Tuning of a central controller for a sewer network using multiple simplified models

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Outline

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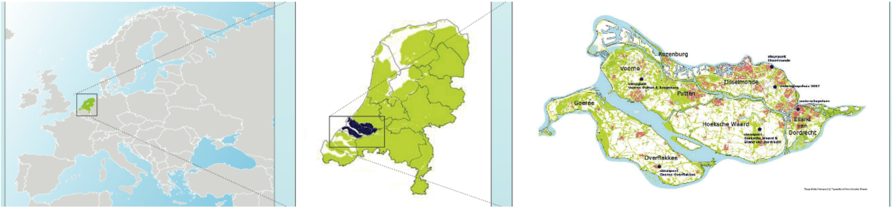
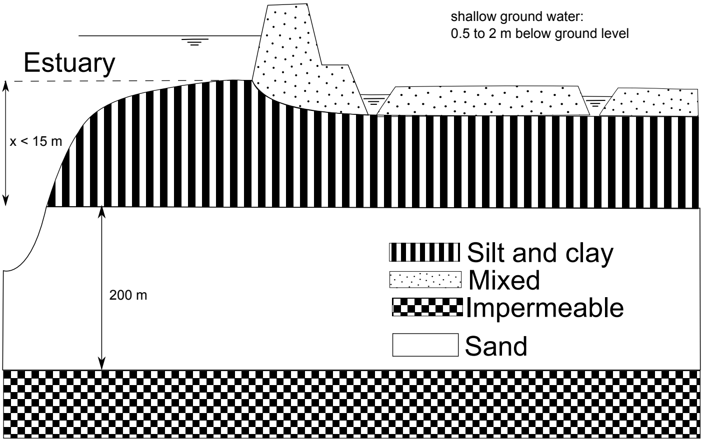
1. Context
   - Geography and System Properties
   - Goal
2. Preliminary experiments
   - Setup
   - Results

Location


Rozenburg
Voorne
IJsselmonde
Putten
Goeree
Hoeksche Waard
Eiland van Dordrecht
Overflakkee

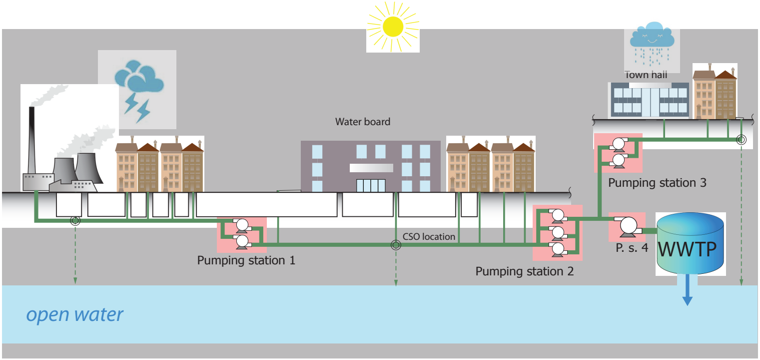
Island in Rhine/Meuse Delta

Not to scale



After Ernst (1969), Fig. 2.

Village sewer systems



Village sewer system properties

- In one system mixture of
  - combined (sanitary and storm in same pipe)
  - separated (sanitary separate from storm)
  - improved separated (sanitary catches "first flush")
- Transport
  - gravity (short distances)
  - pumps (limit on capacity)
  - pressurized pipe lines
- In case of heavy rain
  - Combined sewer overflows (CSO)
  - Settling tank in series with CSO

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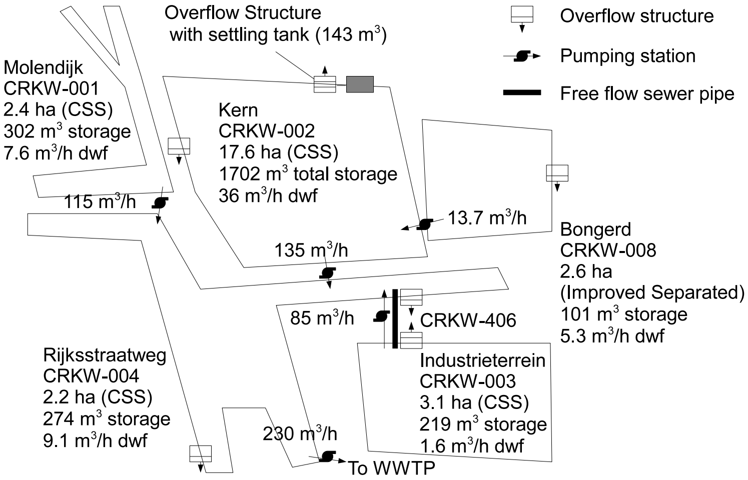
Diagram of system used in experiments



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How to avoid CSO events

- Bigger pumps
  - Costly
  - Eventually means bigger treatment plant
- More storage
  - Costly
  - Must be emptied between events
- Better use of existing storage (Central/Global Control)
  - Can compensate for imbalances due to village expansion
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  - Need to know dynamic effects of
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    - control
- Design influenced by dynamic effects
  - Either: large scale long term measurements
  - Or: detailed and calibrated computer simulation
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Exploring Controller Parameter Space

- One parameter per subcatchment, five subcatchments, hundreds of events = probably many runs needed
- Full hydrodynamical simulation
    - Expensive
        - time
        - data storage
- One simple model for all events
    - Cheap
    - Inaccurate
- One simple model per event (sub-event?)
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- Full hydrodynamical simulation
  - Sobek (Deltares)
  - linked to controller through OpenMI 1.4
- Controller
  - written in Java/Scala at Delft University
- Simple model
  - Matlab
  - linked to controller through Java call interface
- Tests
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Simple model

- Subcatchment is 0D reservoir, calibration parameter
  - volume
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Controllers

- Local
  - On/off with hysteresis
    - on at h_1
    - off at $h_0 < h_1$
- Central
  - Prescribed storage use (local derived from total)
    - pumps used to track storage curve
    - storage curve (local vs global) given per subcatchment

Procedure

- Calibration
  - precipitation inflow from Sobek
  - local controller
    - simple model state as input
  - CSO compared to
    - Sobek under local control
- Validation
  - precipitaton inflow from Sobek
  - central controller
    - simple model state as input
  - CSO compared to
    - Sobek under central control

Outline

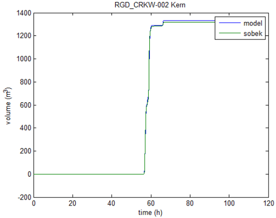
Results in words

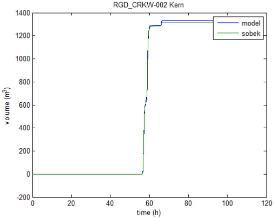
- Time gain 93%, not representative because
  - Matlab code not optimal
  - Coupling between Sobek and central controller not optimal
  - ...
- Accuracy
  - More runs needed for definite answers
  - Variable delay parameter between actual volume and volume in CSO formula may be needed
  - Missing gravity flow connection in model limits calibration to three subcatchments

Best case results in graphs

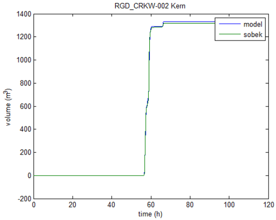
Local

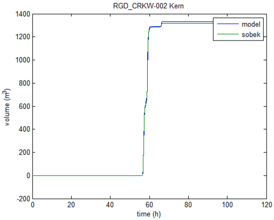
Central





event 21,
$V_{\text{kern}} = 1682$,
$c_{\text{spill}} = 0.001$





event 118,
$V_{\text{kern}} = 1750$,
$c_{\text{spill}} = 0.001$

Results in table

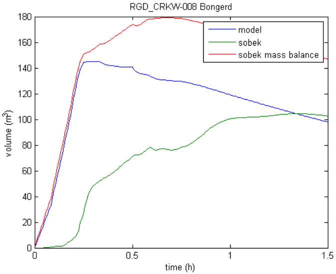
Event	Sobek		Simplified	
	Local	Central	Local	Central
	m^3	m^3	m^3	m^3
2	869	735	871	516
88	1312	1250	1356	1138
118	728	687	733	679
189	6688	6649	6715	6668
14	1447	1411	1450	1415

Total spills (189: one extreme peak)

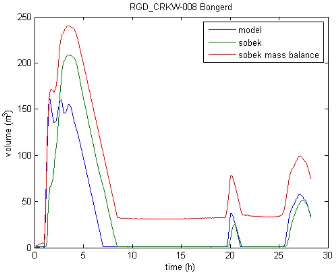
Problem: delays

Fast versus slow filling

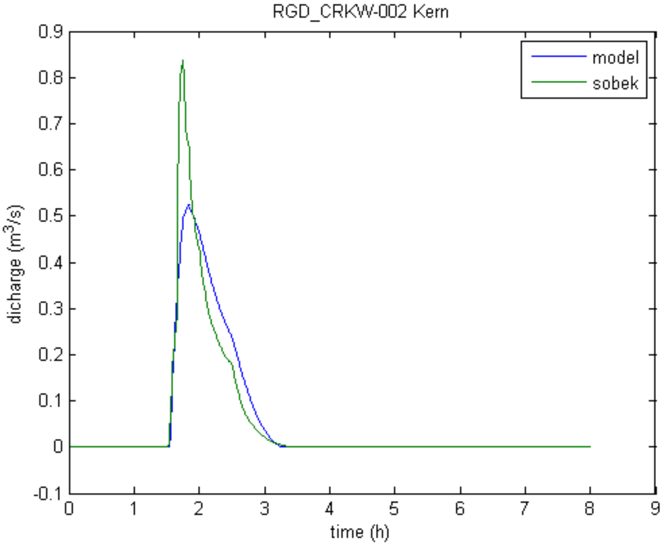
8mm/hour peak



5mm/hour peak



Volume versus shape



Summary

- Simple model per event better than just one simple model
- Simple model is faster
- But more work is needed on
    - Simple model calibration
    - Simple model characteristics
    - Delays when spill location is far from pump

Thank you for your attention I