Risk-based decision making for water quality failures caused by sewer overflows

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Motivation

- Combined sewer overflows (CSO) spills managed by the water utility companies need to comply with the local regulations.
- Utility companies usually face the risk of paying penalties or suffering reputational damage if they fail to comply.
- Urban drainage models are used to simulate CSO quality so as to make appropriate decisions.
- Understanding the potential uncertainty in such models can lead to a better informed decision making.

Uncertainty Propagation - Sewer Water quality modelling

Objective : Design a Storage tank at the CSO structure in order to comply with Ammonia emission standards in the CSO.

- Model: Calibrated urban drainage model to simulate combined wastewater flow quantity and quality
- Software/tool used : **EmiStatR** (R package to estimate combined wastewater emissions)
- Catchment: Haute-Sûre catchment in Luxembourg
- Mode output: Ammonia concentration (mg/L) in the CSO spill
- Performance Criterion: Number of annual failure events
- Failed event criterion: Ammonia Concentration in the Combined Sewer Overflow > 2.5 mg/L for 1 hour. (Austrian emission guidelines)
- Proposed solution: Construction of a storage tank at the CSO structure to comply with emission regulations
- Decision variable: Volume of the proposed storage tank

Model & Data

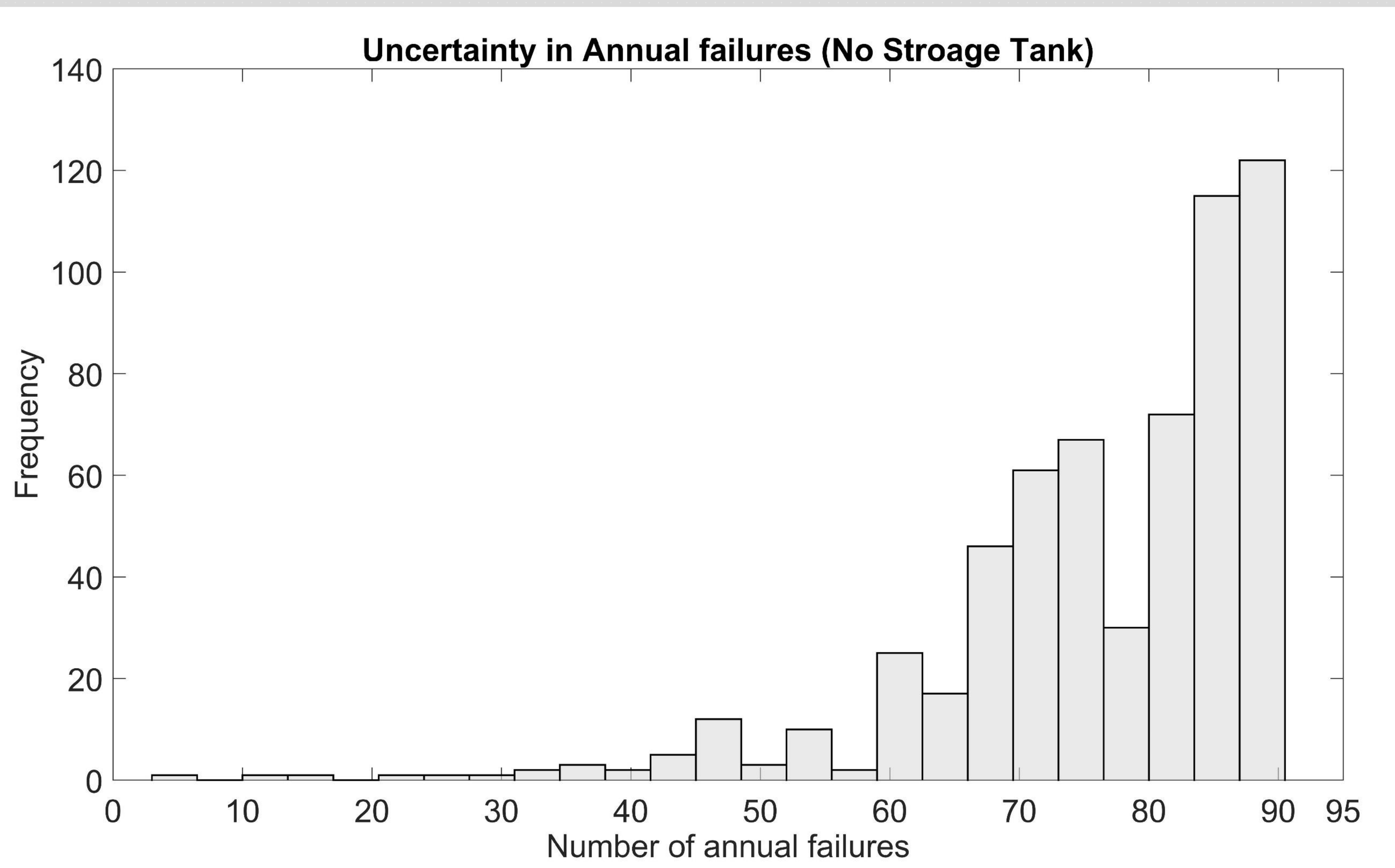
Physical processes modelled:

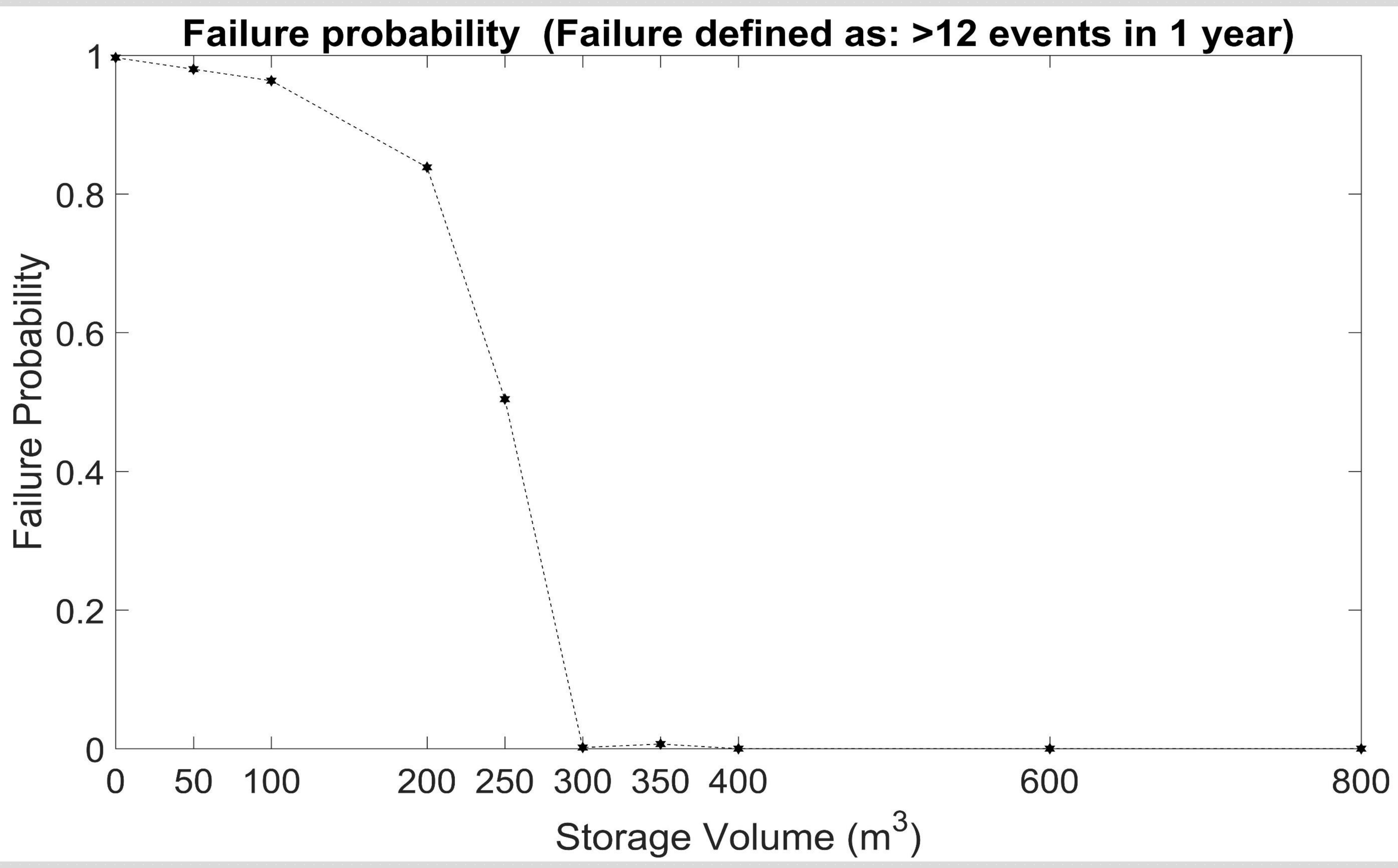
Dry Weather Flow (DWF) : Wastewater input from the households contributing to Combined sewage flow
Pollution of Dry Weather Flow: Ammonia load in DWF
Rain Weather Flow (RWF) : Rainfall runoff from the impervious catchment surfaces contributing to Combined sewage flow
Pollution of RWF : Ammonia load contribution from the catchment surfaces
Combined sewage flow : DWF + RWF
Combined sewage flow pollution : Ammonia load from DWF and RWF
CSO volume and pollution : Flow volume diverted to the receiving water body (lake) and the ammonia (NH4) concentration in this overflow.

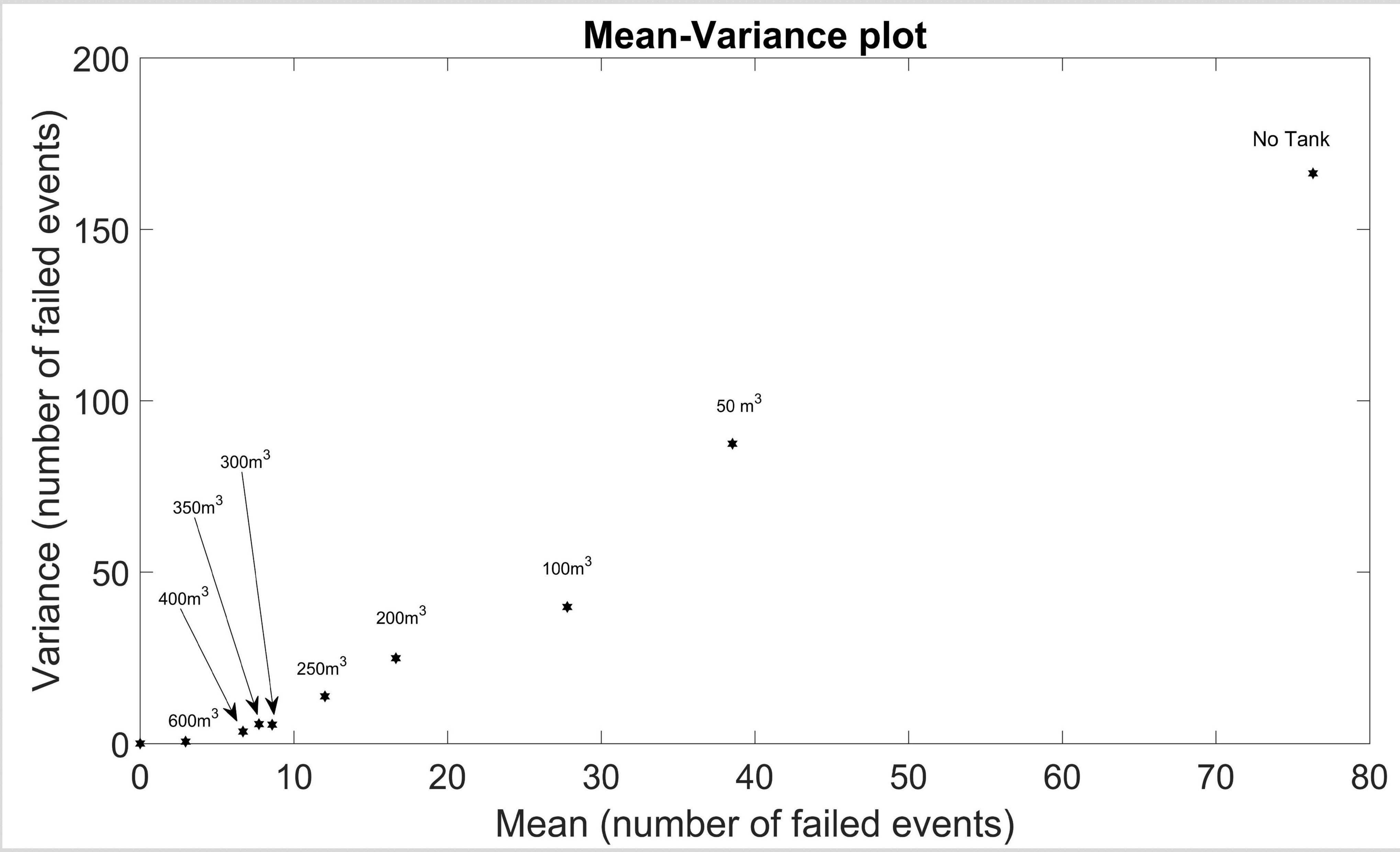
Uncertainty propagation

- Monte Carlo simulations used to propagate uncertainty in model inputs and parameters.
- 1-year rainfall precipitation data was used for these simulations.
- Storage tank volume simulated : 100 m^3, 200 m^3, 400 m^3, 600 m^3 & 800 m^3
- Monte Carlo simulations were repeated by changing storage tank volume
- For each storage tank, 600 Monte Carlo simulations were performed resulting into 600 time series of NH4 concentration in the CSO spill.
- For each time series of NH4 concentration, number of failures were calculated by applying the failure criterion. This resulted into a distribution of failures in the simulated year for each storage volume modelled.

Results







Conclusion & Future Work

- Variability in rainfall measurements needs to integrated in the uncertainty propagation to quantify its impact on the failures.
- Given the nature of the solution proposed, there seems to be no conflict in the mean-variance plot for different storage volumes. Higher tank volume reduces both the mean and variance. Hence, Multi-objective optimization might not be computationally effective in this particular scenario.
- The choice of threshold on ammonia concentration and duration was found to have significant effect on the distribution of failed events. Low threshold values (e.g. 0.175mg/L for NH4 in the UK) result into similar number of failures for all the model simulations.

QUICS

The University Of Sheffield.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 607000.