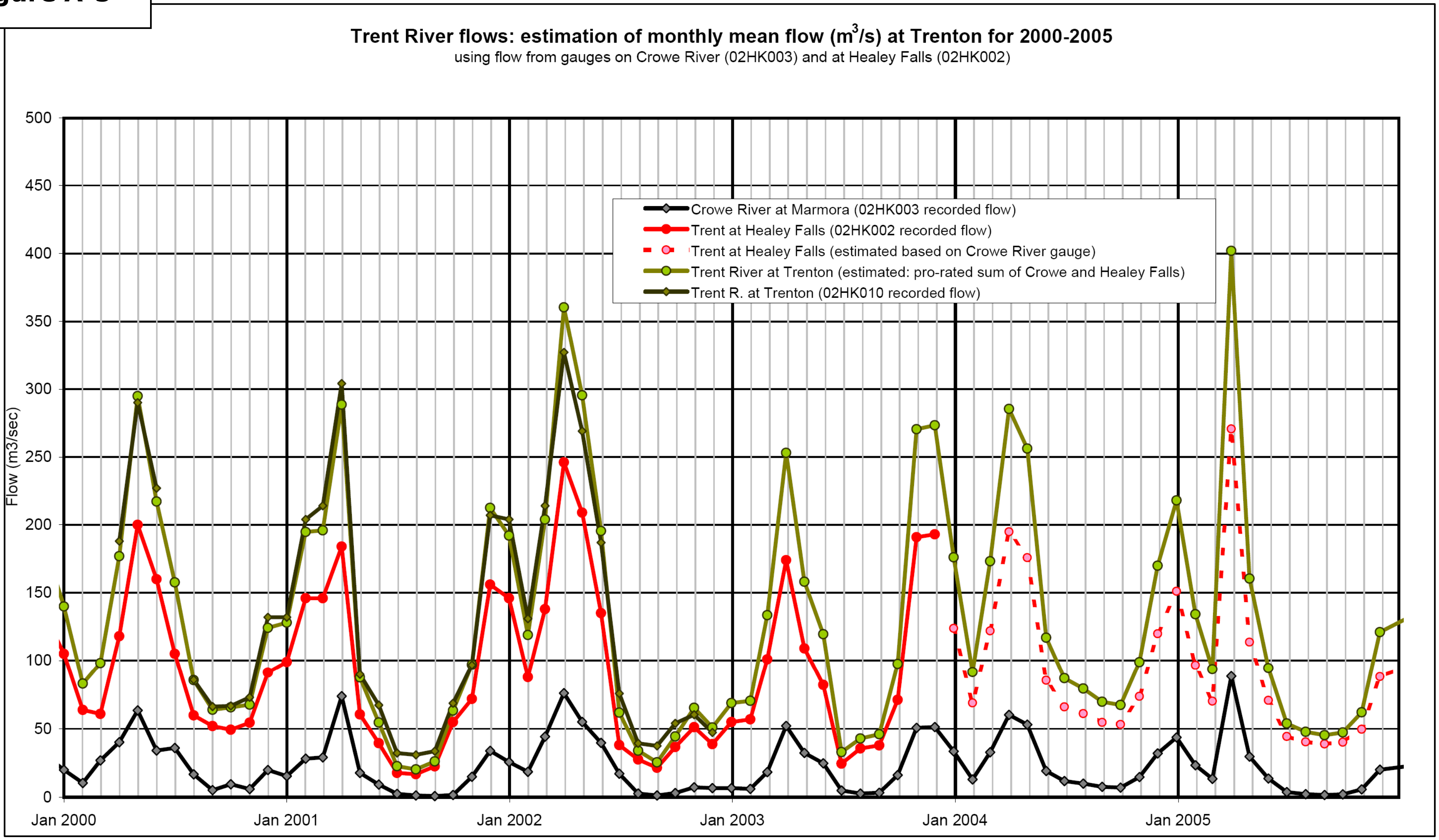
Napanee River monthly mean flow (02HM007, at Camden East)
and TP concentration from PWQMN station downstream of Napanee
02HM007 NAPANEE RIVER AT CAMDEN EAST
TP Concentration (mg/l)
Flow (m^3/s)
Concentration (mg/l)
50
45
40
35
30
25
20
15
10
5
0
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

Figure A-4



Trent River at Trenton: estimated monthly mean flow,
and TP concentration at PWQMN stations at Dixon Drive (Trenton), Healey Falls and Hastings
Trent River at Trenton (estimated: pro-rated sum of Crowe and Healey Falls)
Trent River-Dixon Dr, Trenton PWQMN 17002106802
Trent River-Healey Falls dam PWQMN 17002105702
Trent River-Bridge St, Peterborough Cnty Rd 45, Hastings PWQMN 17002106702
Flow (m3/sec)
TP concentration (mg/L)
500
450
400
350
300
250
200
150
100
50
0
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Jan 2000
Jan 2001
Jan 2002
Jan 2003
Jan 2004
Jan 2005

Figure A-5



Trent River flows: estimation of monthly mean flow (m^3/s) at Trenton for 2000-2005
using flow from gauges on Crowe River (02HK003) and at Healey Falls (02HK002)
Crowe River at Marmora (02HK003 recorded flow)
Trent at Healey Falls (02HK002 recorded flow)
Trent at Healey Falls (estimated based on Crowe River gauge)
Trent River at Trenton (estimated: pro-rated sum of Crowe and Healey Falls)
Trent R. at Trenton (02HK010 recorded flow)
Flow (m3/sec)
500
450
400
350
300
250
200
150
100
50
0
Jan 2000
Jan 2001
Jan 2002
Jan 2003
Jan 2004
Jan 2005

APPENDIX B

WET-WEATHER STORM OUTFALL SAMPLING RESULTS FROM TRENTON, ONTARIO

(EXCERPT FROM THE 1997 TRENTON POLLUTION CONTROL PLANNING STUDY FINAL REPORT)

Wet-weather Storm Outfall Sampling Results from Trenton, Ontario (excerpt from the 1997 Trenton Pollution Control Planning Study Final Report)

4.3.2 Stormwater Contributions to Phosphorus Inputs to the Bay of Quinte

Stormwater Total Phosphorus (TP) Concentrations at Trenton

Some measurements on phosphorus levels in storm discharges from Trenton were collected during the 1997 monitoring program. The wet-weather phosphorus values from storm sewers are listed in Table 11.

Table 11
Wet-weather Total Phosphorus Concentrations (mg/L)
from Various Storm Sewers in the City of Trenton – Summer 1997

Outfall	Total Phosphorus (mg/L)			
	Event No. 1	*Sample type*	*Event No. 2*	*Sample type*
E40* *Dixon Drive	0.26	Event composite	0.06	Event composite
Q30* *Victoria Avenue	0.25	Event composite	0.10	Event composite
Q15* *Parkside Drive	0.25	Mid-event grab	0.08	Mid-event grab
Q90* *South Street	0.39	Mid-event grab	0.08	Mid-event grab
Q110* *Couch Crescent	0.19	Mid-event grab	0.08	Mid-event grab

This data set indicates that wet-weather TP levels in storm drainage from Trenton vary from approximately 0.1 to 0.4 mg/L.

Estimation of Annual TP Load from Trenton Stormwater

The information has been used to examine TP load from storm drainage from Trenton that enters the Trent River and Bay of Quinte. Table 12 provides an estimate of average total annual load from Trenton storm drainage, with comparison to the load from the Trenton Sewage Treatment Plant (STP). Note that the estimated average annual phosphorus load from Trenton land drainage is of the same order as the contribution from Trenton's upgraded STP.

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