Integrated Systems Modelling to support Decision-Making on Sustainable Infrastructures

WEAO Specialty Seminar Collection and Conveyance Systems: Sustainability and affordability

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Overview

- General introduction
- The riv*EAU* project
- Test case + Experimental proof of concept
- Control strategy
- Model – first approach (SWMM)
- Model – second approach (WEST)
- Conclusion

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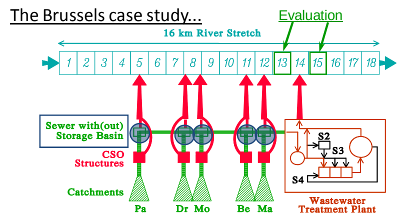
General introduction

Integrated modelling:

Model combinations of different systems

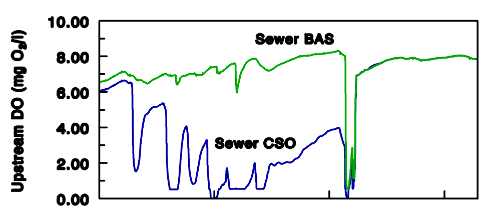
For water systems:

Catchment + River + Sewer + WWTP



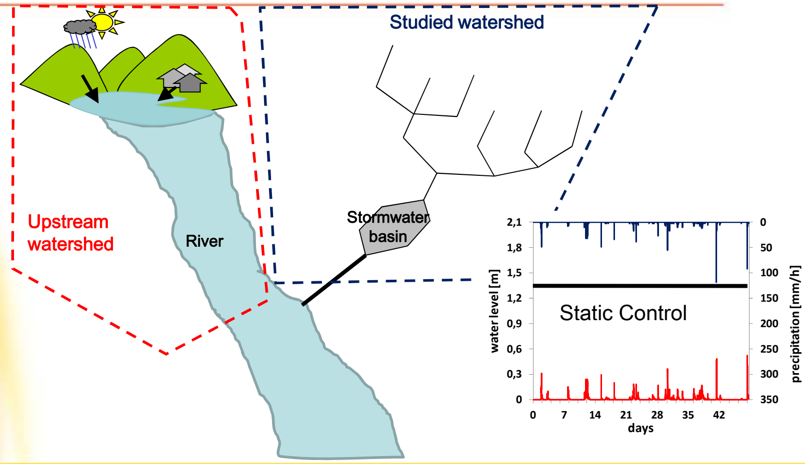
General introduction

- What can we do with integrated modelling ?
  - Predict the future for different operation conditions
  - Test different configurations



  - Optimize the use of existing systems

The riv*EAU* project



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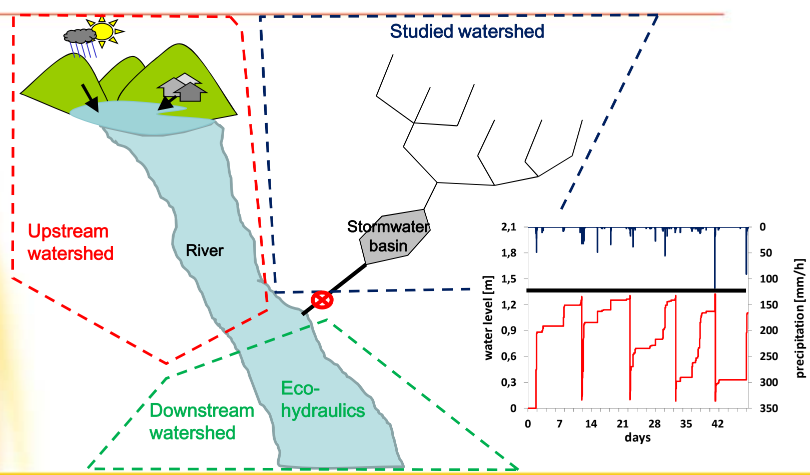
The riv*EAU* project



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The riv*EAU* project

- Improve Eco-hydraulics:

and

Reduce hydraulic stress

Reduce effects on the quality (pathogens, heavy metals...)

Idea
Focus on TSS and contaminants

Fine particles account for less than 10 % of TSS but contain:

- 25 % of COD
- 30 % of N
- 50% of P
- More than 50 % of Heavy Metals

(Brombach et al. 1992)

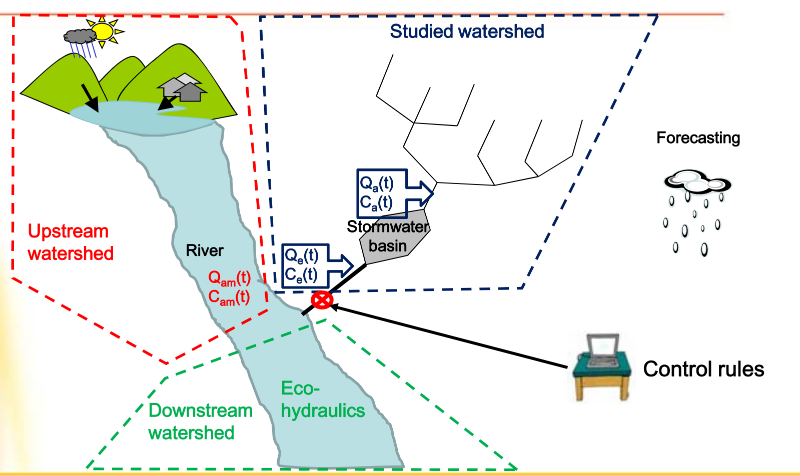
Idea

Focus on TSS and contaminants

Control outlet of basin to

- Extend the hydraulic retention time
- Increase the removal efficiency for TSS and agglomerated contaminants

The riv*EAU* project



Proof of principle: Test case
Stormwater Basin Chauveau - overview

- Separate System
- Stormwater part designed as dual drainage system
- Residential area
- ~15 ha
- Degree of imperviousness ~30 %
- ~900 inhabitants

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Proof of principle: Test case
Stormwater Basin Chauveau - overview

- 3300 m^3
- Max. water level 1.4 m
- Max. outflow ~350 l/s

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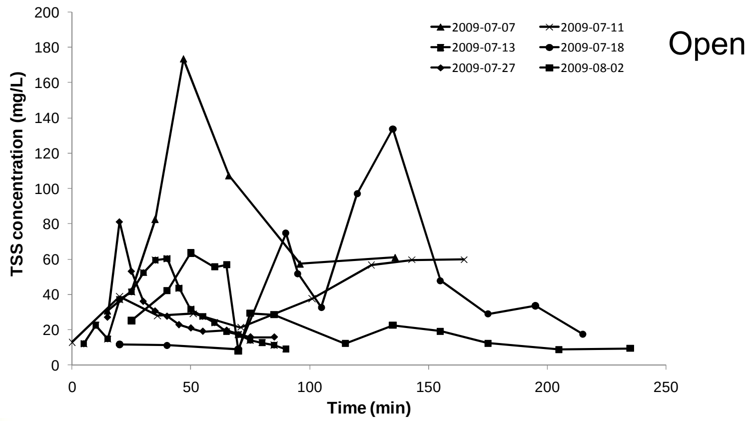
Proof of principle: Test case

Experimental results: TSS outlet



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Proof of principle:Test case

Experimental results: TSS outlet

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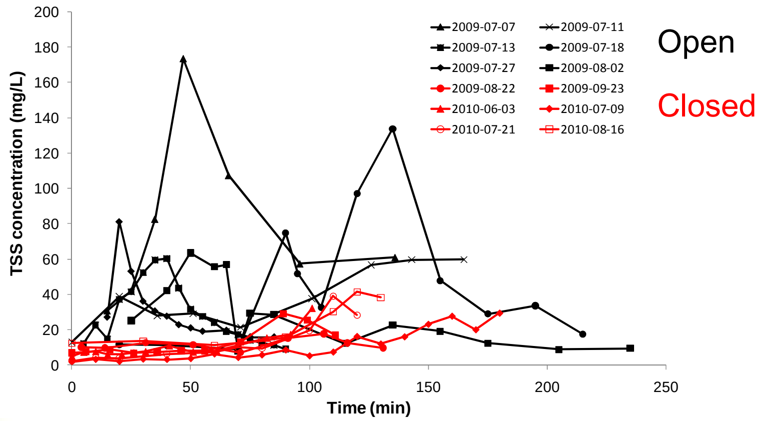
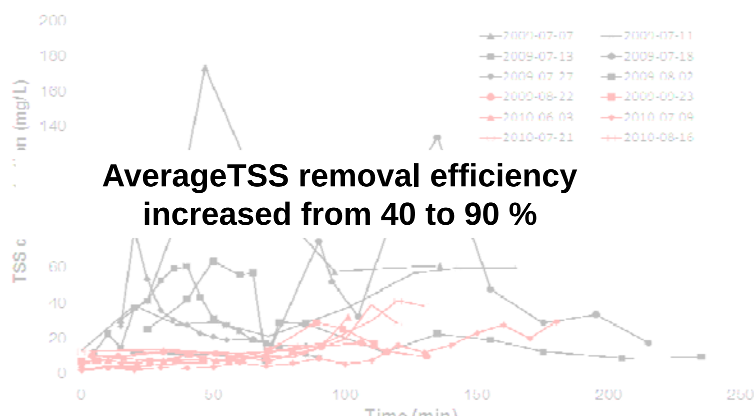
Proof of principle: Test case

Experimental results: TSS outlet



Proof of principle: Test case

Experimental results: TSS outlet



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- **Model – first approach (SWMM)**
- **Model – second approach (WEST)**
- **Conclusion**

Control strategies
Objectives

- Decrease loads of TSS
  and agglomerated contaminants
  by increasing time for sedimentation
- Decrease hydraulic peaks
  by limiting maximum outflow
- Avoid overflows
- Consider aquatic life stages of mosquitoes as limiting factor on the time water can be stored

Control strategies
Rules examined

- Static control (10 Scenarios)
  - Fixed maximum outflow between 15 and 150 l/s (~3 l/(s*ha) and ~33 l/(s*ha)
- Dynamic Control (basic set)
  - **If** runoff **then** close outlet
  - **If** runoff and defined water level is reached **then** open outlet to a defined percentage
  - **If** defined maximum water level is reached **then** open outlet completely

Control strategies
Rules examined

Dynamic Control (updated)

- Mosquito control
  - Basic set
  - **If** stormwater is stored longer than 80% of the aquatic life span of Mosquitoes **then** open outlet to a defined percentage
- Volume free-up control
  - Basic set
  - **If** stormwater is stored longer than time span needed to settle finest particles **then** open outlet to a defined percentage

Model – first approach (SWMM)

- Build-up and wash-off
- TSS model for stormwater basin based on 6 particle size fractions

$$C_{TSS,i} = TSS_i \cdot e^{-\frac{v_{s,i} \cdot \Delta t}{depth}}$$

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Model – first approach

Size fraction i	Particle size range (µm)	Average settling velocity of particles in size fraction i, $V_{s,i}$ (m/s)	Fraction of total mass contained in size fraction i (%) - MOEE	Fraction of total mass contained in size fraction i (%) - measured
1	x ≤ 20	2.54E-06	20	83.4
2	20 ≤ x ≤ 40	1.30E-05	10	9.1
3	40 ≤ x ≤ 60	2.54E-05	10	4.4
4	60 ≤ x ≤ 130	1.27E-04	20	4.1
5	130 ≤ x ≤ 400	5.93E-04	20	-
6	400 ≤ x ≤ 4000	5.50E-03	20	-

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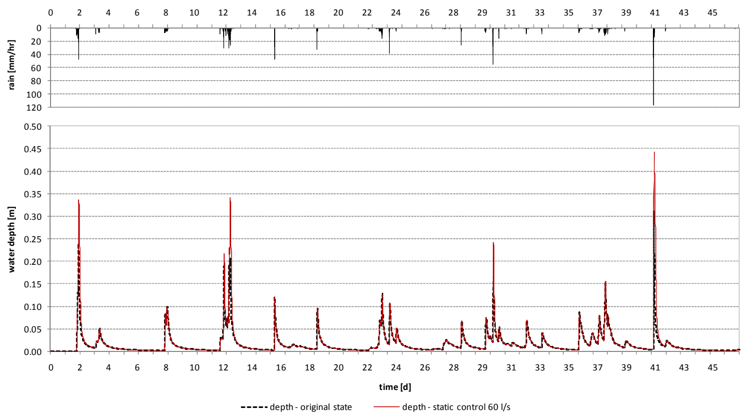
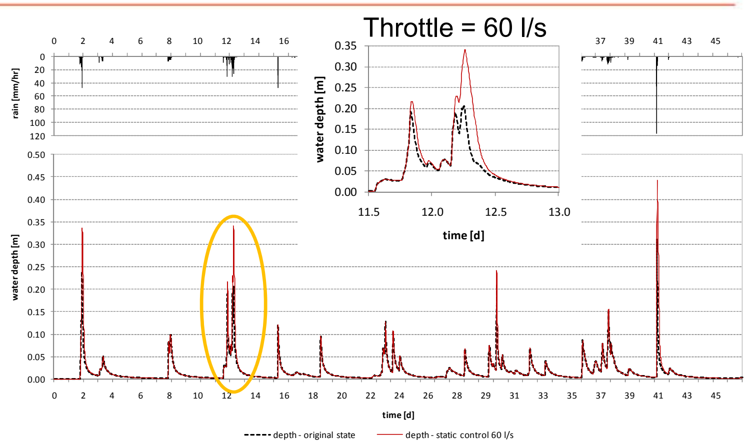
Simulation results

Hydraulic behaviour – static control



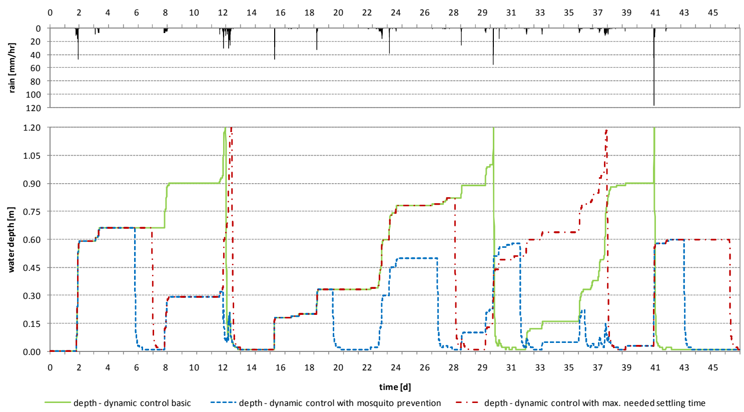
Simulation results

Hydraulic behaviour – static control



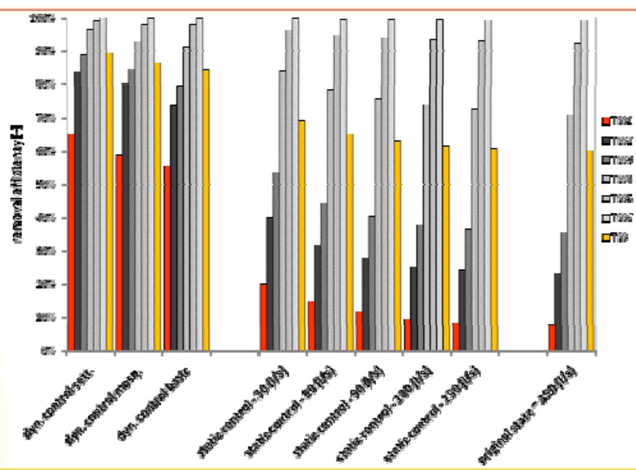
Simulation results

Hydraulic behaviour – dynamic control



Simulation results

TSS removal efficiency



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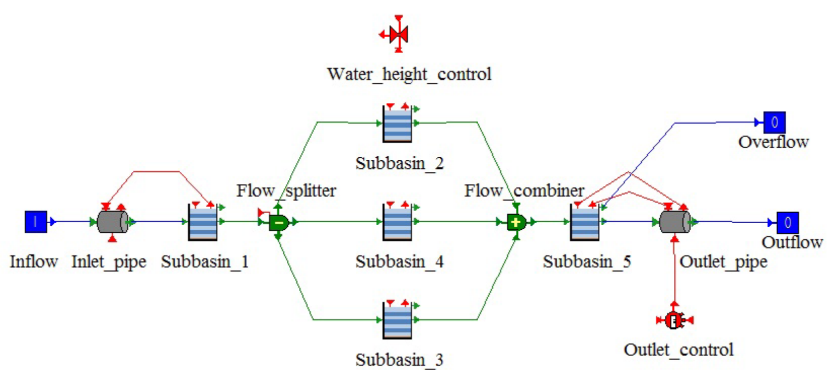
Model – second approach (WEST™)



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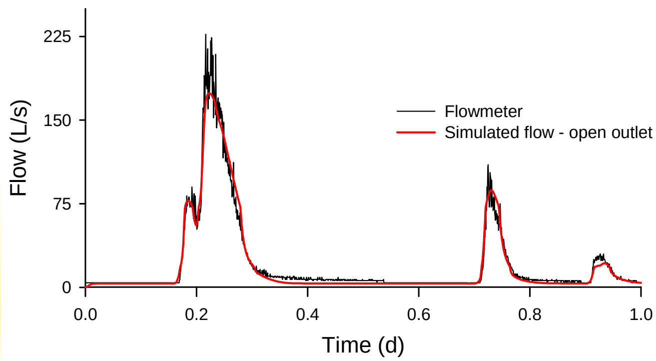
Model – second approach (WEST™)

- Hydraulics – outlet flow (open outlet)



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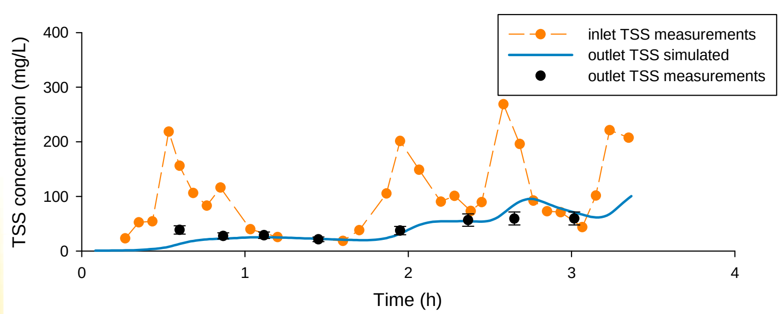
Model – second approach (WEST™)

- TSS dynamics (inlet – open outlet)



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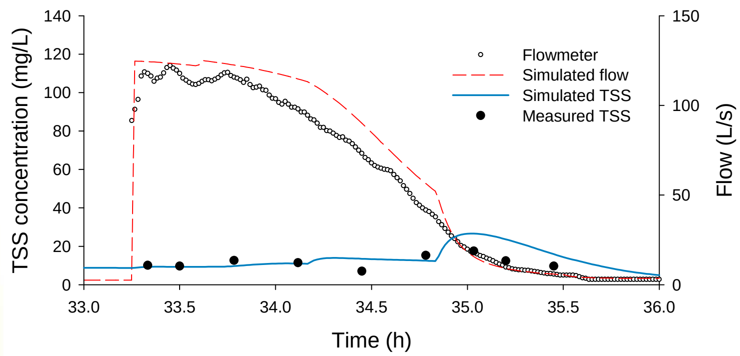
Model – second approach (WEST™)

- TSS dynamics : emptying after closed outlet



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Integrated modelling developments

- Make long-term simulations with the calibrated model
- Confirm the effect of control strategies on TSS released in the river
- Determine the best control strategy, not on the TSS removal but on the river water quality improvement

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Conclusion

- Integrated modelling is an important tool to consider different options.
- It helps to predict future and to take advised decisions.
- It can be used to test new configuration or use (riv*EAU*).
- It is better with calibrated models but can also be used with default parameters to check ideas

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Acknowledgements

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