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Evaluation of Wet Weather Operation Alternatives using Innovative WRRF Models

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UNIVERSITÉ LAVAL

modelEAU

Technical Sessions

Content

- Control strategies developed for full-scale implementation evaluated by simulation:
  - CEPT : Chemically Enhanced Primary Treatment
  - ATS : Aeration Tank Settling
  - Scenarios for emptying of combined sewer retention tanks for minimal bypass of WRRFs
- Focus on innovative models used

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Québec City East WRRF

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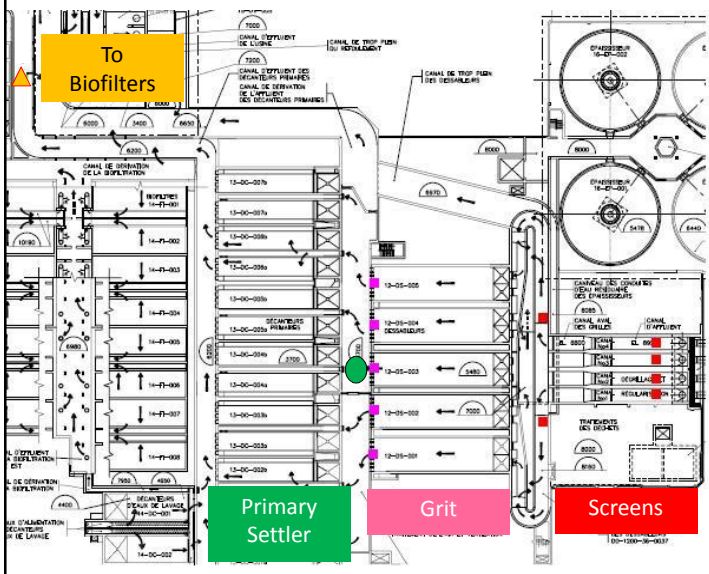

Québec City East WRRF schematic

Injection points

- Alum
- Polymer
- On-line monitoring station
- Turbidity sensor

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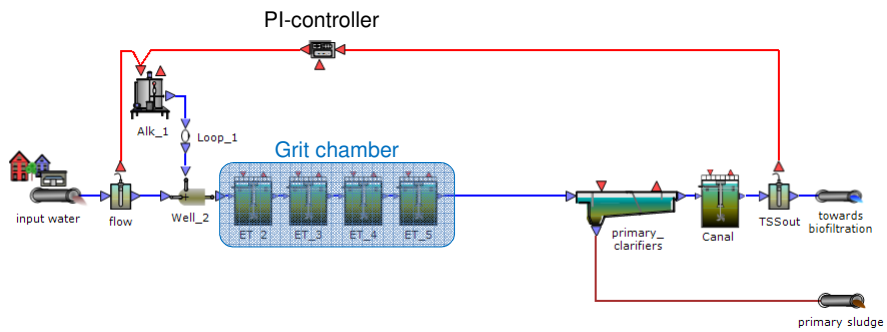
CEPT controller

- Feedforward-Feedback controller



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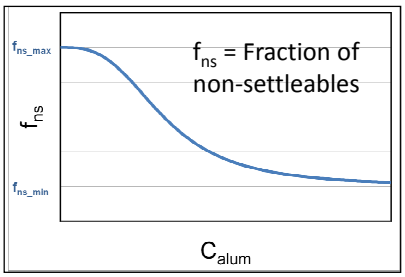
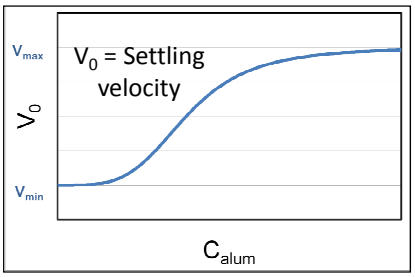
CEPT model – effect of alum addition

- Variation of f_{ns} and V_0 with alum concentration

$$f_{ns} = f_{ns_max} - \left(f_{ns_max} - f_{ns_min}\right) \frac{C_{al}^{\ n}}{K_{al}^{\ n} + C_{al}^{\ n}}$$





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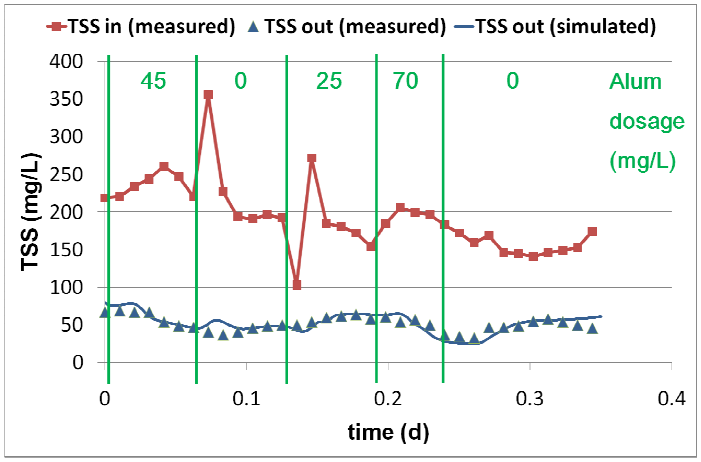
CEPT model – calibration (dry weather)



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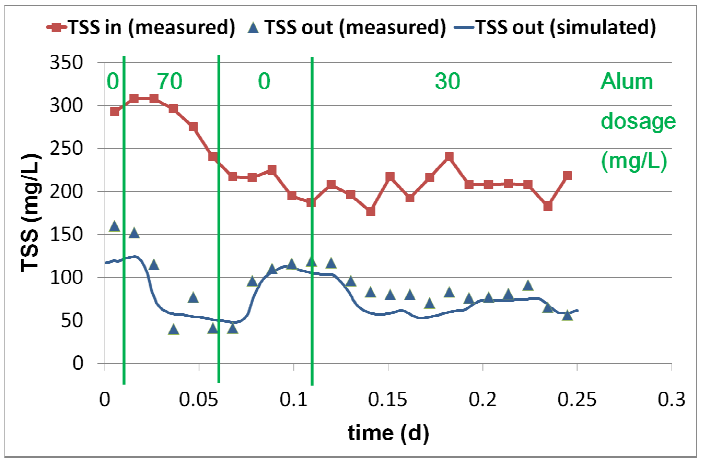
CEPT model – validation (wet weather)



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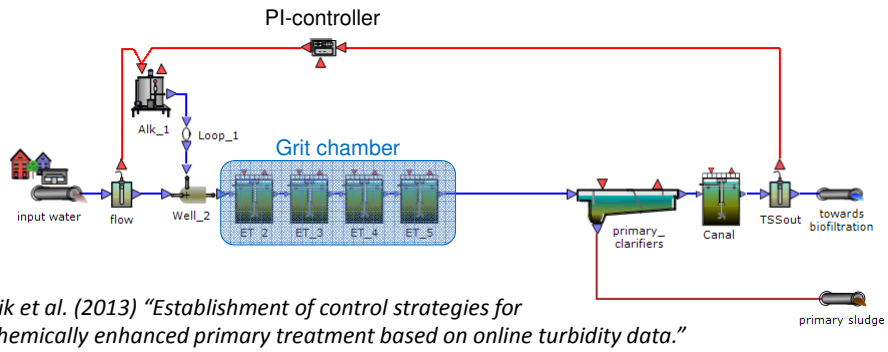
CEPT controller

- Feedforward-Feedback controller



Tik et al. (2013) "Establishment of control strategies for chemically enhanced primary treatment based on online turbidity data." Proceedings ICA2013, Narbonne, France, September 2013

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CEPT controller - scenarios

- Input : 3 days of turbidity data from monitoring station
- Set-point on outlet turbidity : 45 mg/L
- Three simulated scenarios :
  1. without alum
  2. constant alum addition
  3. feedback control on alum addition

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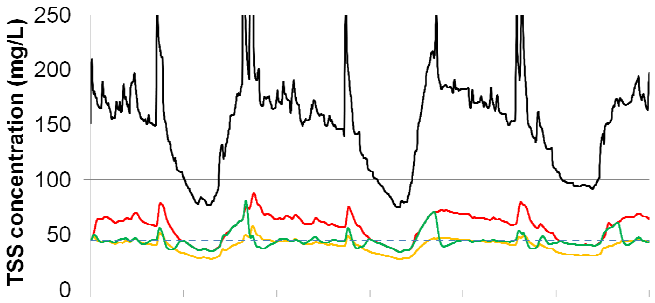
CEPT controller

- Controller performance



Controlled system uses 30% less alum than constant addition

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  - Scenarios for emptying of combined sewer retention tanks for minimal bypass of WRRFs

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Plant Introduction

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Plant Introduction

- Location
  - Lynettefælles-skabet, DK
- Lynetten WWTP
  - 700 000 PE
  - 5 - 6,6 m^3/s
- Receiving water
  - Øresund straight

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Plant Introduction

- Advanced nutrient removal plant + an. digestion (Biodenipho)

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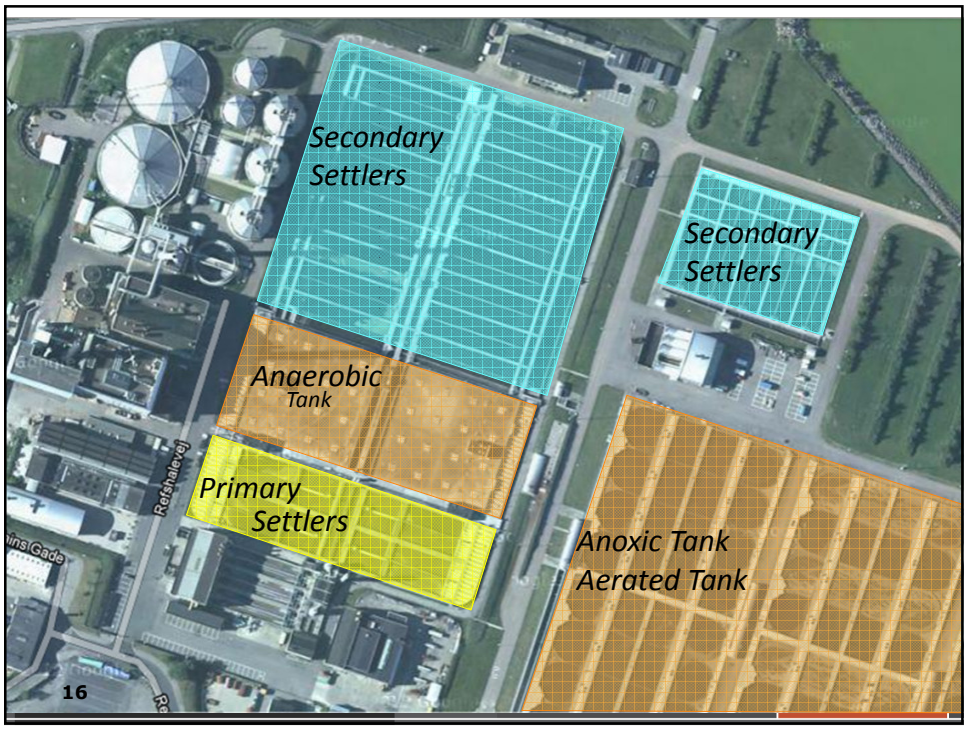
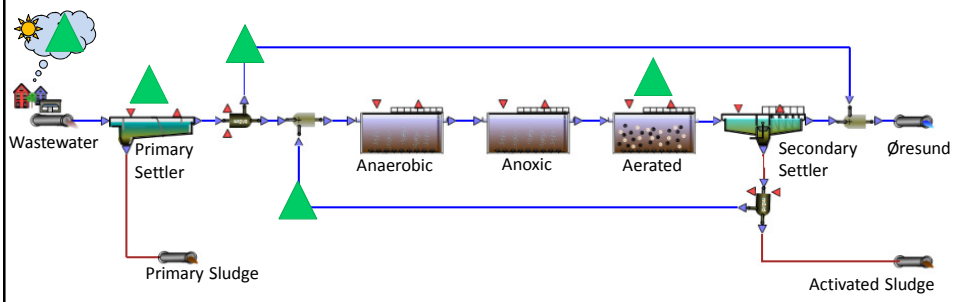


Wet Weather Control Strategies



- Chemically Enhanced Primary Treatment
- By-Pass
- Activated Sludge Recycling
- Aeration Tank Settling

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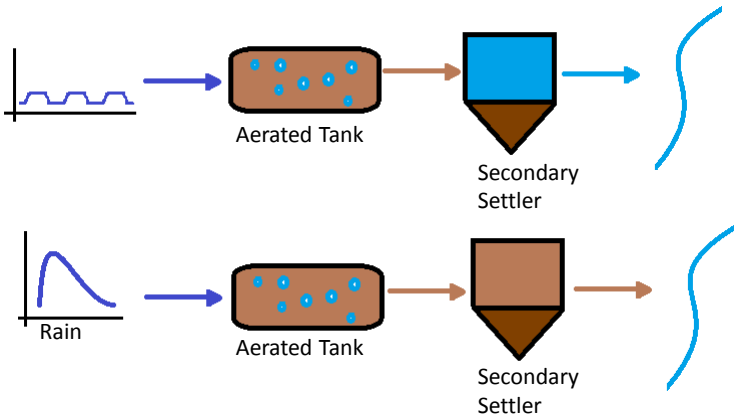
Control Strategies : Aeration Tank Settling



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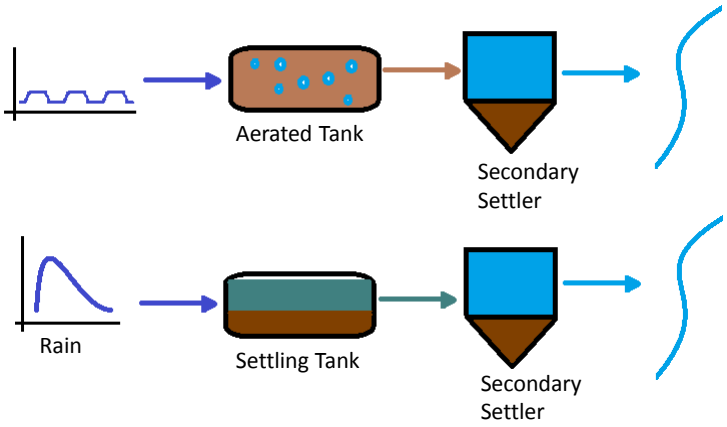
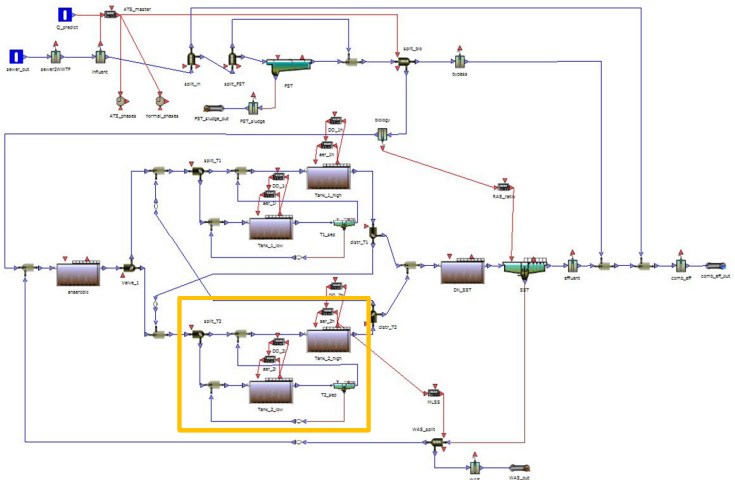
Control Strategies :
Aeration Tank Settling

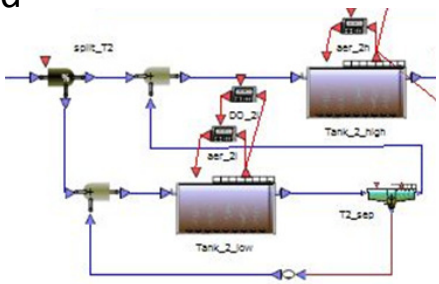


Modeling ATS



Modeling ATS

- Flow split in two compartments
- Bottom compartment with "settler" activated under ATS operation
- Sludge is stored in bottom compartment until "settler" is switched off.



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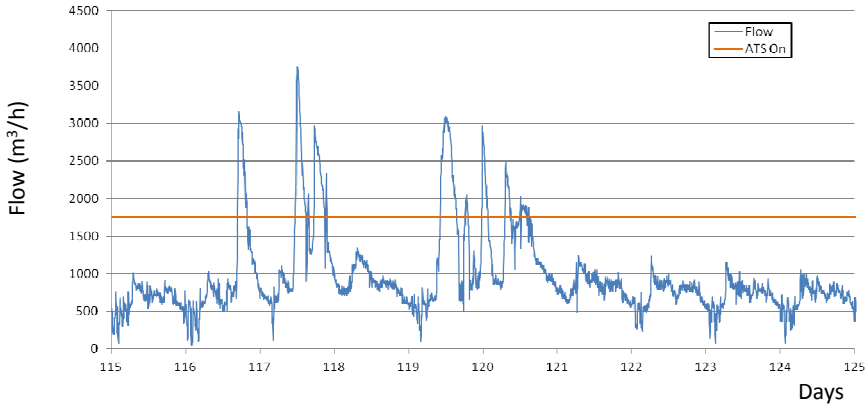
Control Strategies :
Aeration Tank Settling



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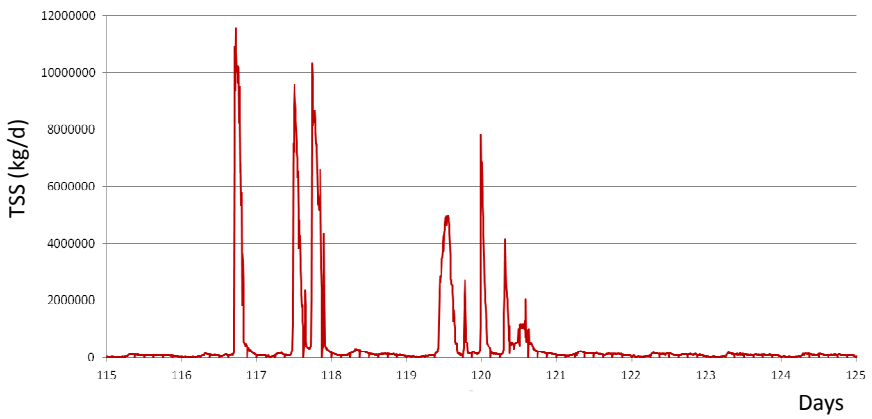
Control Strategies
ATS performance : The case of TSS



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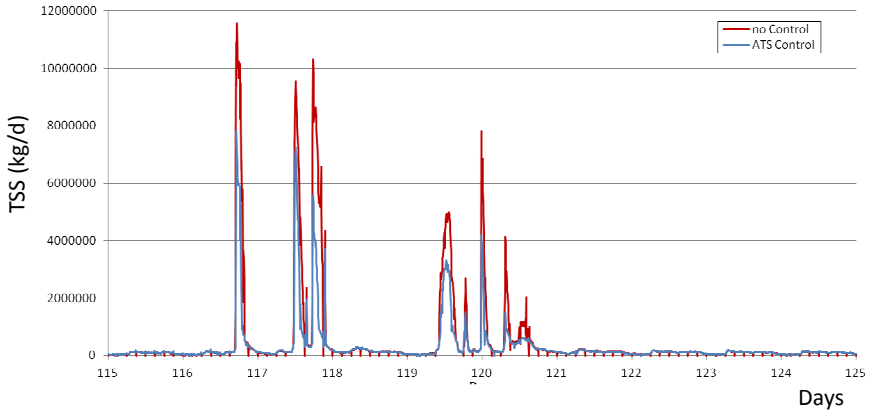
Control Strategies
ATS performance : The case of TSS



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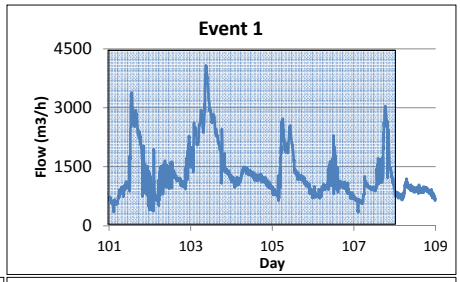
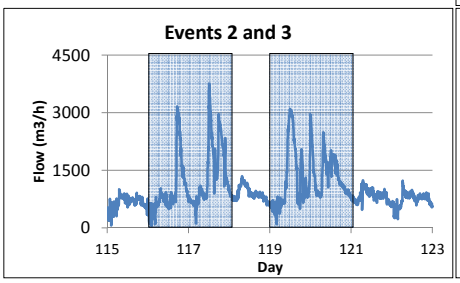
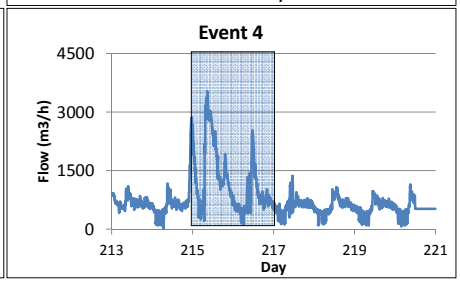
Control evaluation events

- 4 selected events
  - High intensity
  - Variable length
- ➢ Be general







Environmental performance with ATS

Rain event	Duration (d)	EPI (%)	Org. (%)	TKN (%)	NO (%)	TP (%)
1	7	27	39	28	-10	12
2	2	43	50	39	12	33
3	2	41	46	44	-27	36
4	2	28	46	26	-22	-21
Rain event average		35	45	34	-12	15
Whole period	150	18	33	18	-4	-5

$$EPI = w_1(TSS)+w_2(COD)+w_3(BOD)+w_4(TKN)+w_5(NO)+w_6(TP)$$

Environmental Performance Index

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Integrated sewer-WRRF control

- Improved combined sewer retention tank emptying

Tik et al. (2014)
Proc. International Conference on Urban Drainage (ICUD2014)
Kuching, Malaysia, Sept. 7-11

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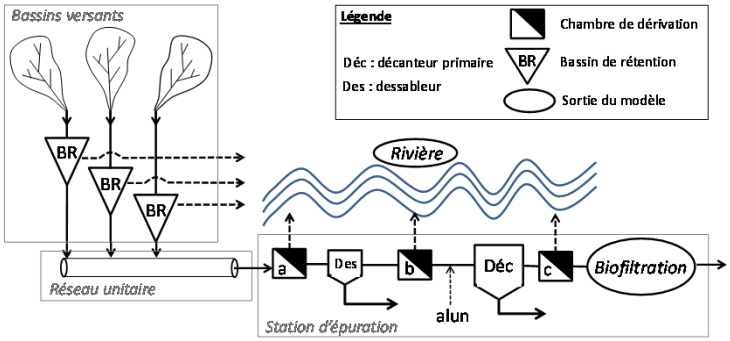
Integrated sewer-WRRF control

- Improved retention tank emptying to minimize WRRF overload



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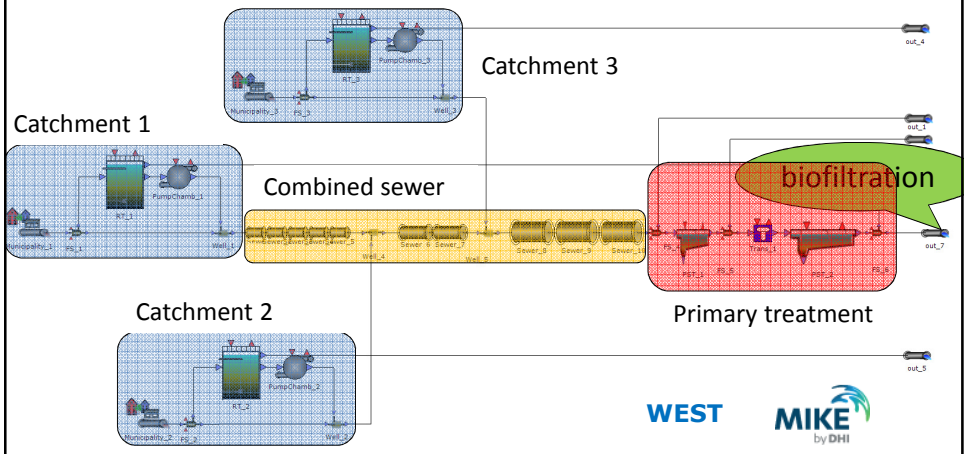
Integrated sewer-WRRF control

Evaluation through integrated WQ simulation



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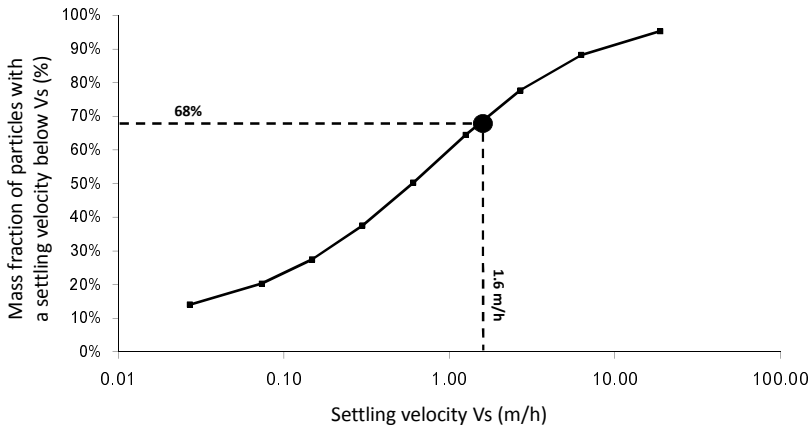
Modeling approach for TSS dynamics



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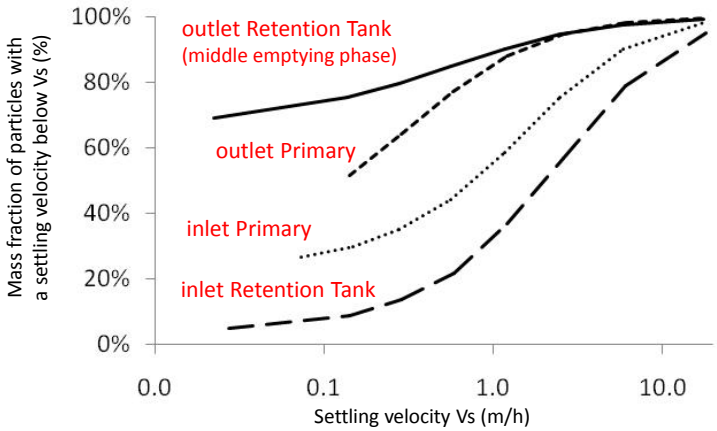
Modeling approach for TSS – PSVD



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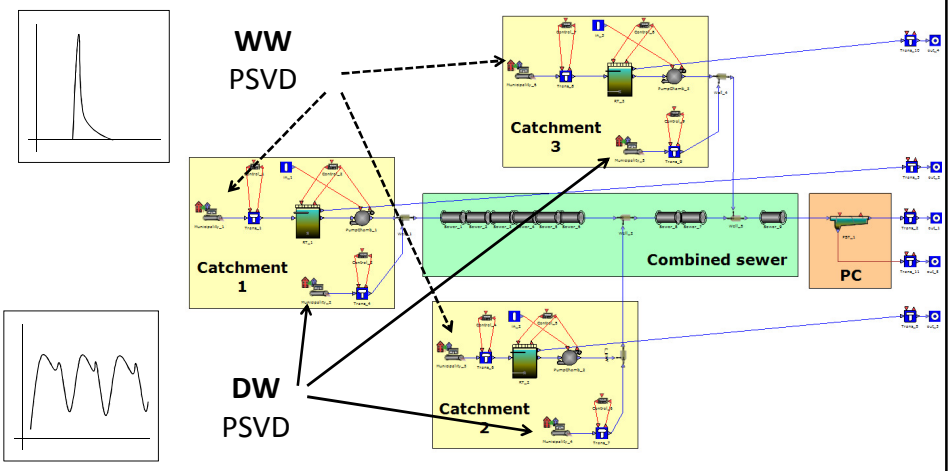
Modeling approach for TSS – PSVD



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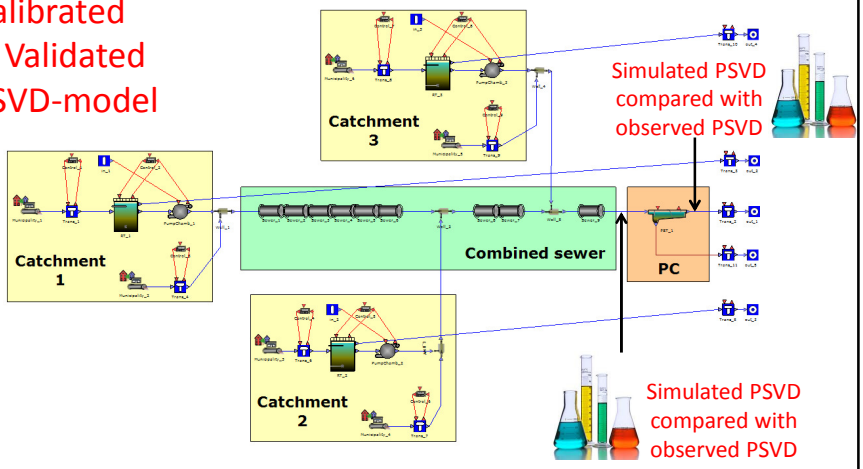
Modeling approach for TSS – PSVD

Calibrated
& Validated
PSVD-model



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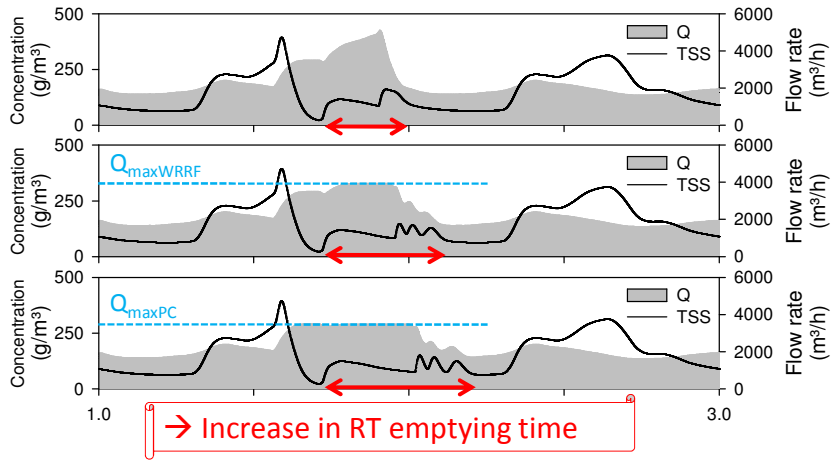
Modeling results – impact on WRRF



→ Increase in RT emptying time

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Modeling results – impact on WRRF

Emptying time : 4h20 → 9h10

	Bypass upstream of	*QmaxPump*			QmaxWRRF			QmaxPC		
		-	alum	alum +	-	alum	alum +	-	alum	alum +
Water discharged (m³)	WRRF	2430	2430	2430	0	0	0	0	0	0
	PC	2038	2038	2038	1943	1943	1943	0	0	0
	Bio	8041	8041	4394	8997	8997	4777	9691	9691	5187
	Total	12509	12509	8862	10940	10940	6720	9691	9691	5187
TSS load discharged (kg)	WRRF	259	259	259	0	0	0	0	0	0
	PC	211	211	211	188	188	188	0	0	0
	Bio	441	136	68	478	147	71	500	154	76
	Total	911	606	538	666	335	259	500	154	76

-13% -22% -55%

-30% -27% -45% -90%

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Conclusions

- Control strategies developed for full-scale implementation evaluated by simulation:
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- Focus on innovative models used

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Acknowledgments

Canada Research Chair in Water Quality Modeling
Ville de Québec
NSERC CRSNG
Otto Mønsted - FREMMER DANSK HANDEL OG INDUSTRI
SWI Storm- and Wastewater Informatics
WATERWAYS
VEOLIA ENVIRONNEMENT
Primodal Earth Essential Technologies
DTU
Aalborg Universitet
København's Spildevandscenter Avedøre
DHI WATER • ENVIRONMENT • HEALTH
PH-CONSULT
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