

# REAL TIME CONTROL OF URBAN FLOODING: A CASE STUDY OF DAMHUSAEN CATCHMENT COPENHAGEN DENMARK



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# Contents

- 1 Introduction
- 2 Study Area
- 3 Data Collection
- 4 Methodology
- 5 Results
- 6 Conclusions
- 7 Recommendations

# Introduction

- frequency and severity of floods due to climate change
- Forecasted increase in population 54 % to 70% by 2050 (WHO)
- Cost effective
- Improvement into receiving water quality

## **Main Objective**

- To develop the real time control strategies for reducing overflow without increasing flood risk.

# Scope of the study:

- Review of Literature
- Data Collection (Meteorological data, sewer pipes data, observed flow)
- Data quality assurance and filling of missing data
- Development of Mike urban model (Rainfall-runoff, pipe flow)
- Calibration and validation of model
- Identification of weirs which are discharging into Damhusaen Lake
- Testing of control strategies in MIKE Urban control module to reduce overflow into Lake

# Study Area – Damhusaen Catchment:

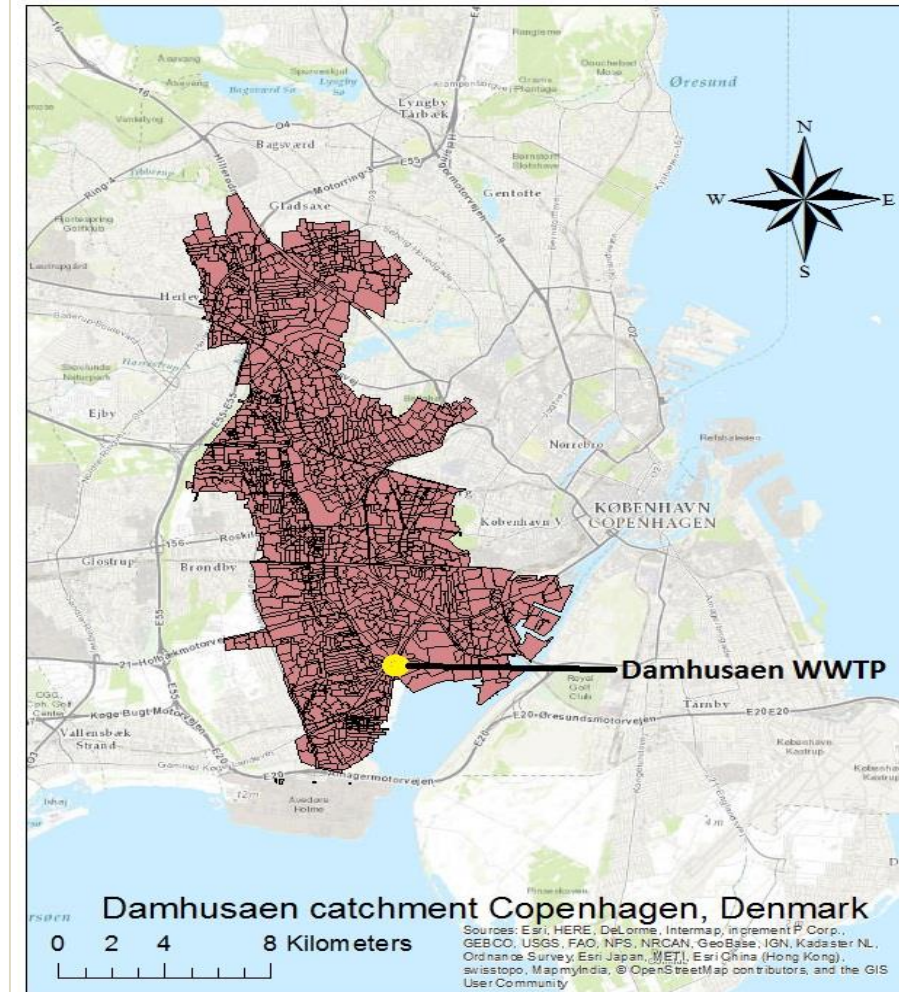
- Total Area = 37 km<sup>2</sup>
- Designed capacity of the plant = 350,000 PE
- Maximum flow, inlet = 684,000 m<sup>3</sup>/day
- Maximum capacity to treat Ammonia = 3200 kg/day
- Volume of water at inlet per year = 27.4 mill.m<sup>3</sup>
- Volume of water Bypass per year = 1.9 mill.m<sup>3</sup>
- Receiving water body = Øresund coast

## *Population statistics:*

- Population 2015: 262,327

- Average annual rainfall = 613 mm

**Source: HOFOR & BIOFOS**

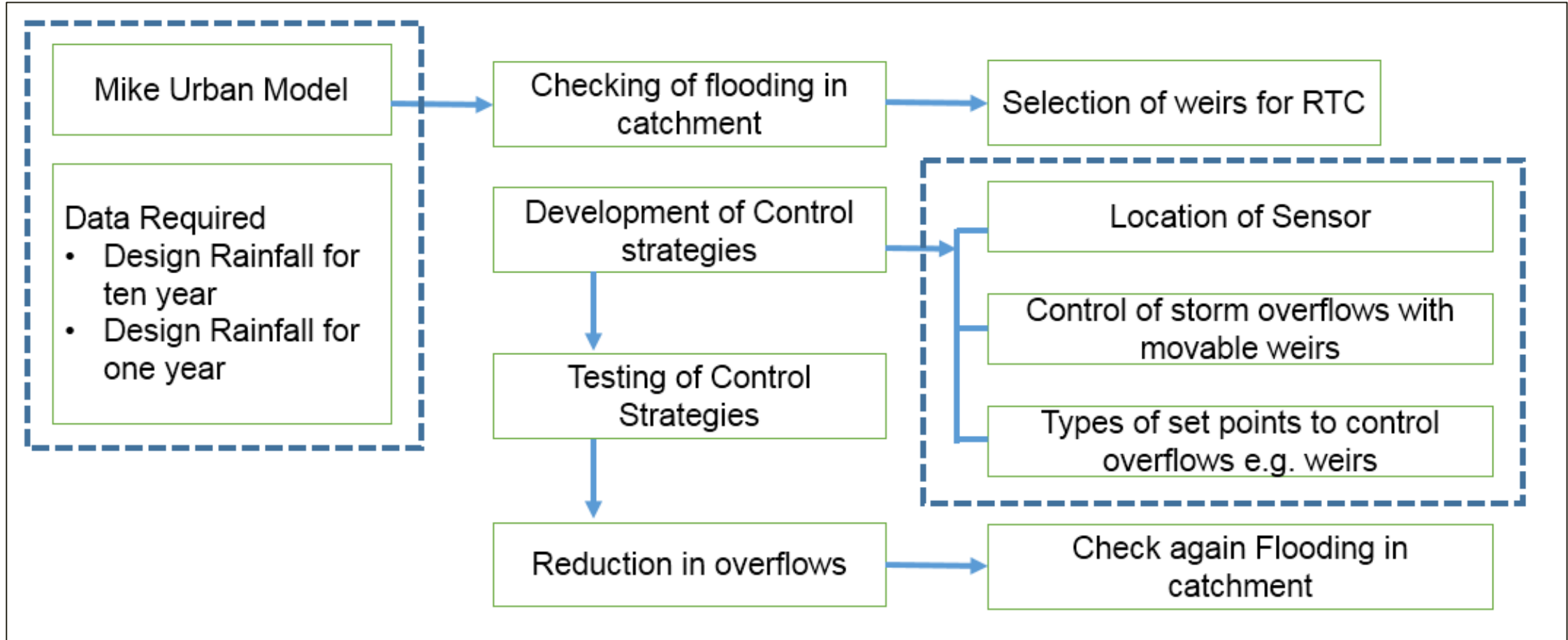


# Collected Data

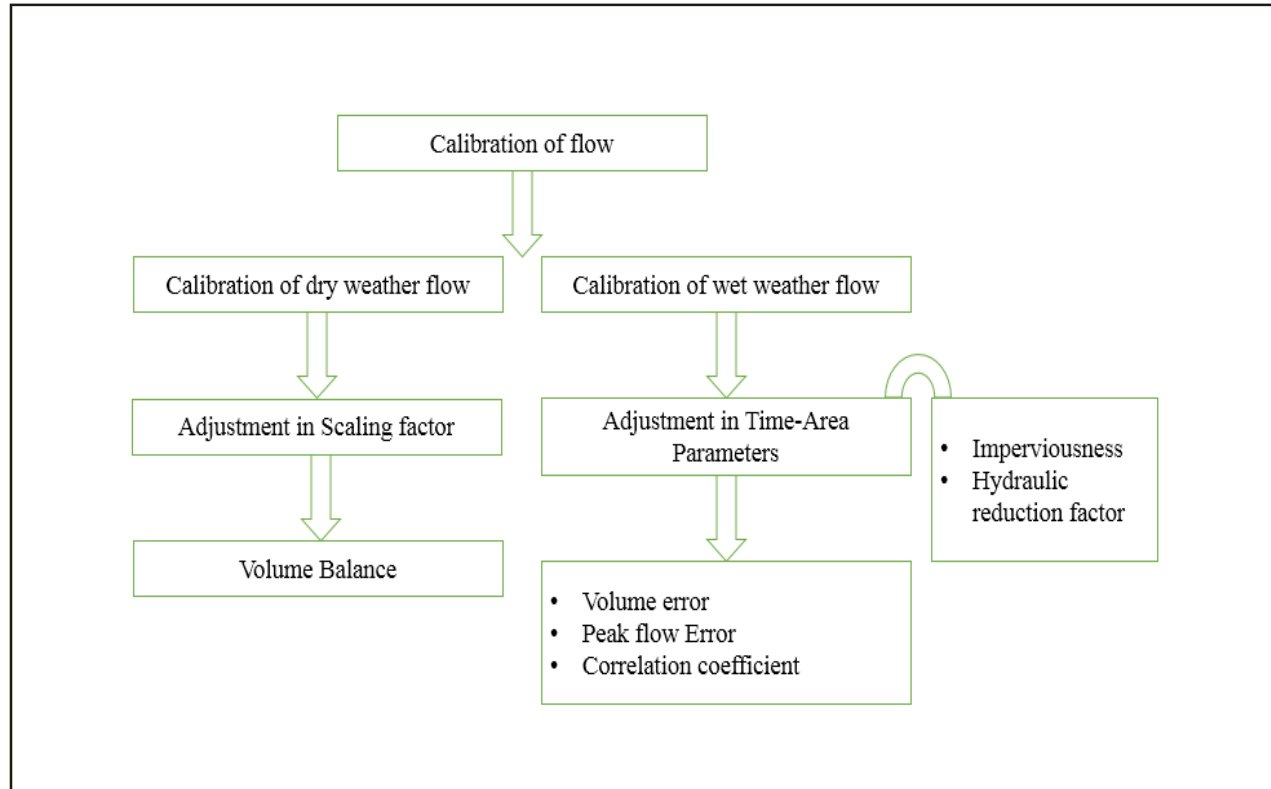
<b>S.N.</b>	<b>Data type</b>	<b>Time period</b>	<b>Frequency</b>	<b>Department</b>
1	Topographical map	-	-	DHI, Denmark
2	Meteorological Data (Precipitation)	Jan, 2010 To March,2017	01 minute	Danish Meteorological Department, SVK Rain gauges
3	Forecasted Rainfall Data	Feb, 2017 To onward	10 minutes	Danish Meteorological Department
4	Observed Flow Data	Jan, 2010 To Feb, 2017	2 minute	BIOFOS

**Summary of collected data**

# To develop the real time control strategies for reducing overflow without increasing flood risk.



# Calibration Strategy for flow at the inlet point of WWTP



- Selection of Dry weather days

- How we define Dry weather flow into model?

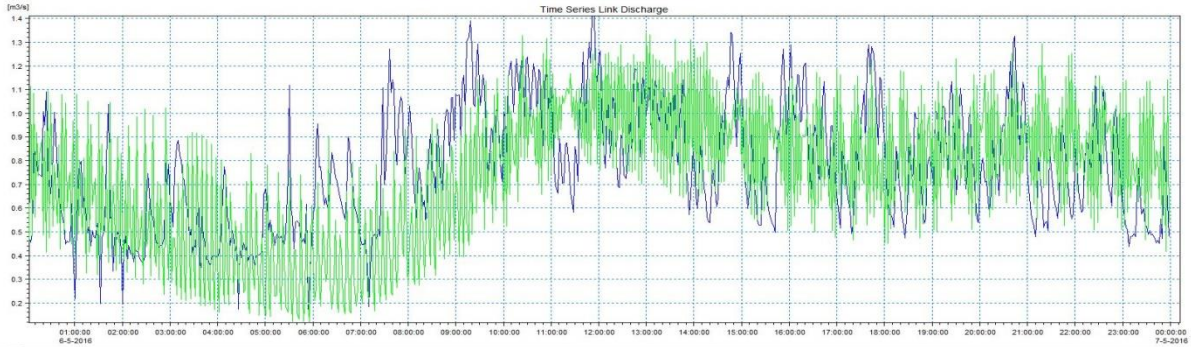
- Selection of rainfall events

- Selection of sensitive parameter

- Location of calibration

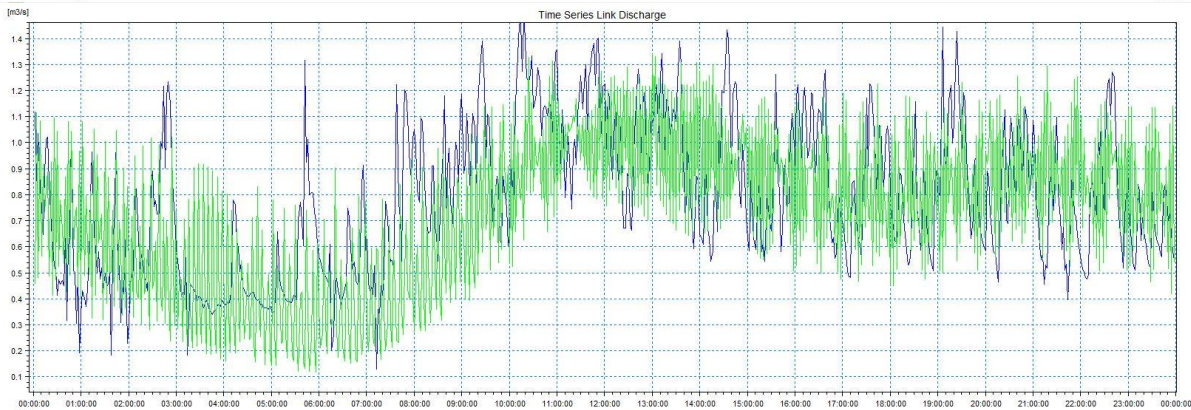


# Results: Calibration of Dry weather flow

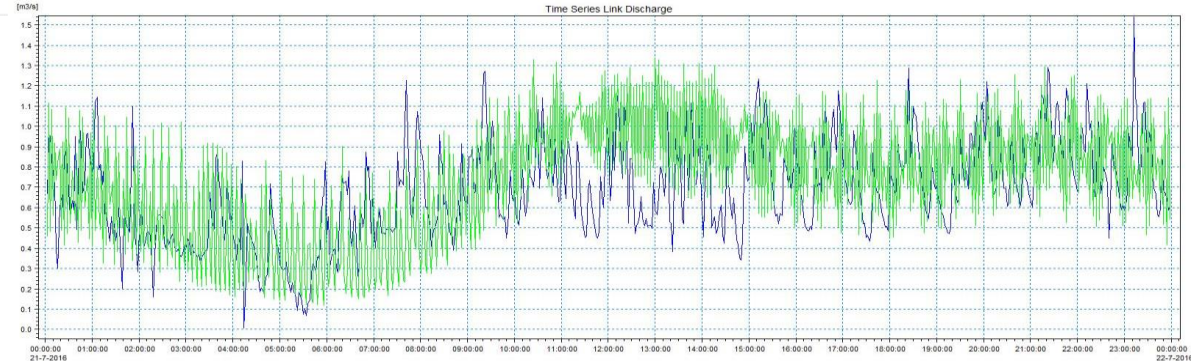


- Observed Flow: Blue
- Simulated Flow: Green

Event Date	=06-05-2016
Observed volume	=66348.23 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=3.7 %

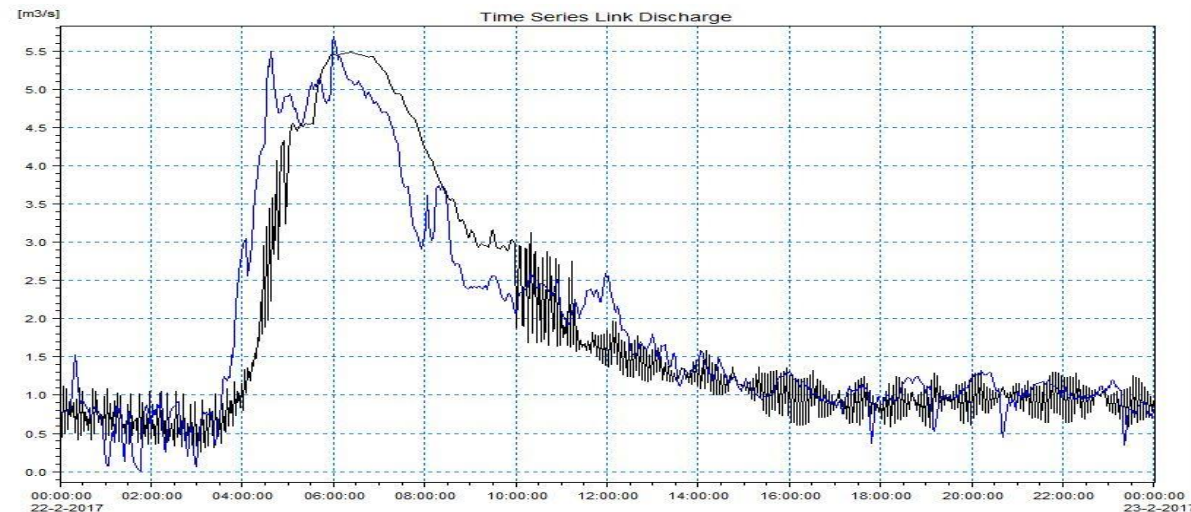
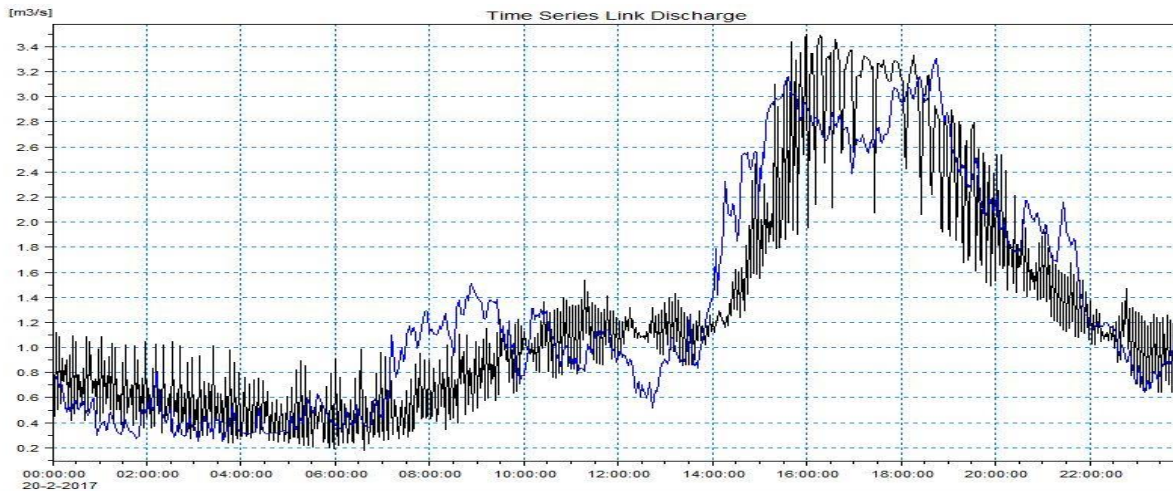


Event Date	=05-05-2016
Observed volume	=68121.93 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=6.2 %



Event Date	=21-07-2016
Observed volume	=59729.6 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=-6.9 %

# Results: Calibration of Wet weather flow

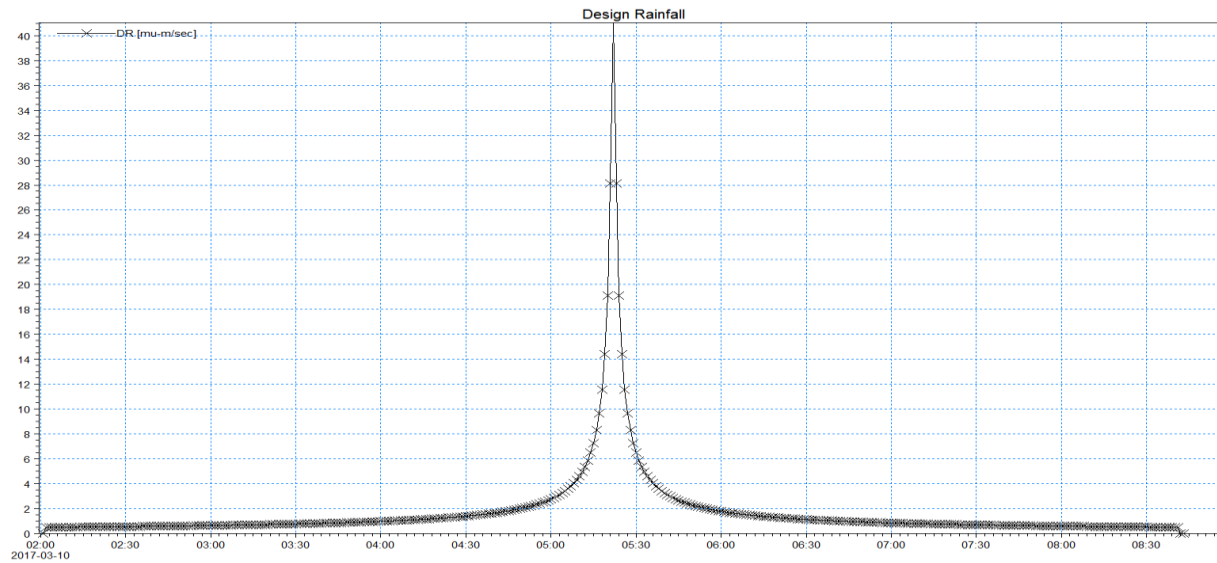


- Observed Flow: Blue
- Simulated Flow: Black

Event Date	=20-02-2017
Error in volume	=2.8 %
Observed peak	=3.3 m <sup>3</sup> /sec
Simulated Peak	=3.5 m <sup>3</sup> /sec
Peak Error	=5.7%
Correlation coefficient	=0.781

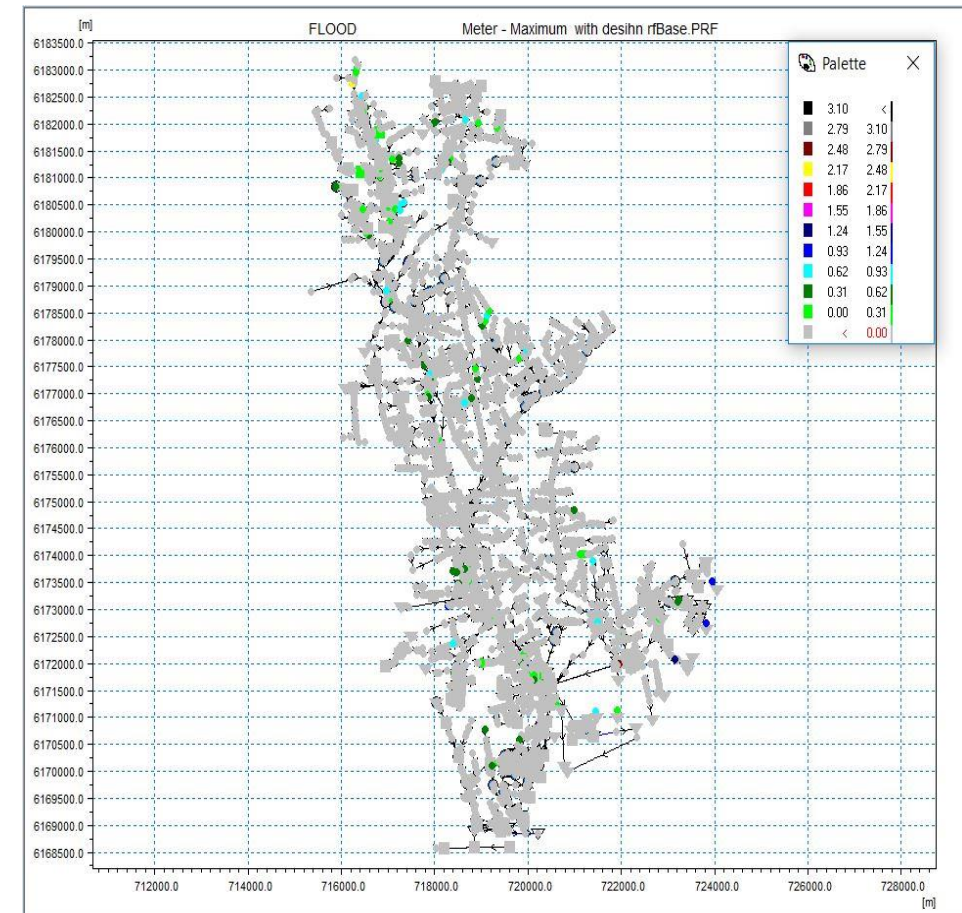
Event Date	=22-02-2017
Error in volume	=3.2 %
Observed peak	=5.68 m <sup>3</sup> /sec
Simulated Peak	=5.48 m <sup>3</sup> /sec
Peak Error	=3.63 %
Correlation coefficient	=0.843

# Results: Real Time Control



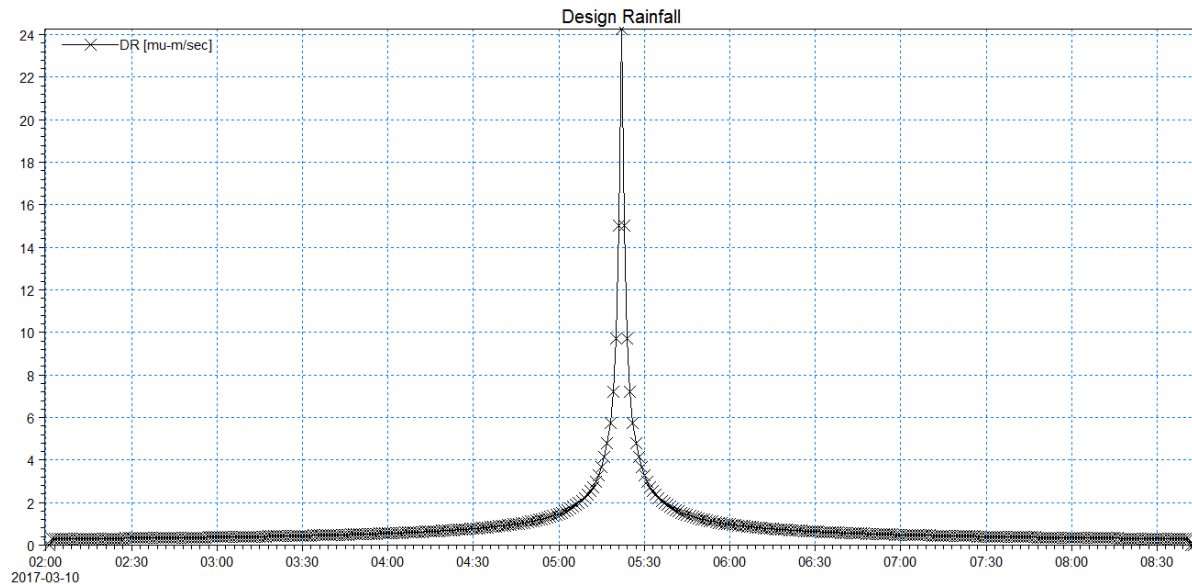
Design rainfall for 10 years in Damhusaen catchment

- Depth of design rainfall = 42.1 mm
- Colored part shows flooding into nodes with 10 years design Rainfall.
- Danish criteria of flooding



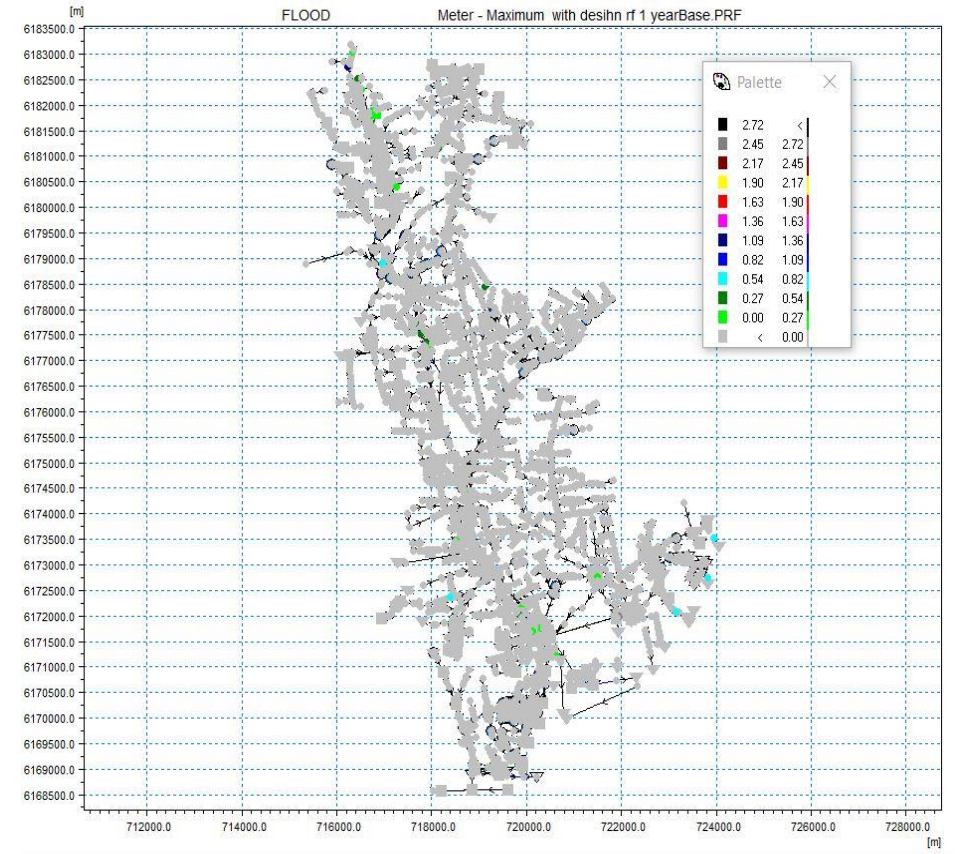
Flooding into drainage system with 10 years design rainfall before RTC

# Results: Real Time Control



Design rainfall for 1 year in Damhusaen catchment

- Depth of design rainfall = 22.81 mm
- Colored part shows flooding into nodes with 1 year design Rainfall.
- Danish criteria of flooding



Flooding into drainage system with 1 year design rainfall before RTC

# Results: Real Time Control

## Selection of weirs for RTC

- Most critical weirs
- Weirs discharging into Lake
- Environmental problems
- Overflow volume



Location of Damhusåen Lake

# Results: Real Time Control

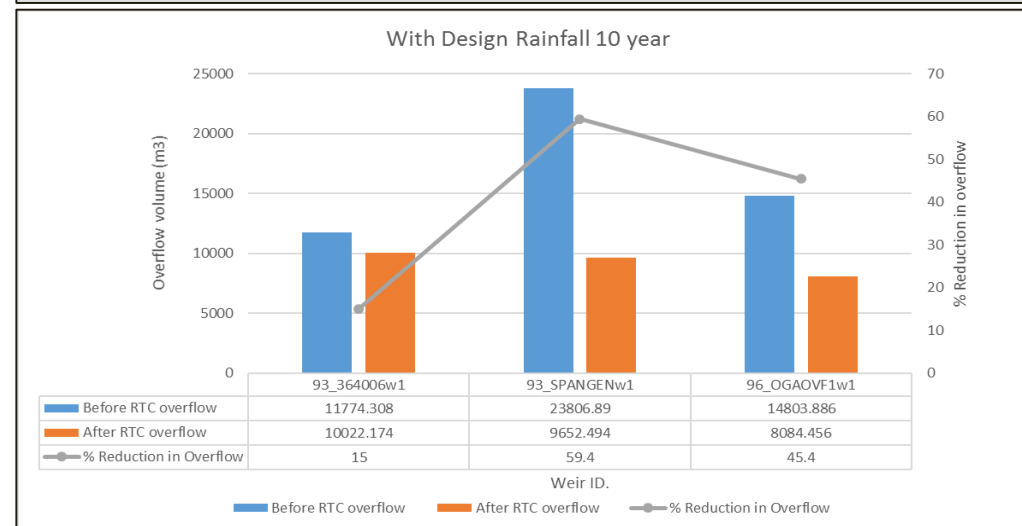
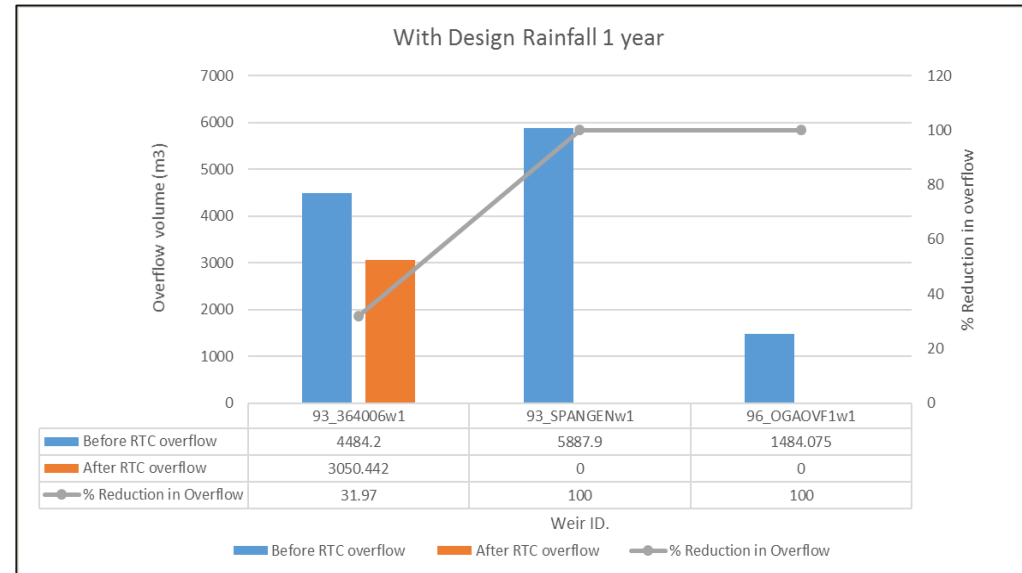
## Development of Control Strategies

- Location of sensors

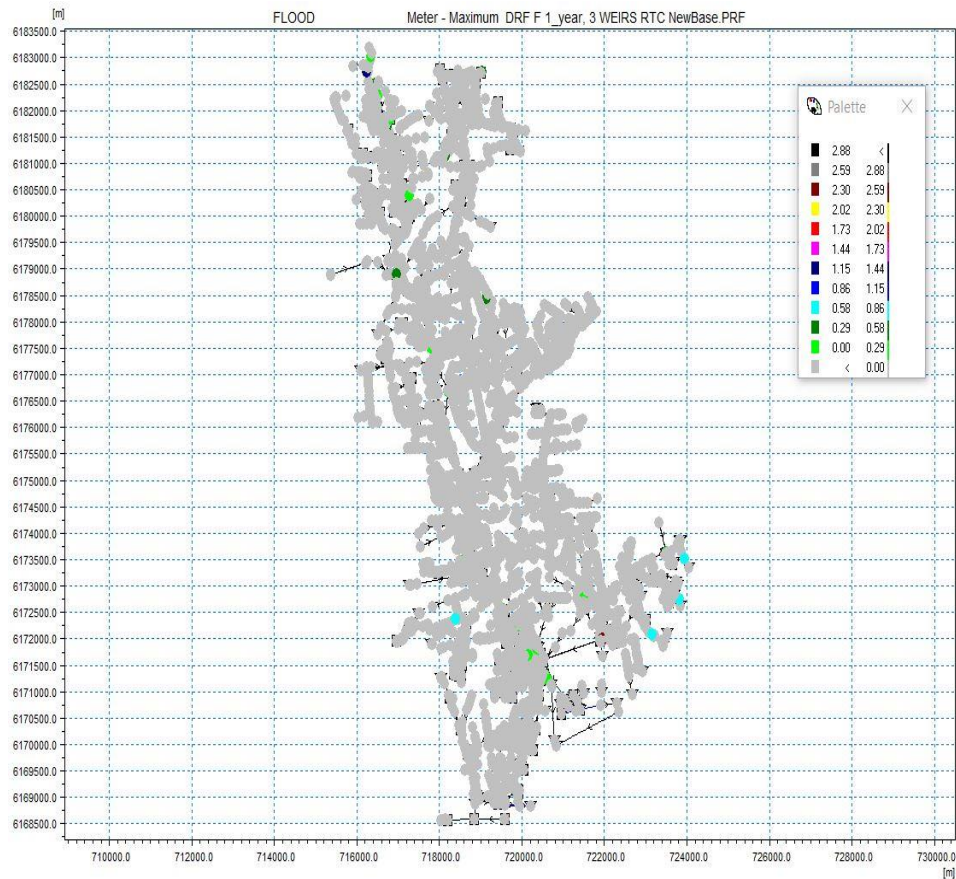
- Development of control strategies for all weirs

- Status of flooding

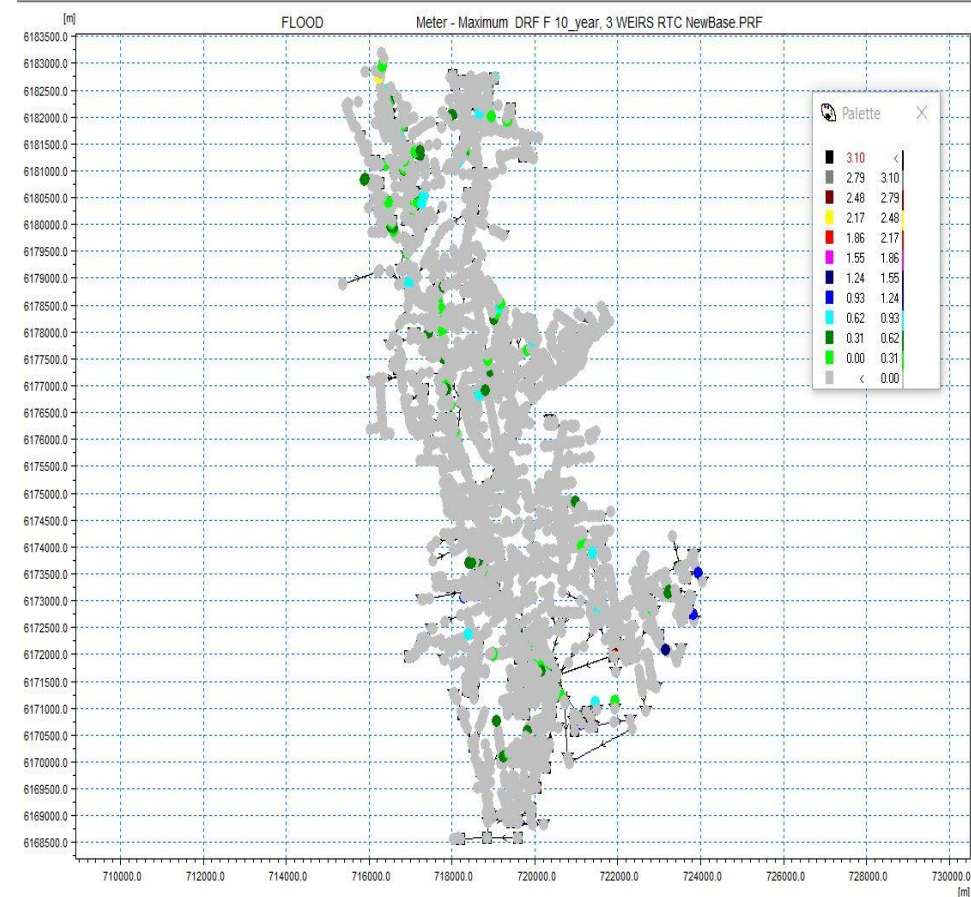
- Reduction in overflow



# Results: Real Time Control



Flooding into drainage system with 01 year design rainfall after RTC



Flooding into drainage system with 10 years design rainfall after RTC

# Results: Conclusions & Recommendations

- Calibration results confirmed model reliability for further applications.
- Flood maps from design rainfall indicates a need to modify the existing system.
- The developed RTC strategies directs a reduction potential of 40-60% to the overflow to solve environmental problems in Damhusaen Lake.
- RTC approach helps to reduce the huge potential of Bypass from wastewater treatment plant by using the storage volume of drainage system.
- As compared to static measures (construction/extension of storage volumes), RTC results are not only cost-efficient, but a flexible alternative as well.

## **Recommendations**

- Return period of rainfall analysis can be done for different climate change scenarios to check the impact of climate change.
- Existing calibrated model can also be used to forecast urban flooding in the catchment.



A white speech bubble sticker is pinned to a corkboard. The text "Thank you!!" is written in a bold, black, sans-serif font. The corkboard has a natural, textured appearance with small, light-brown granules. The entire scene is set against a solid red background.

Thank  
you!!

# Study Area – Damhusaen Catchment

## Topography:

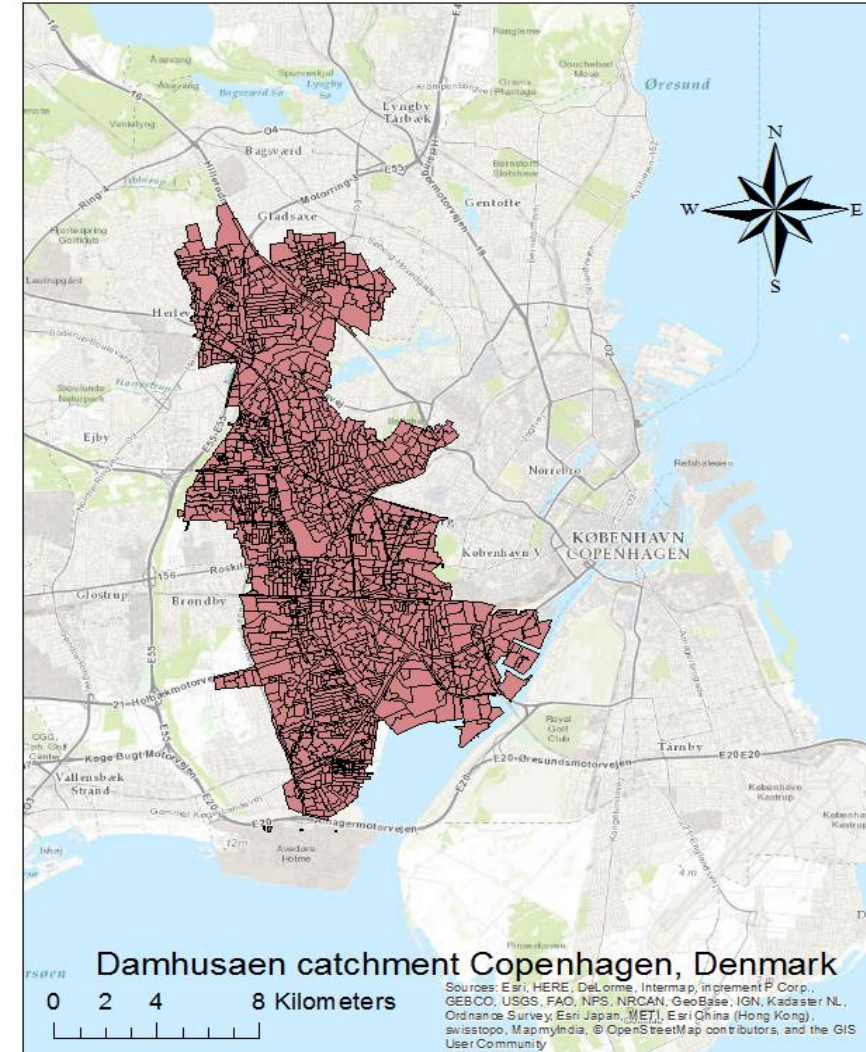
- Latitude :  $55^{\circ} 61'$  to  $55^{\circ} 73'$  N
- Longitude:  $12^{\circ} 43'$  to  $12^{\circ} 51'$  E
- Area :  $37 \text{ km}^2$

## Network Information:

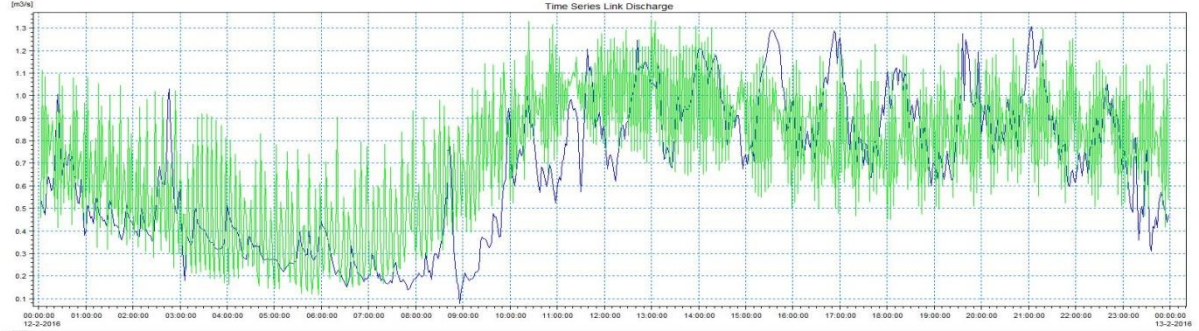
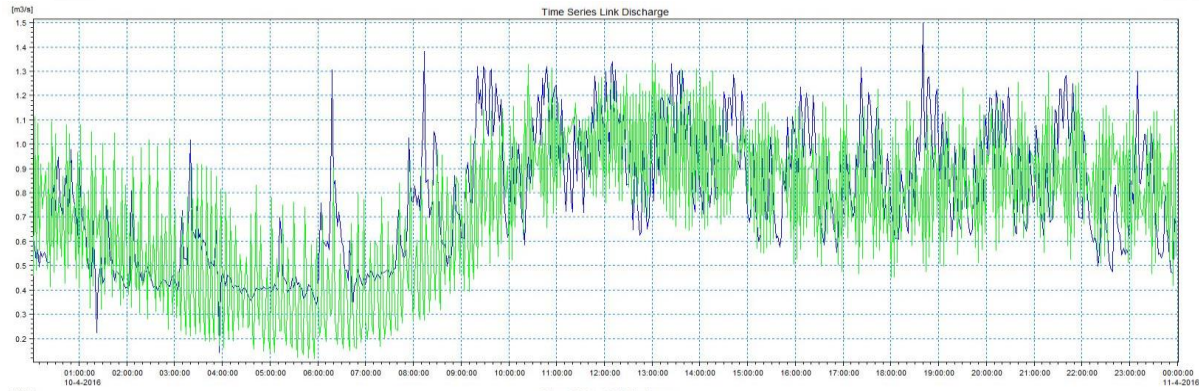
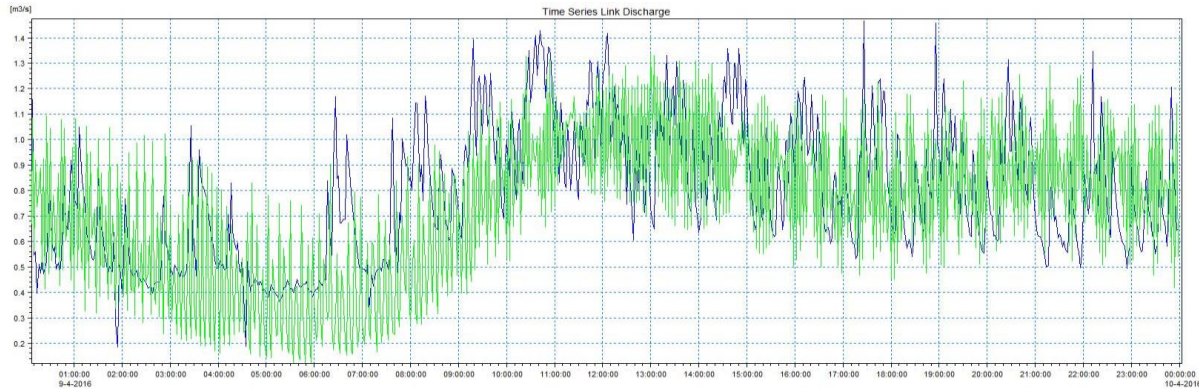
- No. of Pumps: 90
- No. of Weirs: 268
- No. of Orifices 81

## Population statistics:

- Population 2015: 262,327
- Population 2025: 306,858



# Results: Calibration of Dry weather flow



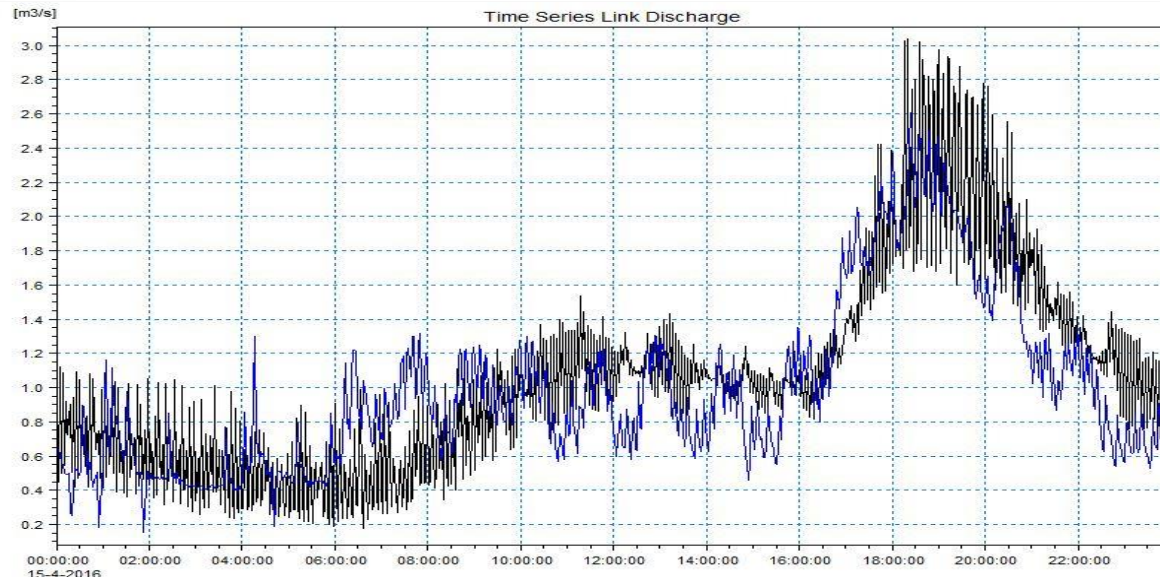
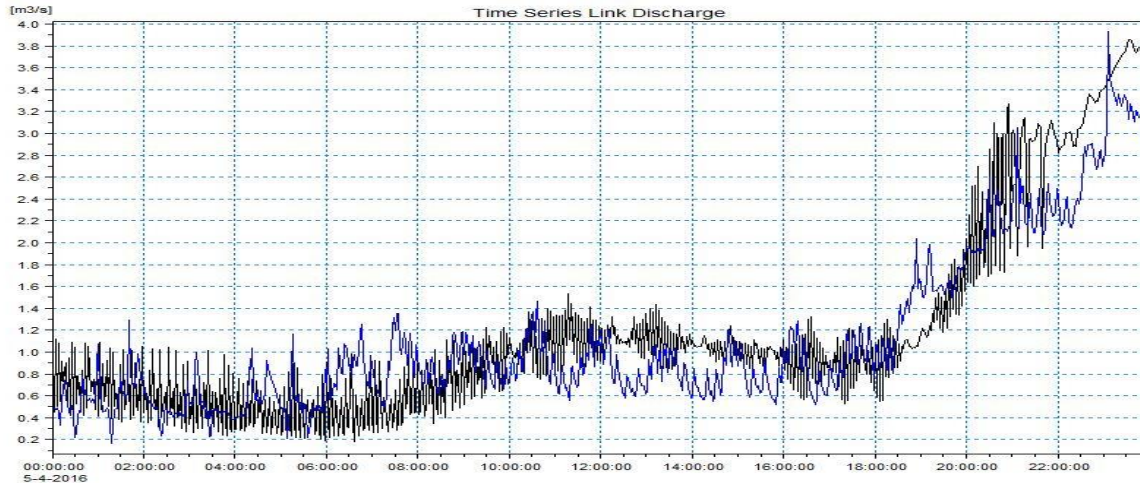
- Observed Flow: Blue
- Simulated Flow: Green

Event Date	=09-04-2016
Observed volume	=68136.47 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=6.2 %

Event Date	=10-04-2016
Observed volume	=67209.9 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=4.9 %

Event Date	=09-04-2016
Observed volume	=65829.2 m <sup>3</sup>
Simulated volume	=63881.28 m <sup>3</sup>
Error in volume	=2.9 %

# Results: Calibration of Wet weather flow



- Observed Flow: Blue
- Simulated Flow: Black

Event Date	=05-04-2016
Error in volume	=6.8 %
Observed peak	=3.931 m <sup>3</sup> /sec
Simulated Peak	=3.853 m <sup>3</sup> /sec
Peak Error	=1.98 %
Correlation coefficient	=0.827

Event Date	=15-04-2016
Error in volume	=6.0 %
Observed peak	=2.6 m <sup>3</sup> /sec
Simulated Peak	=2.9 m <sup>3</sup> /sec
Peak Error	=11 %
Correlation coefficient	=0.70

# Results: Overall results of calibration of wet weather flow

- Comparison of actual and simulated volume
- Comparison of actual and simulated peaks
- Correlation coefficients for all events

