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Urban water quality modelling: quantifying the fecal coliform load in the Beauport River

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September 6th 2012
9th UDM Conference

Centre - Eau Terre Environnement

Ville de Québec

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Water quality in Quebec

Canada

Quebec city's Beauport Bay

Photo: LeSoleil

Case Study – Beauport River

Collaboration with Quebec City

- Engineering Services
- Public Works
- Environmental Services

VILLE DE QUÉBEC

Objectives

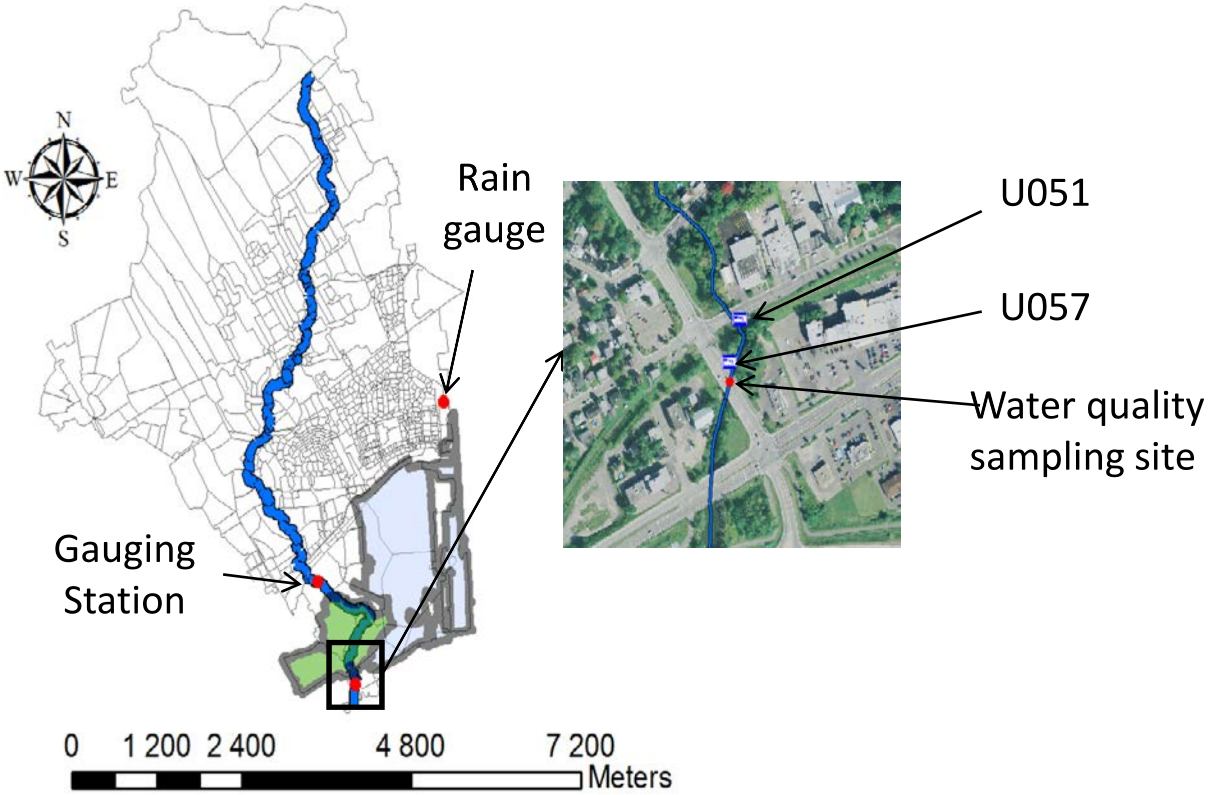
1) Identify sources of fecal coliform in the Beauport River
2) Look for relationship between potential explanatory variables
3) Quantify fecal coliform load from different sources

Plan

1. Presentation of Beauport River watershed
2. Available data
    - Potential explanatory variables
3. Modelling
    - Hydrologic/hydraulic
    - Quality
4. Results
    - Potential explanatory variables
    - Estimation of fecal coliform load

1. Beauport River watershed – Drainage systems

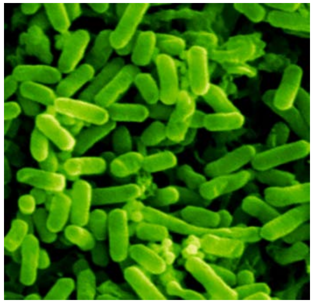
Beauport River characteristics	
Watershed	28.7 km²
River length	22 km
Average flow	0.74 m³/s
Minimum flow	0.18 m³/s
Land use	**%**
Residential	**51**
Commercial	2
Industrial	6
Agriculture	4
Open	36

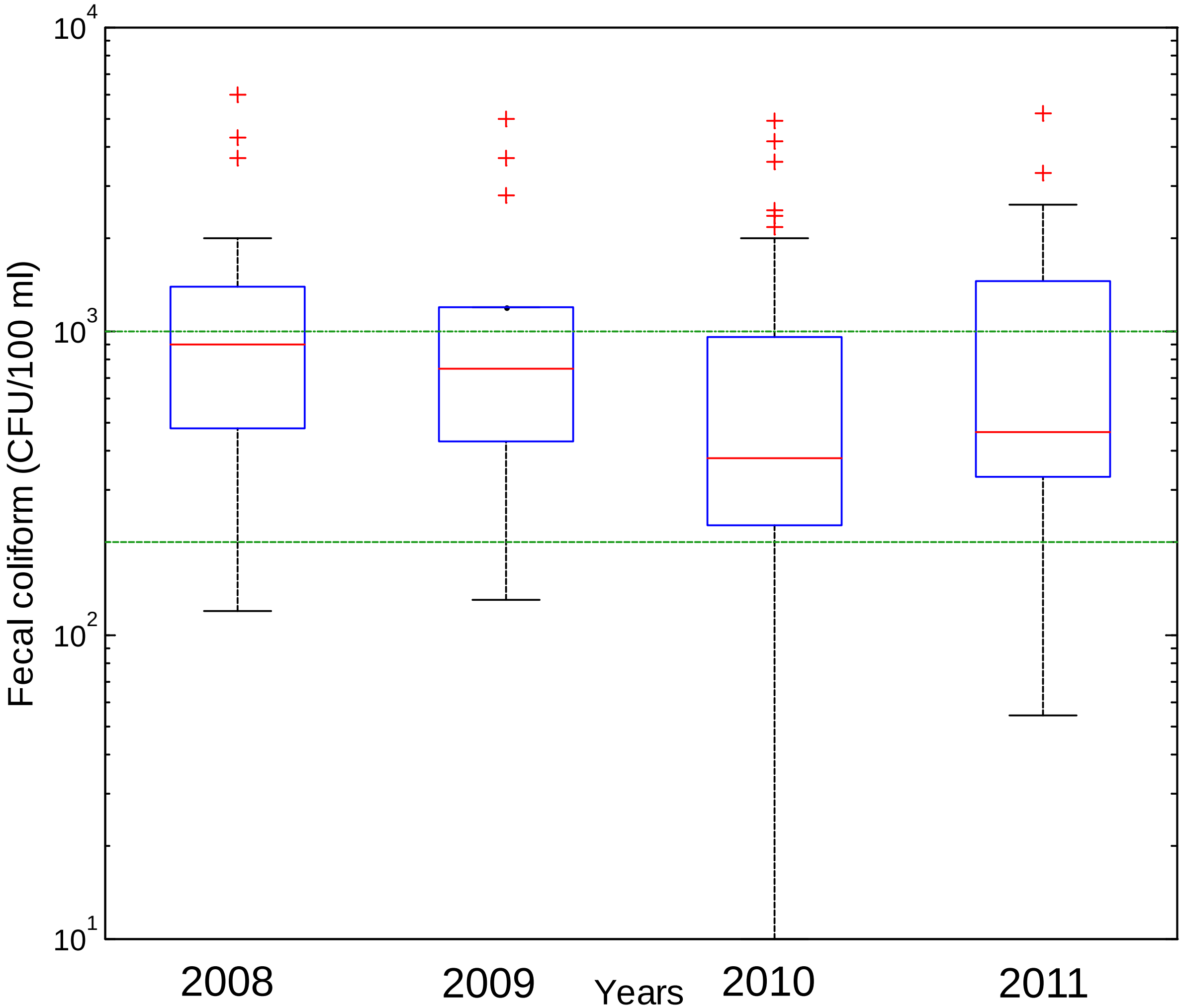


2. Available data - Microbiological quality

Data

- May to August
- 2008 to 2011
- 148 daily data





2. Available data – Potential explanatory variables

- Rainfall
- Combined sewer overflow - SOMAE
  - U057 → h_c = 1.4 mm
  - U051→ h_c = 4.4 mm

Year	Rainfall (mm) May to August	Number of rainfall events May to August	Number of CSOs caused by rainfall May to August	
		> 5 mm	U051	U057
2008	560.0	31	25	55
2009	507.8	26	34	41
2010	243.2	16	13	30
2011	627.4	25	15	50


Bernard Brault, La Presse


Samuel Bolduc

3. Modelling

Stormwater management model – SWMM

- Parameters of the hydrologic/hydraulic model

Physical characteristic	Separate model	Combined model	Unit
Total area	25.5	3.2	km^2
Number of subcatchments	914	157	-
Average area of subcatchments	31,000	73,000	m^2
Average slope of subcatchments	2.00	1.67	%
Average imperviousness	31	76	%
Beauport River's length	21.4	N/A	km

- Quality model : Event mean concentration - EMC

$$FC = EMC \times Q \times T$$

FC = Fecal coliform load, [M]

EMC = Event mean concentration, $[M]/[L^3]$

Q = Flow rate, $[L^3]/[T]$

T = Time of runoff, [T]

4. Results and Discussion

Relationship between FC concentration and rainfall

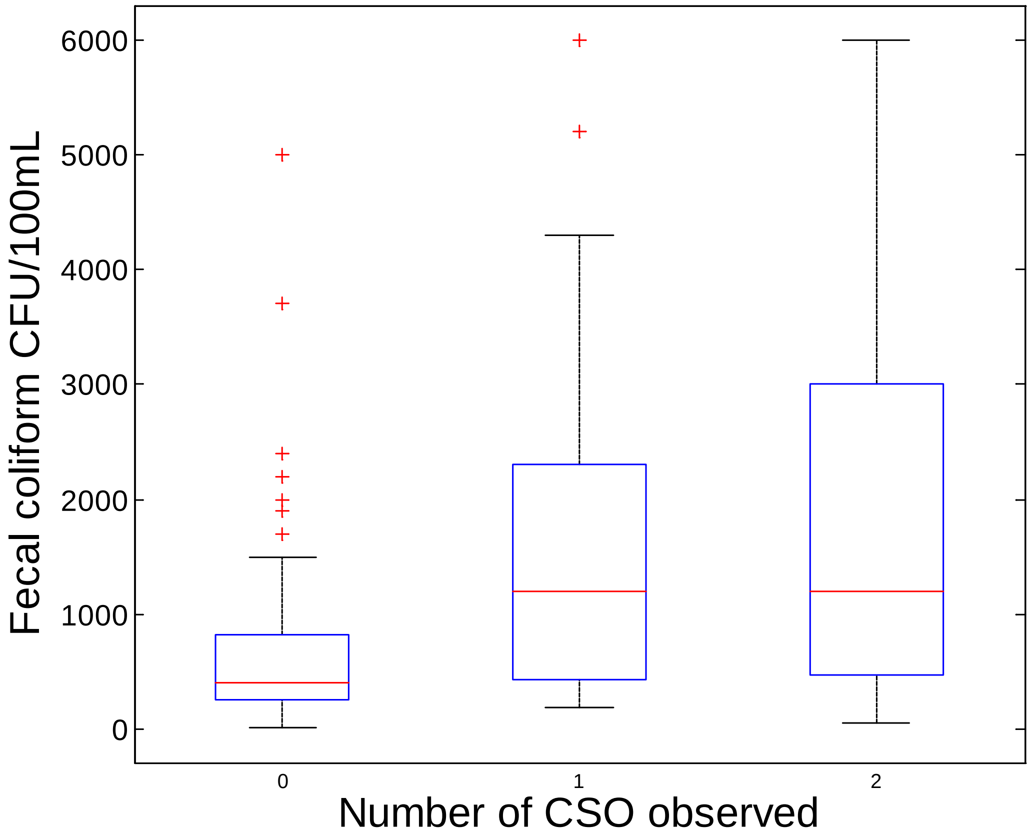
- Inlfuence of rainfall up to 1 day after

Rainfall day	Geometric mean [FC] CFU/100 ml — Rainfall threshold		ANOVA p-value
	< 5 mm	≥ 5 mm	
Day $_0$	502	1030	< 0.001
Day $_{-1}$	493	1061	< 0.05
Day $_{-2}$	432	771	> 0.05

4. Results and Discussion

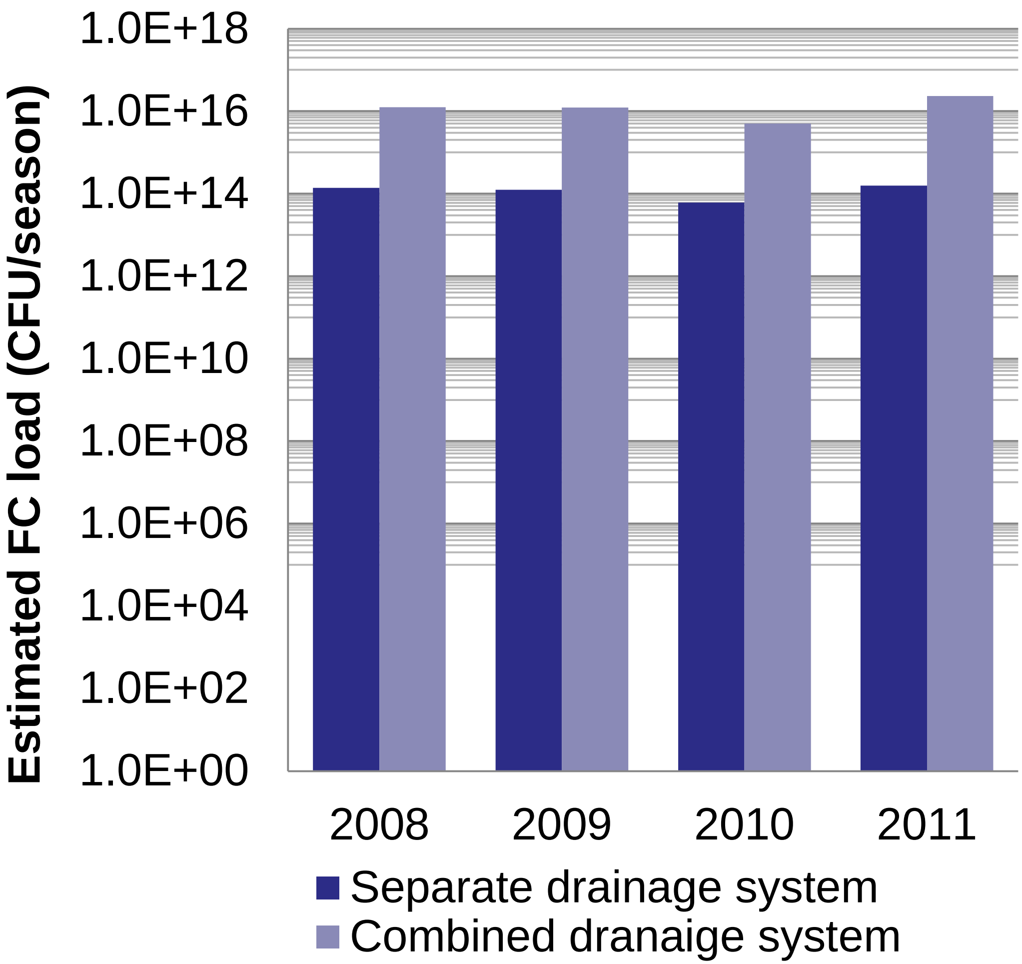
Relationship between FC concentration and CSOs

- Number of CSO the same day



4. Results and Discussion

Estimation of FC loads by simulation



FC load per season (CFU)

Drainage system	**Minimum** (2010)	**Maximum** (2011)
Separate (25.5 km^2)	6.0×10^{13}	1.6×10^{14}
Combined (3.2 km^2)	5.1×10^{15}	2.3×10^{16}

Conclusion

Summary

- Influence of FC in Beauport River
  - Rainfall
  - CSO
- Simulations
  - CSO > Stormwater
  - EMC method

And now…

- Construction of retention basins are currently taking place
- New Stormwater management guide
  - Fist 25 mm must be treated
  - Peak flow must be the same before and after the project.
- Validate the positive impact of these measure

Thank you – Questions?

References

Hubert, W.C. and R.E. Dickinson (1988). *Stormwater Management Model, SWMM Version 4 User's Manual*, US-EPA, Athens, GA.

Schroeder, K., et al, (2011). Evaluation of effectiveness of combined sewer overflow control measures by operational data, Water Science and Technology, 63(2), 325–330.

NSQD (2004). *Findings from the National Stormwater Quality Database*, *Research Progress Report*. Prepared by the Center for Watershed Protection, Ellicott City, MD.

Shaver, E., R. Horner, J. Skupien, C. May and G. Ridley (2007). *Fundamental of Urban Runoff Management – Technical and Institutional Issues*. North American Lake Management Society and US-EPA, Madison, WI.

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3. Modelling

SWMM – Quality modelling – EMC

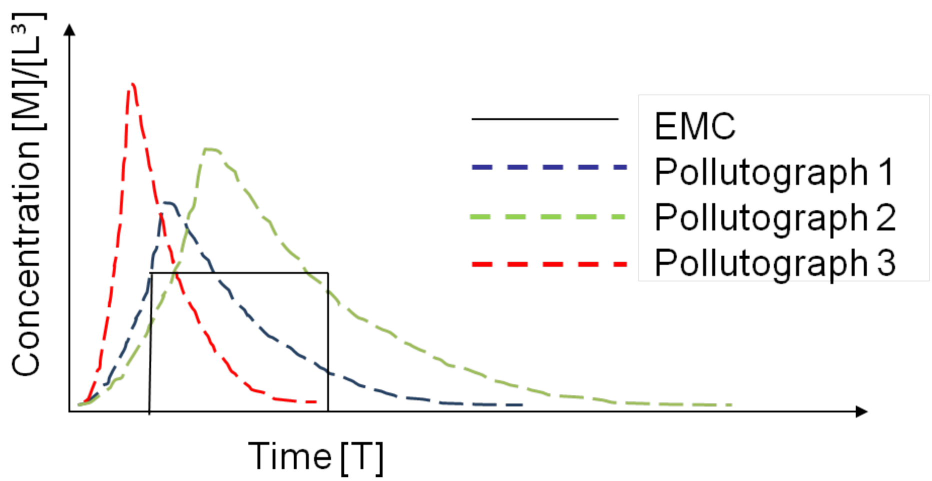
$$FC = EMC \times Q \times T$$

FC = Load, [M]

EMC = Event mean concentration, [M]/[L^3]

Q = Flow rate, [L^3]/[T]

T = Time of runoff, [T]



EMC values for the different land uses

(NSQD, 2004, cited in Shaver *et al.*, 2007)

Sources	**EMC** CFU/100 ml
Stormwater - Land use	
Residential	7,750
Commercial	4,500
Industrial	2,500
Open	3,100
Agriculture	10,000
CSO	10^6