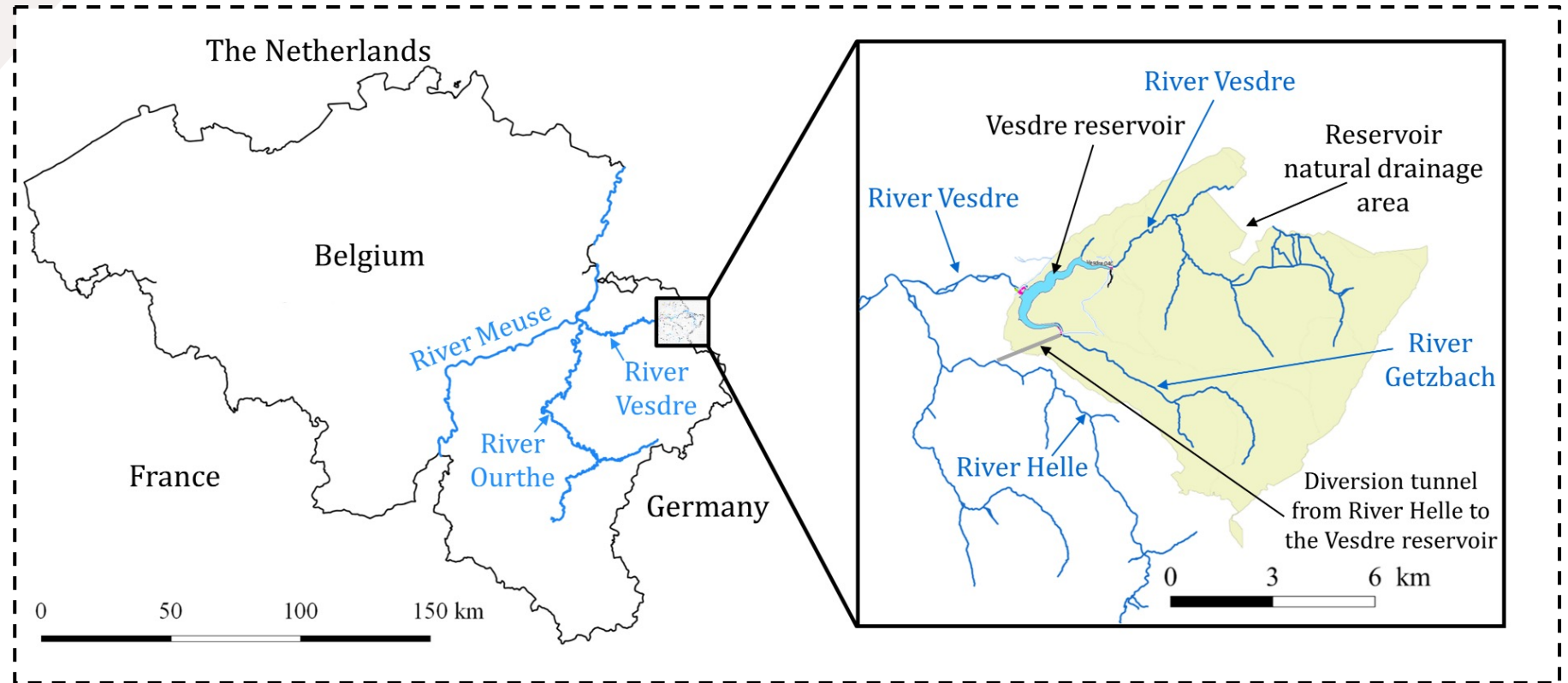


# Flood control capacity of a large reservoir under moderate and extreme flood conditions

P. Chakraborty • S. De Kock • P. Archambeau • M. Pirotton • S. Erpicum • B. Dewals

# The Eupen dam



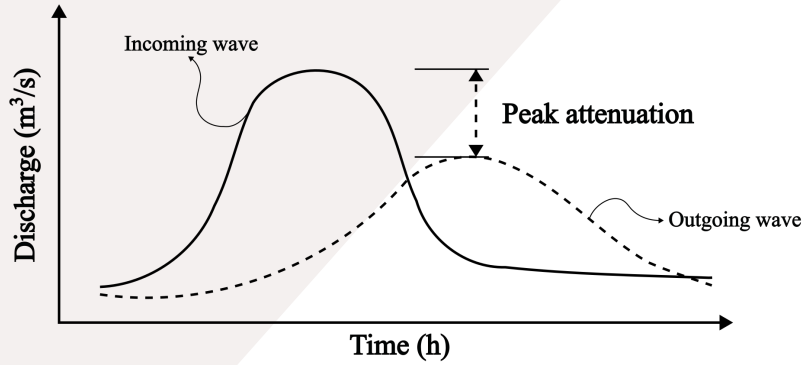
## Multipurpose dam:

*Storage for drinking water supply* | *Sufficient reservoir capacity for floods*

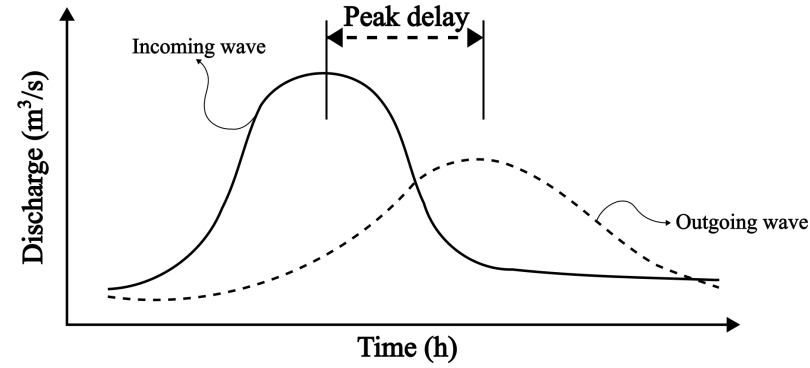
## Goal of the study:

*Analysis of flood control capacity in context of major flood events (18 nos.)*

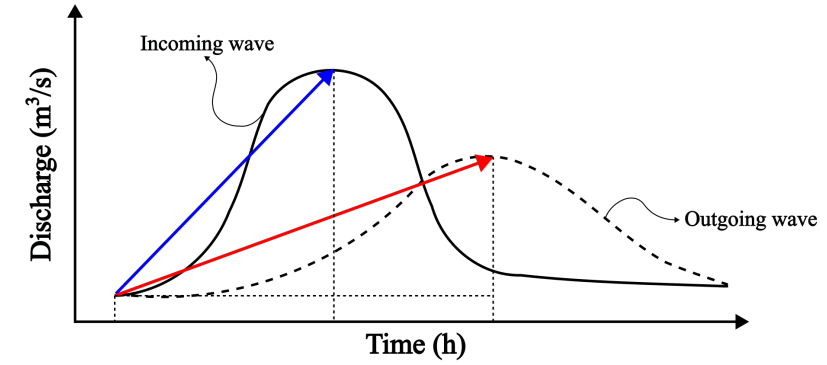
# Aspects of 'dam-effect' studies



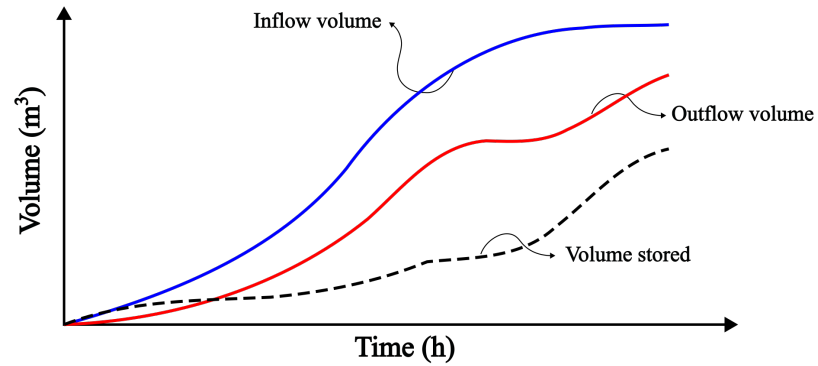
(1) ✓



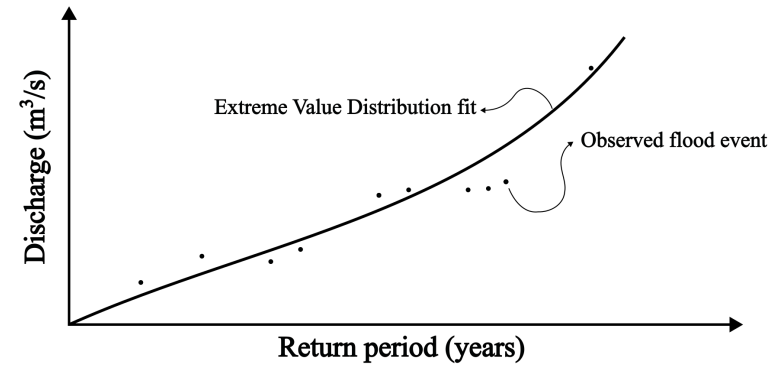
(2) ✓



(3) ✓

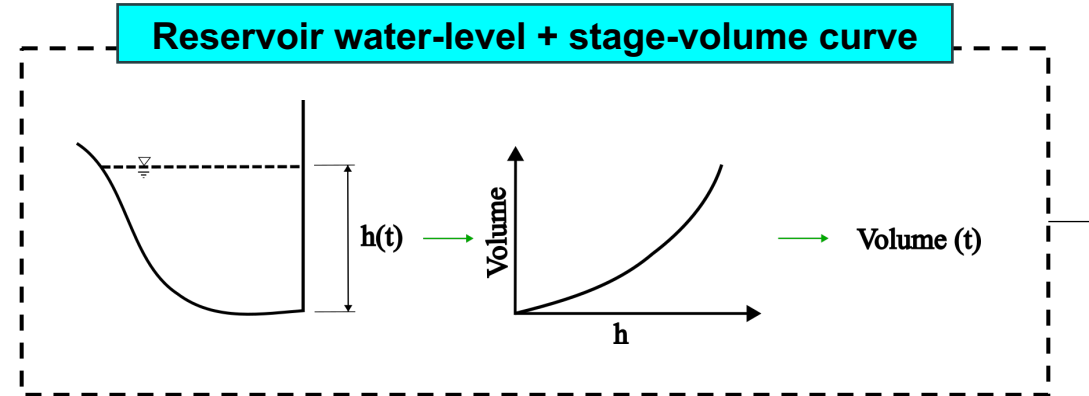
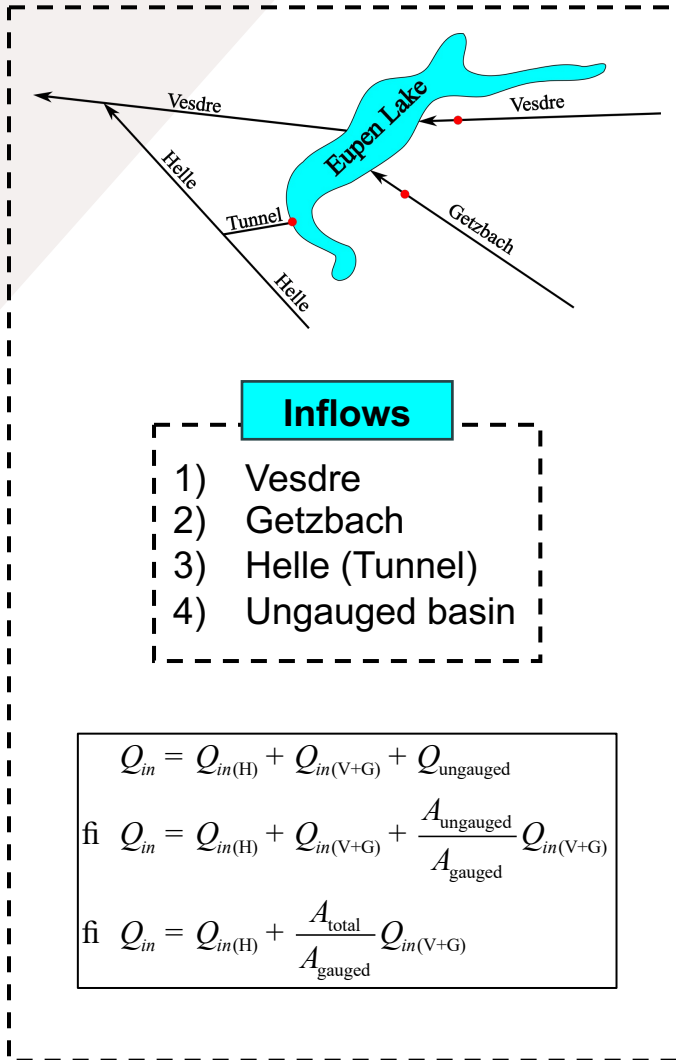


(4) ✓



(5) ✓

# Data and Method



**Mass balance**

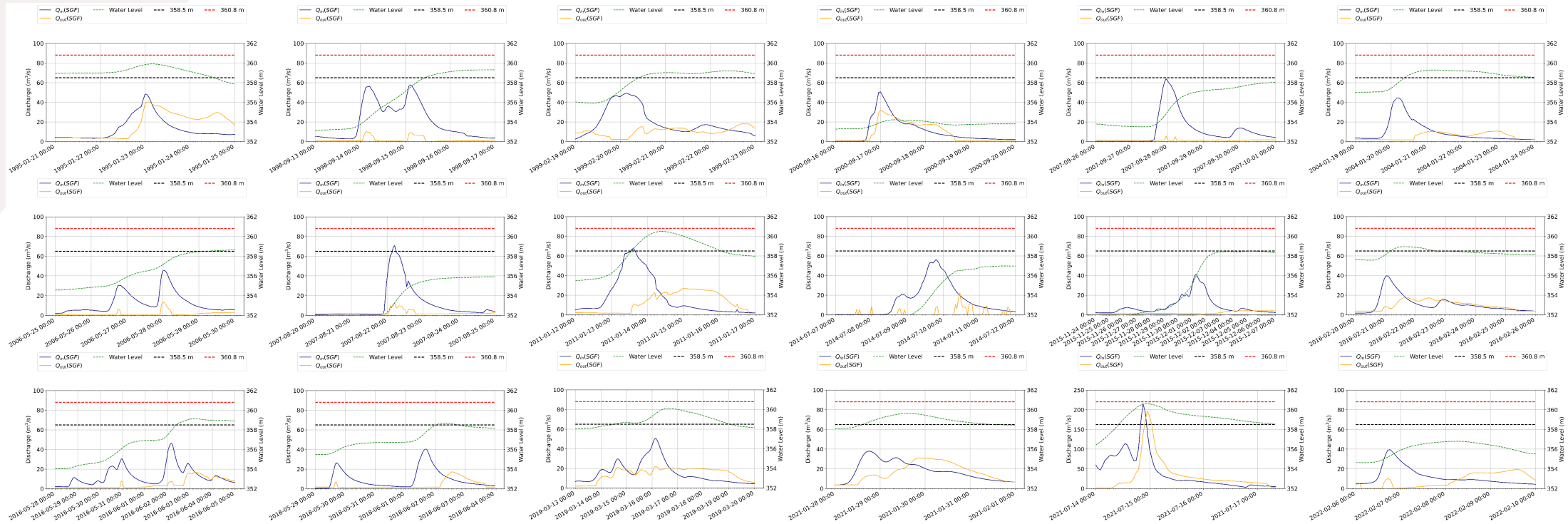
$$Q_{out}(t + Dt) = Q_{in}(t + Dt) - \frac{V(t + Dt) - V(t)}{Dt}$$



# Base output of computations



## 18 Inflow & Outflow Hydrographs

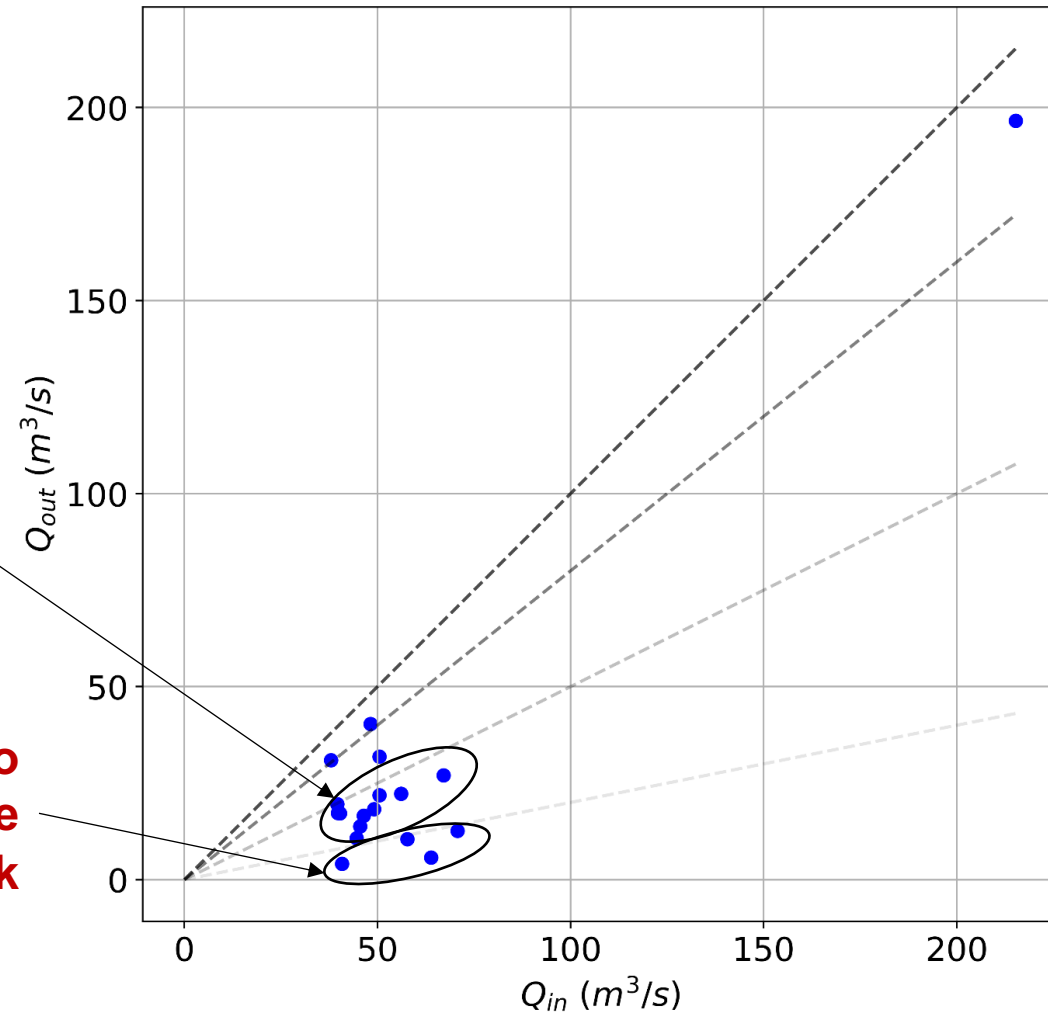


# Flood peak attenuation

----- No damping    - - - - 20% damping    - - - - 50% damping    - - - - 80% damping

**Majority of the floods are damped by 50-80%**

**Some peaks are damped to the extent of no appreciable outflow peak**



# Flood peak attenuation



## Water level

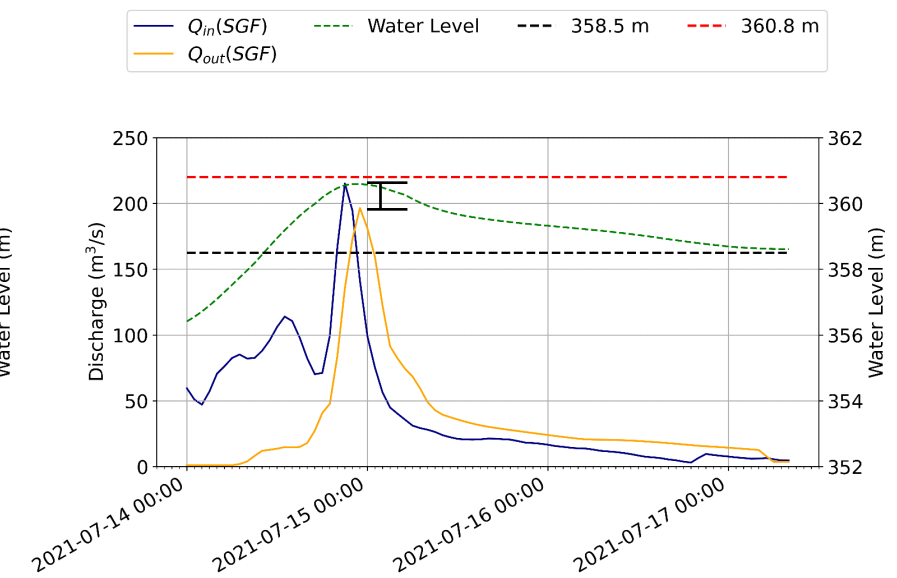
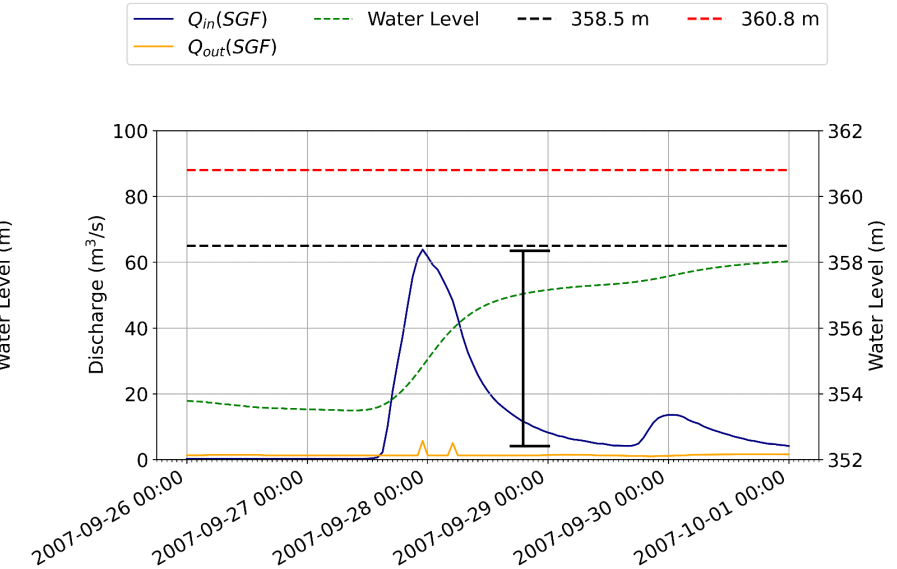
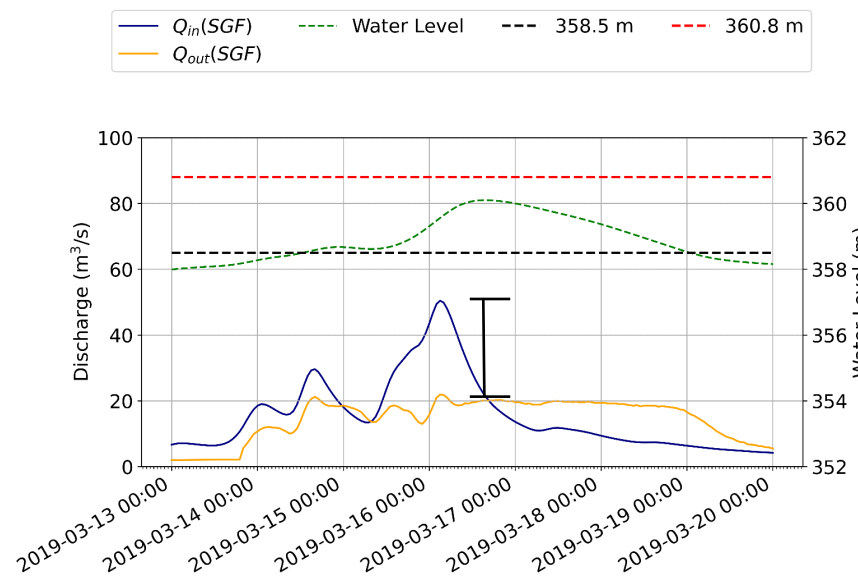
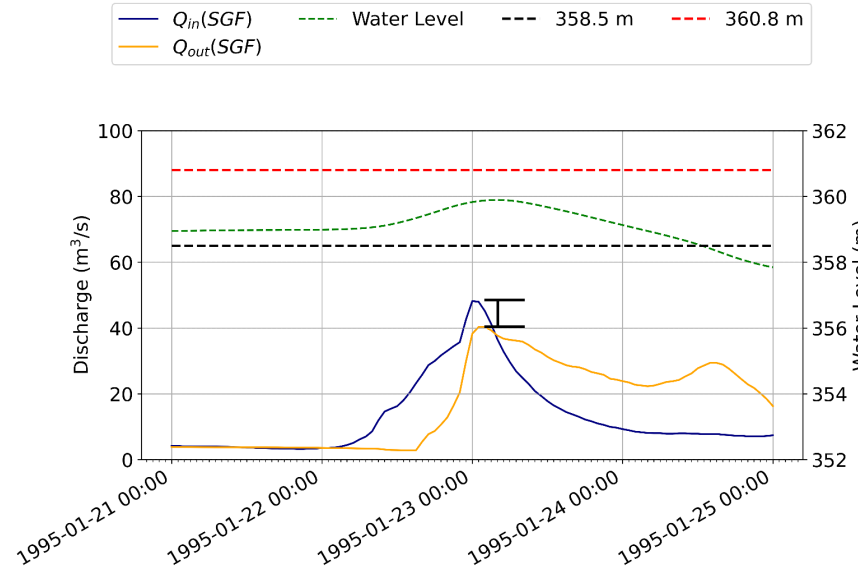
- ~ at critical level
- < critical level
- << critical level

## Inflow discharge

- High
- Very High

## Release discharge timing

- Pre-emptive
- Late
- None



# Flood peak attenuation



## Water level

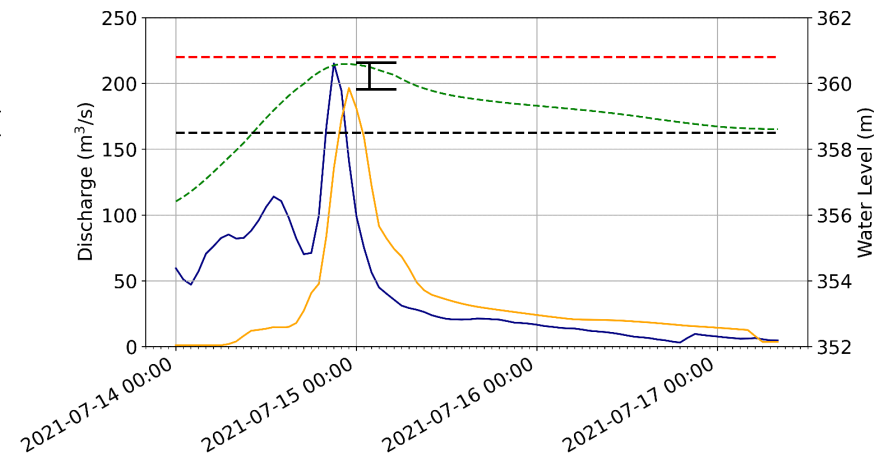
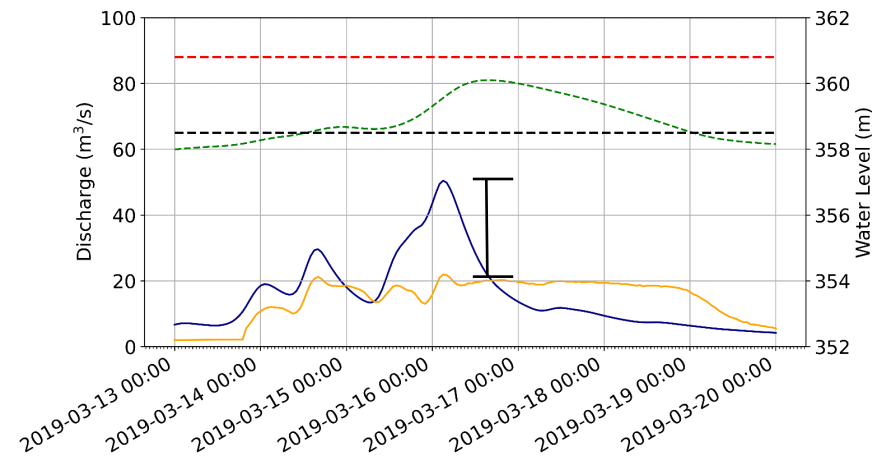
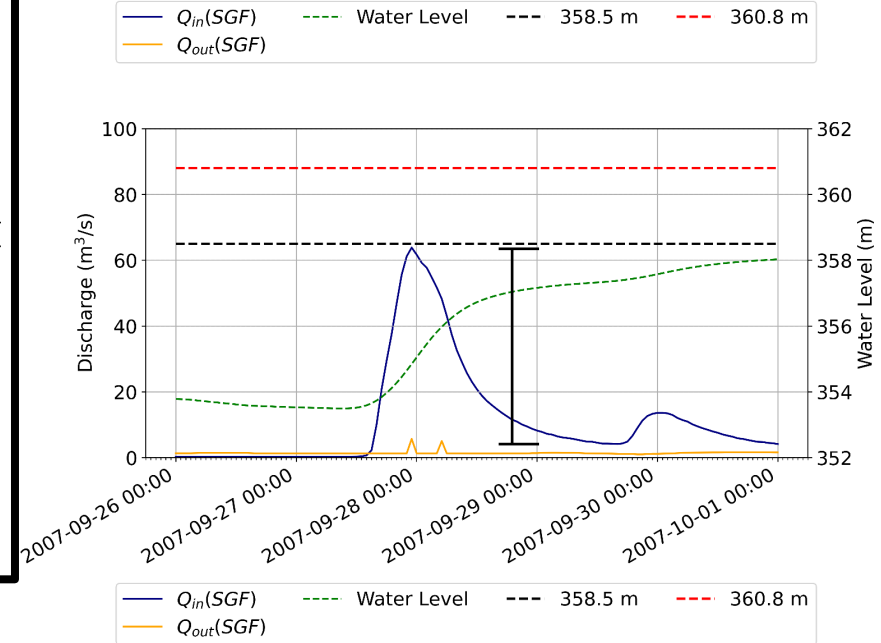
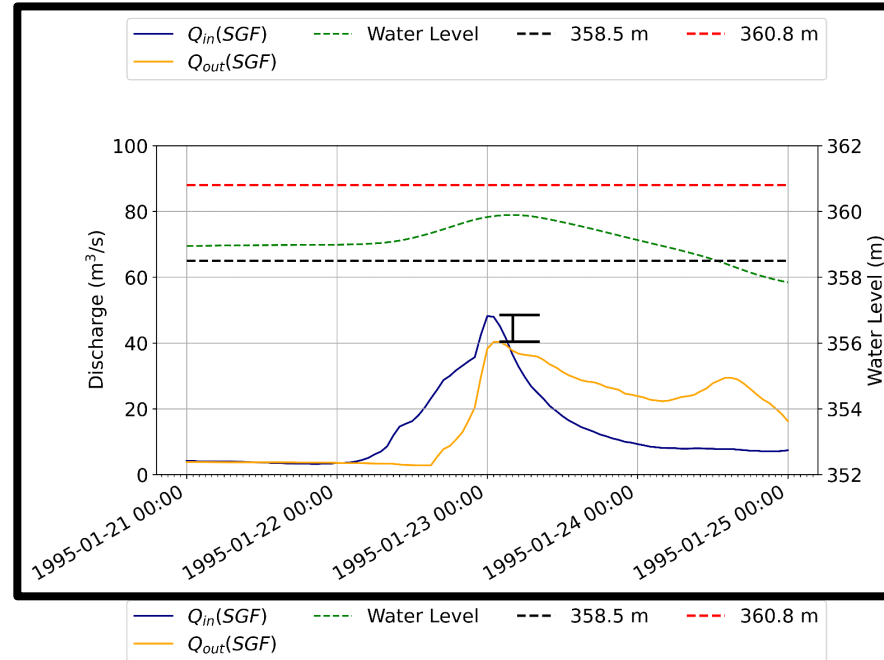
- ~ **at critical level**
- < critical level
- << critical level

## Inflow discharge

- **High**
- Very High

## Release discharge timing

- Pre-emptive
- **Late**
- None



# Flood peak attenuation



## Water level

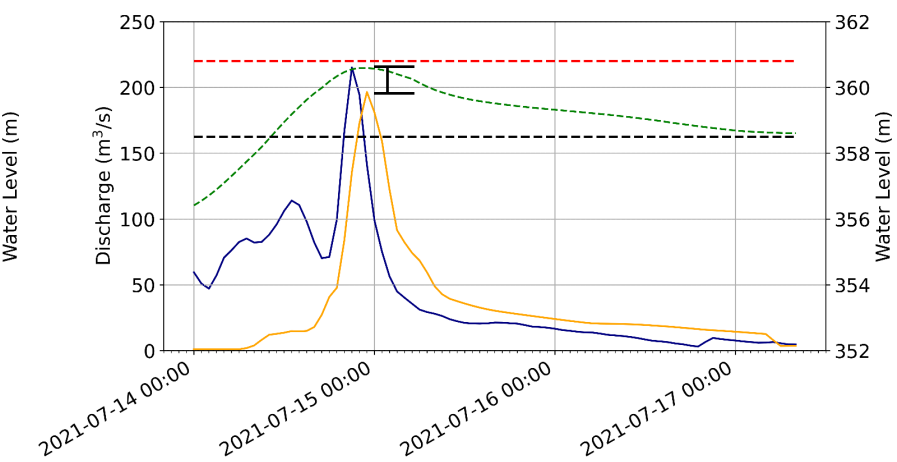
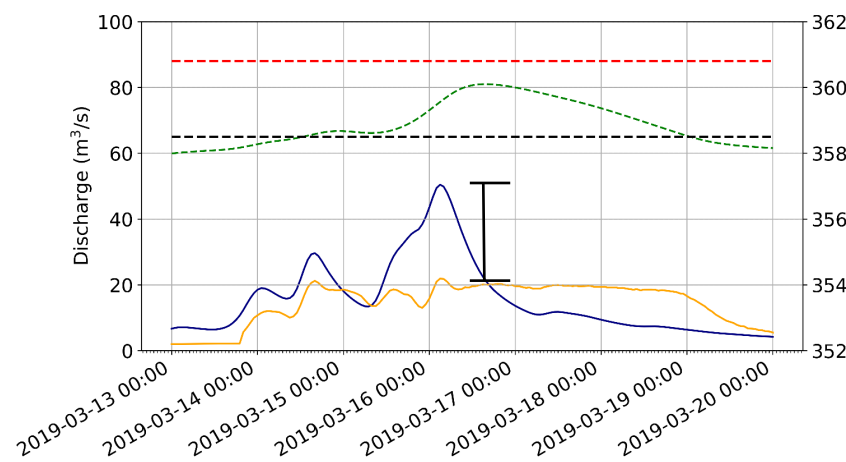
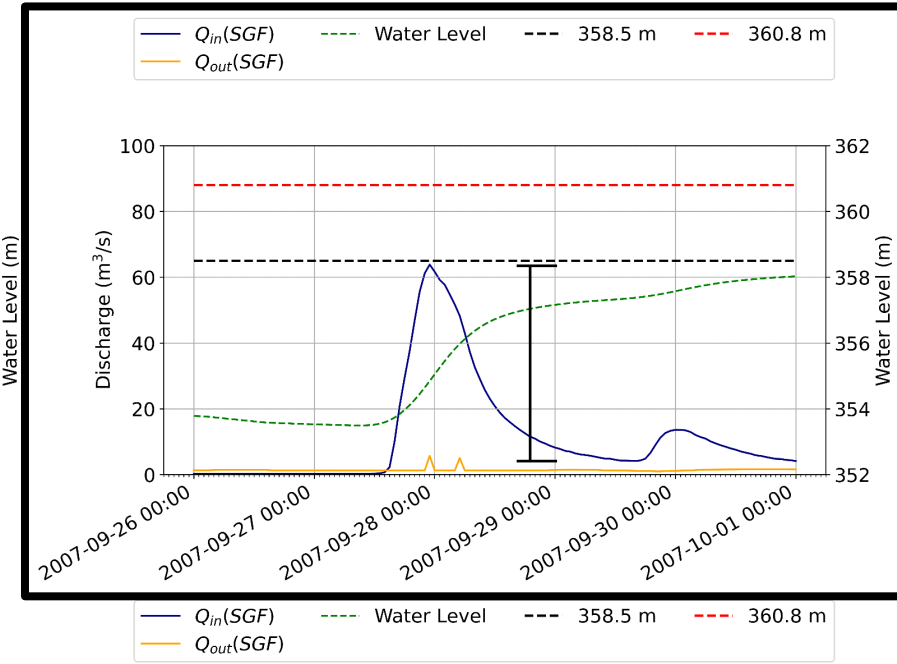
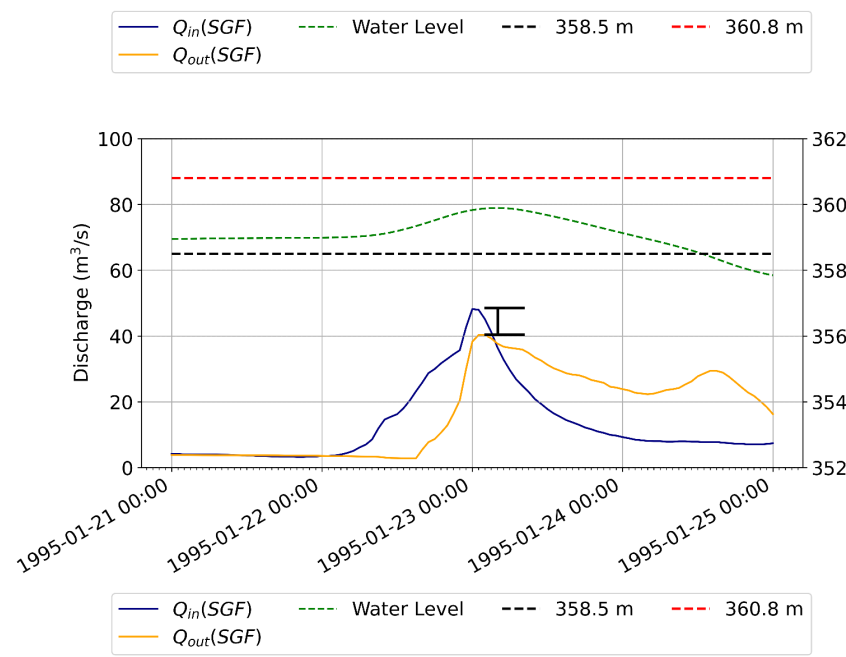
- ~ at critical level
- < critical level
- << critical level

## Inflow discharge

- High
- Very High

## Release discharge timing

- Pre-emptive
- Late
- None





# Flood peak attenuation



## Water level

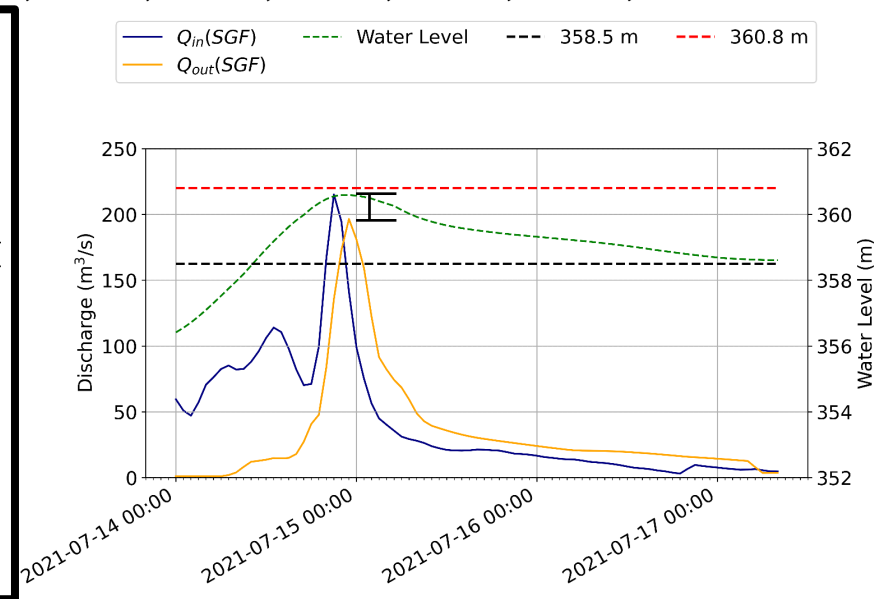
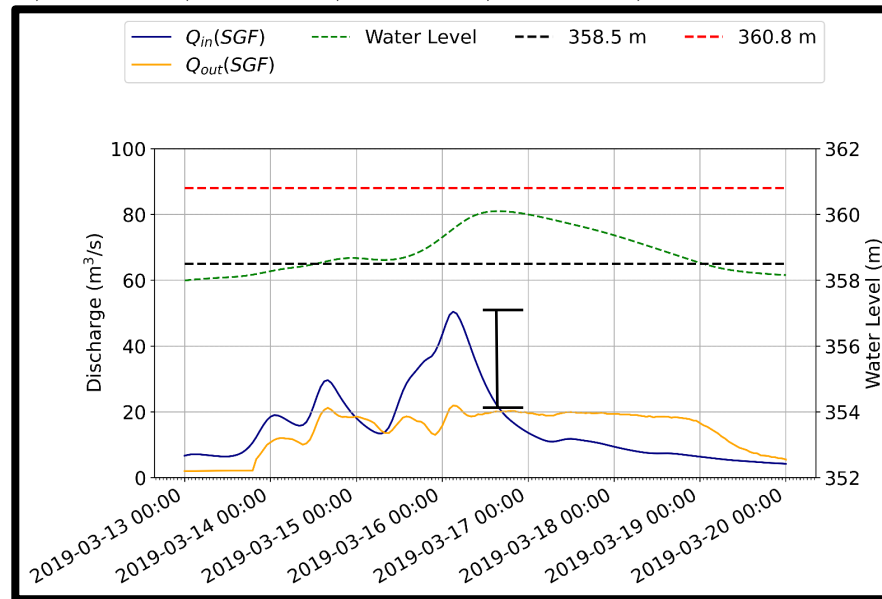
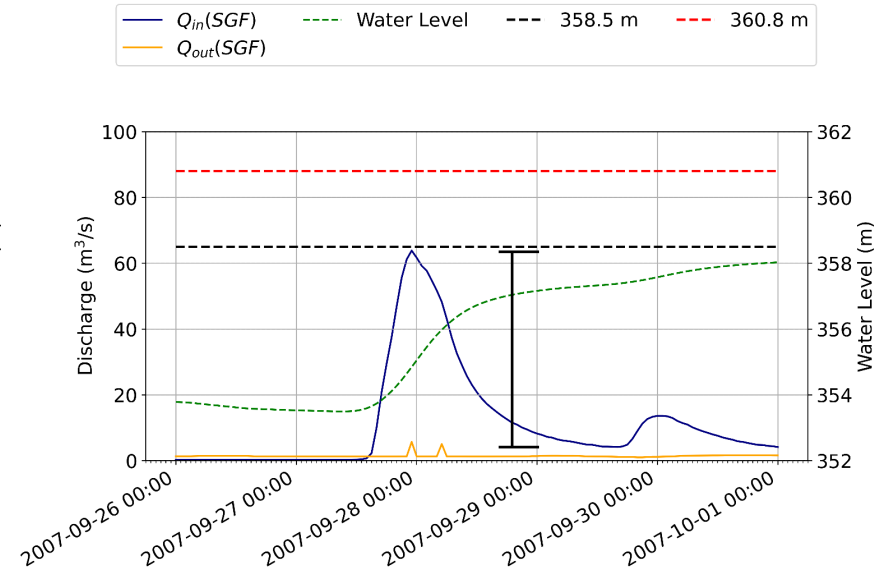
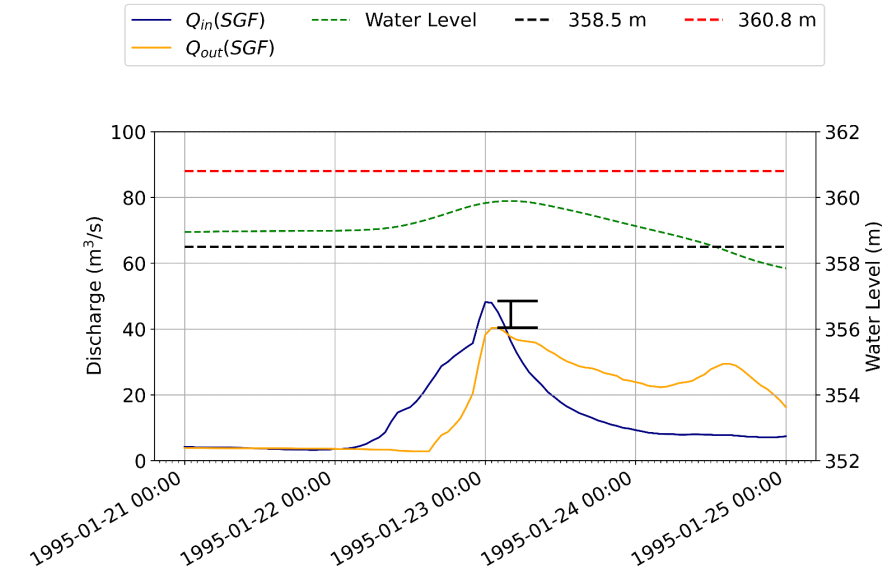
- ~ **at critical level**
- < critical level
- << critical level

## Inflow discharge

- **High**
- Very High

## Release discharge timing

- **Pre-emptive**
- Late
- None



# Flood peak attenuation



## Water level

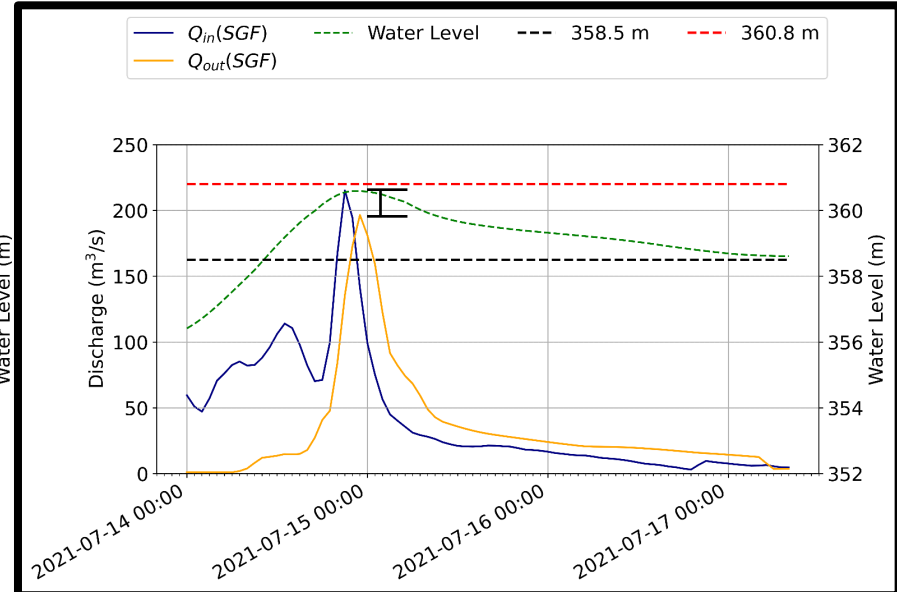
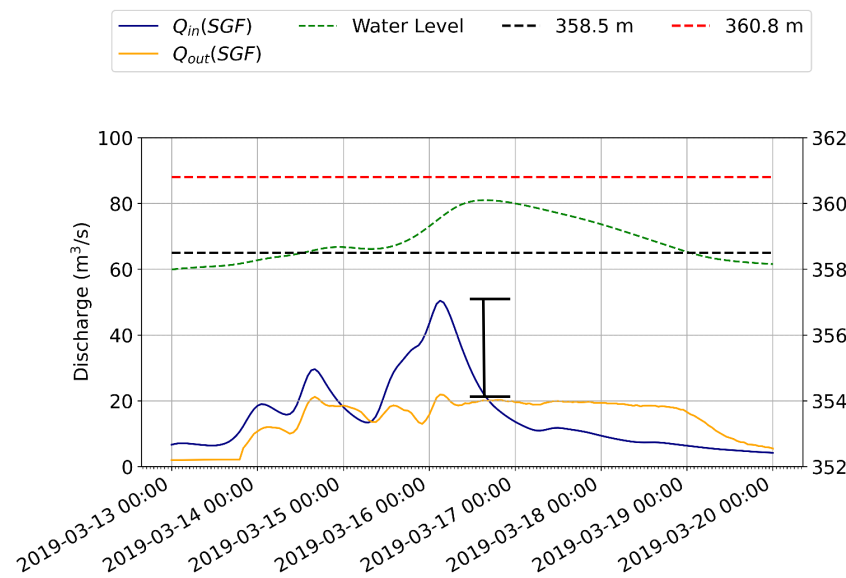
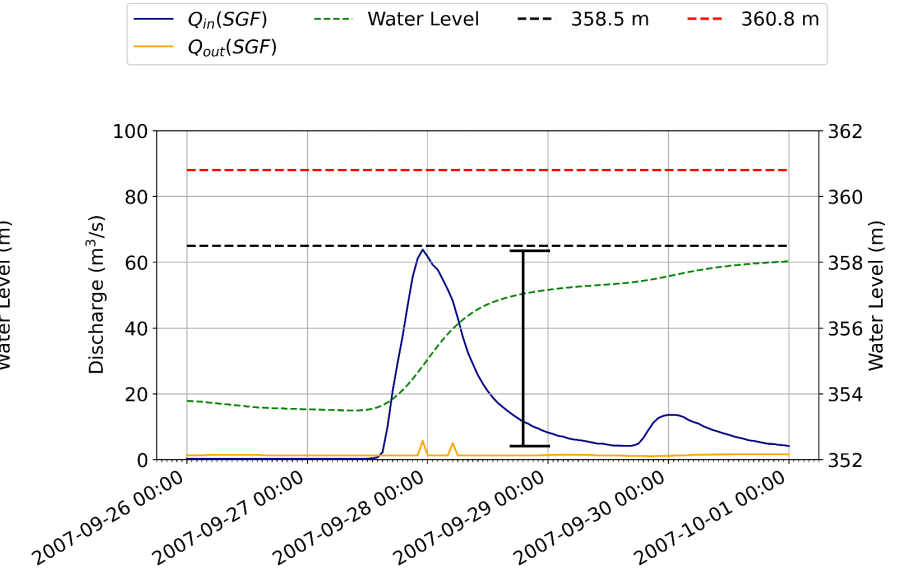
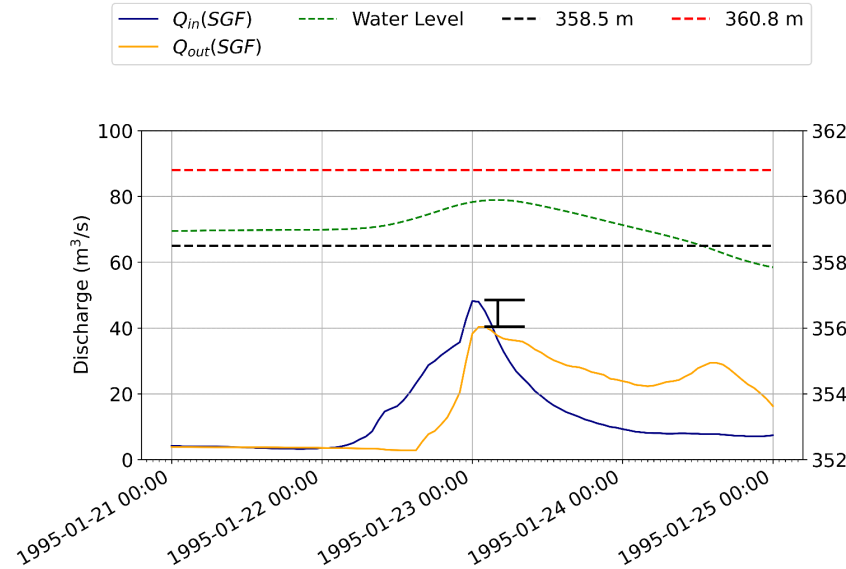
- ~ at critical level
- **< critical level**
- << critical level

## Inflow discharge

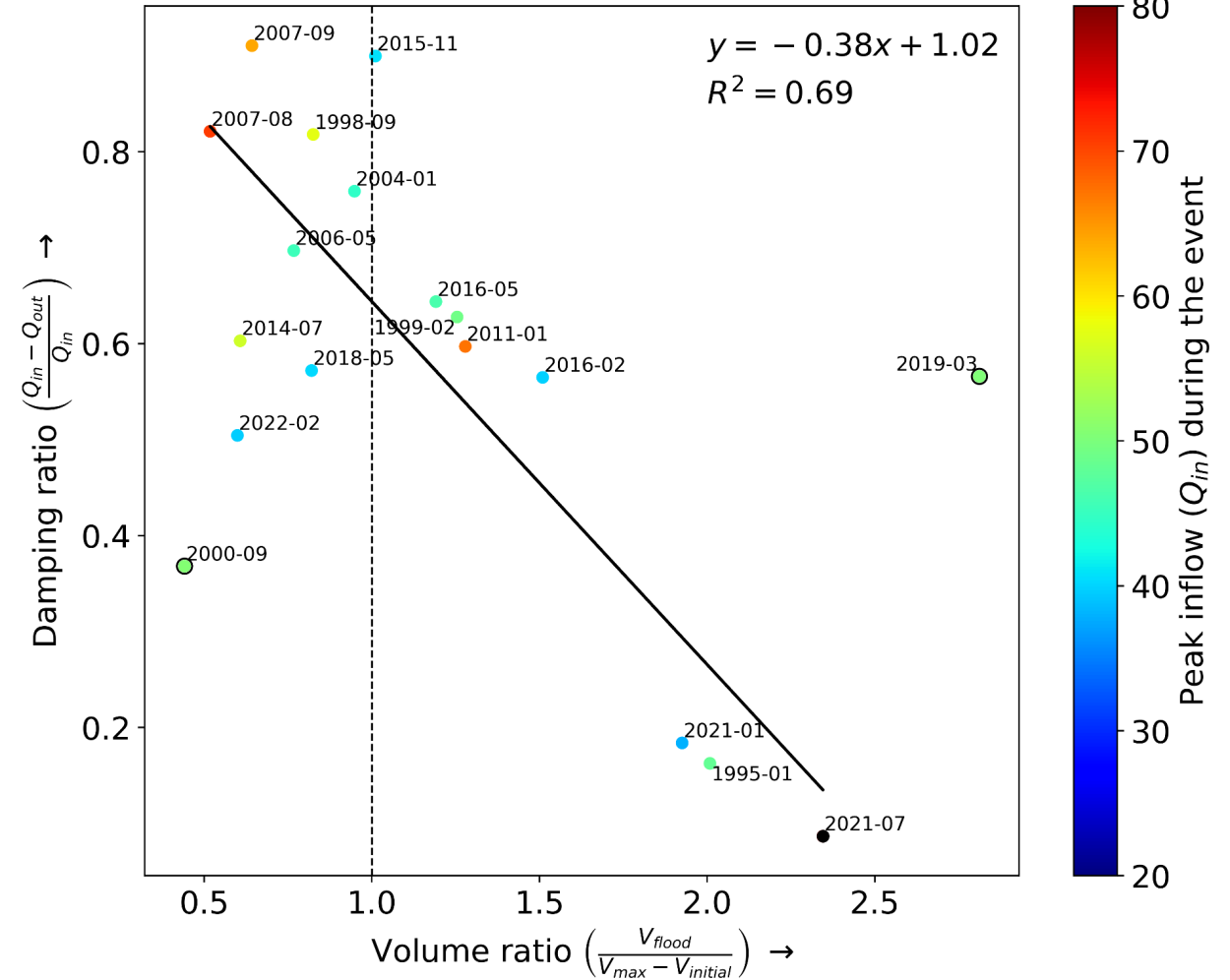
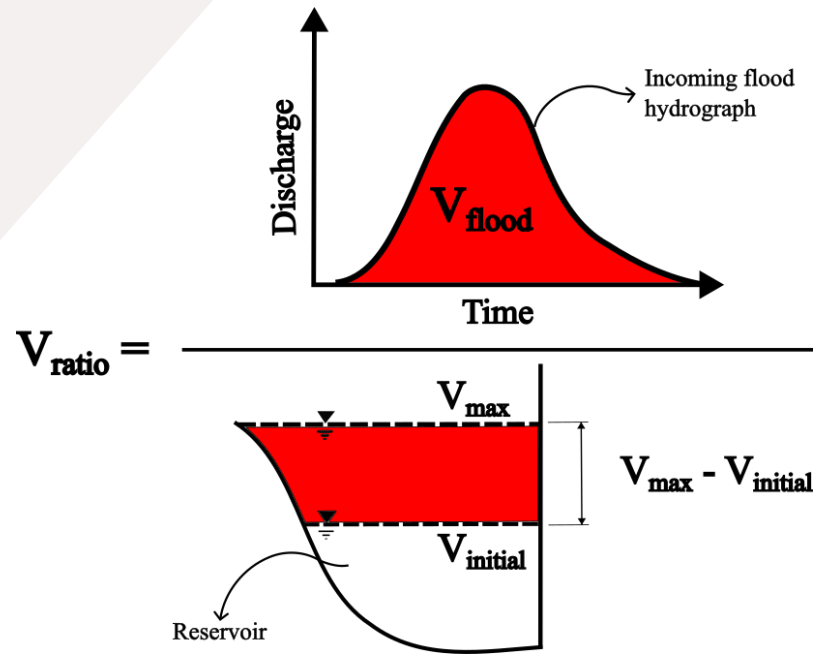
- High
- **Very High**

## Release discharge timing

- Pre-emptive
- **Late**
- None



# What is determining the extent of damping of an incoming flood wave?



# What is determining the extent of damping of an incoming flood wave?

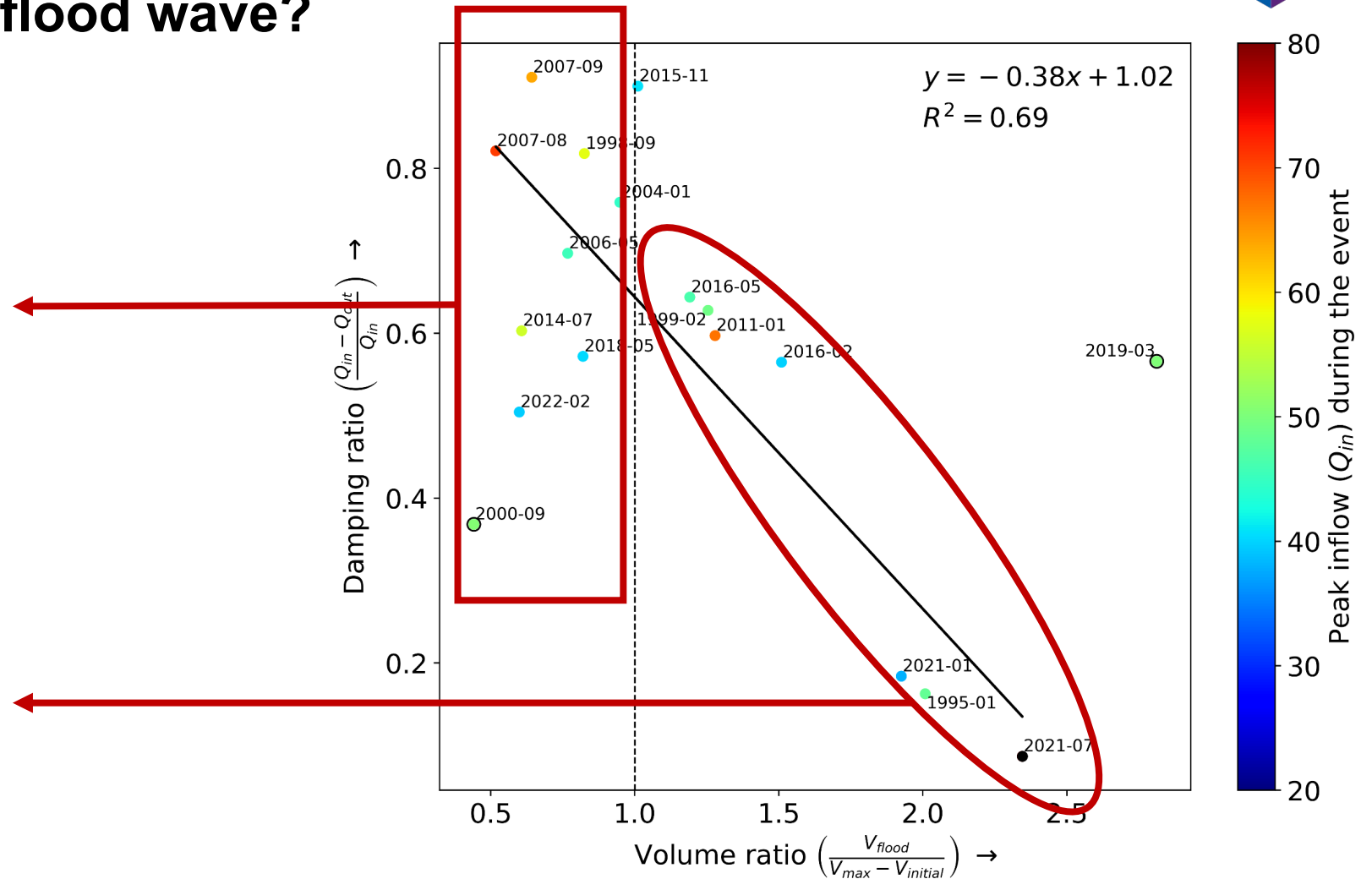


$$V_{ratio} < 1$$

Range of damping ratio values possible for similar  $V_{ratio}$ .

$$V_{ratio} > 1$$

Role of pre-emptive dam management increases



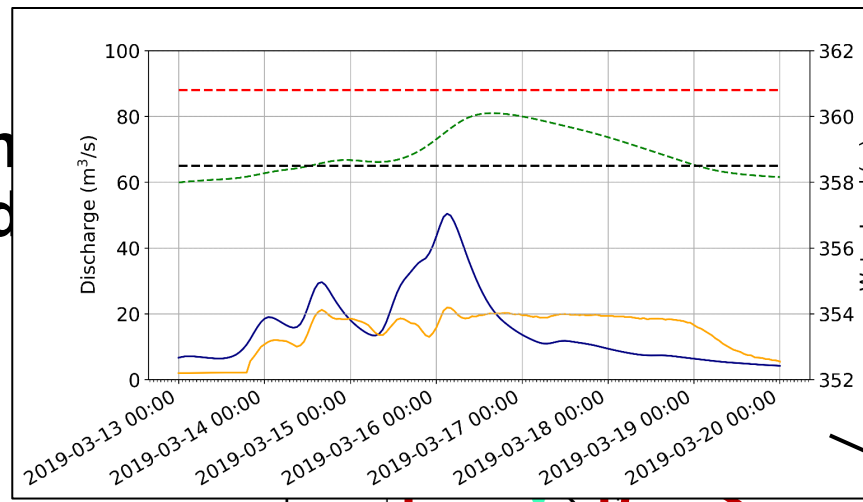
# What is determining the extent of damping of an incoming flood

$V_{ratio} < 1$

Range of damping ratio values possible for similar  $V_{ratio}$ .

$V_{ratio} > 1$

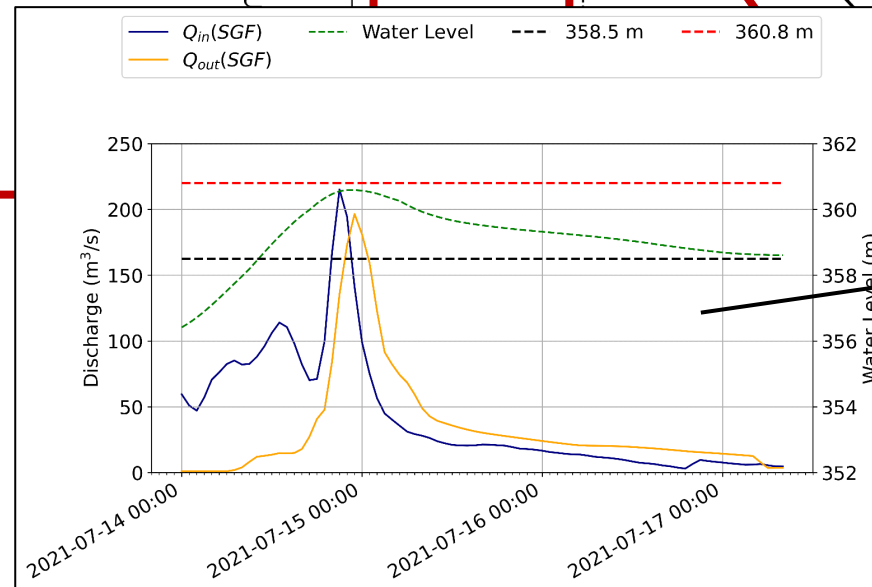
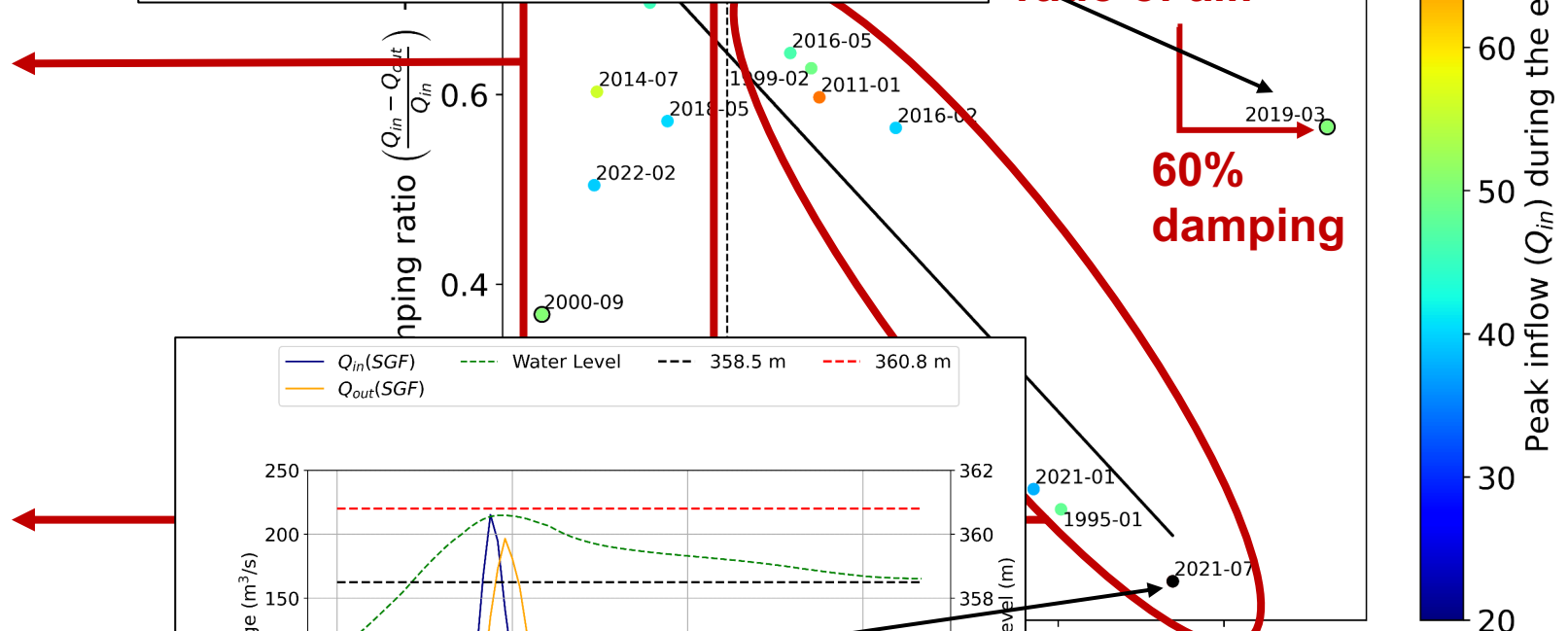
Role of pre-emptive dam management increases



$y = -0.38x + 1.02$   
 $R^2 = 0.69$

Highest volume ratio of all!

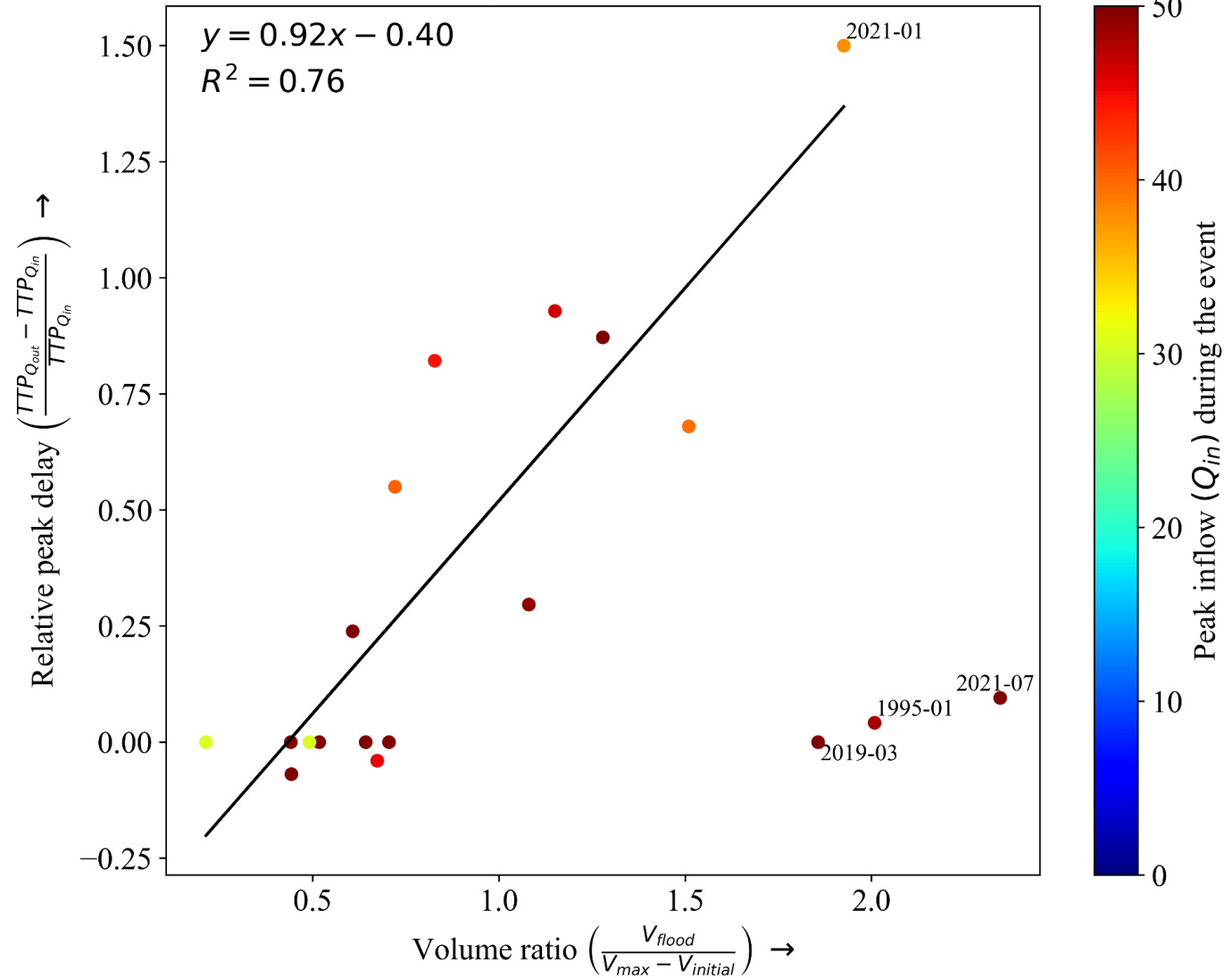
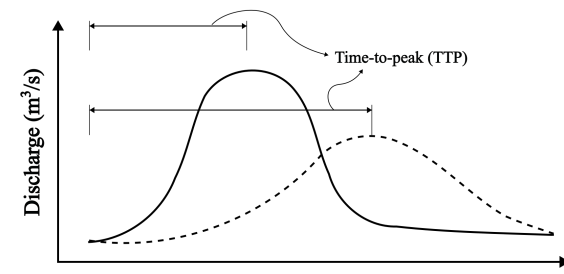
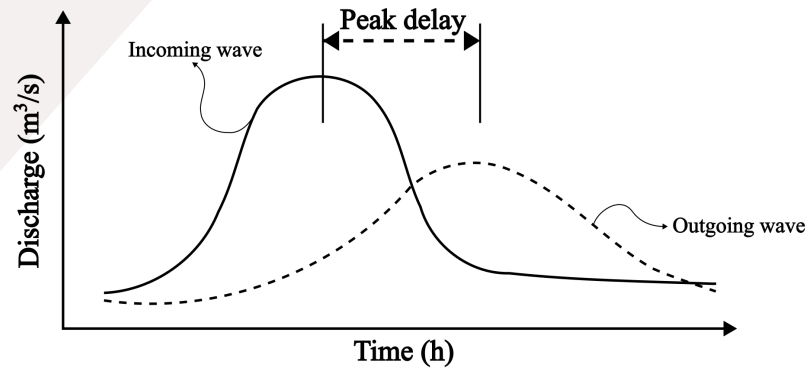
60% damping



$\frac{Q_{out}}{Q_{in}}$



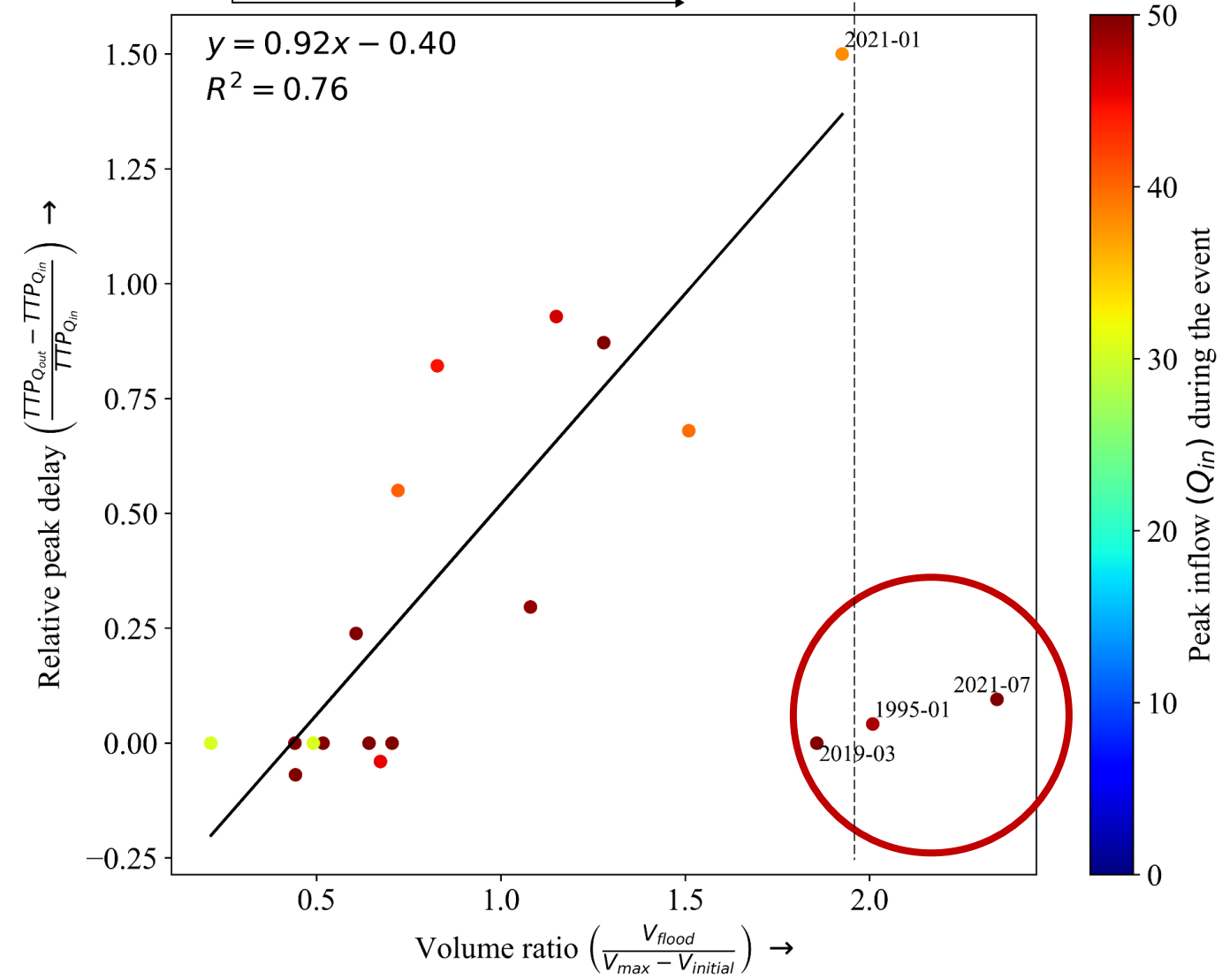
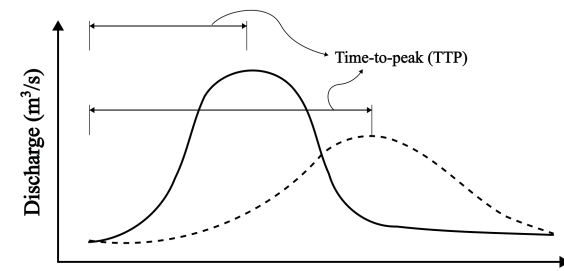
# Peak delay



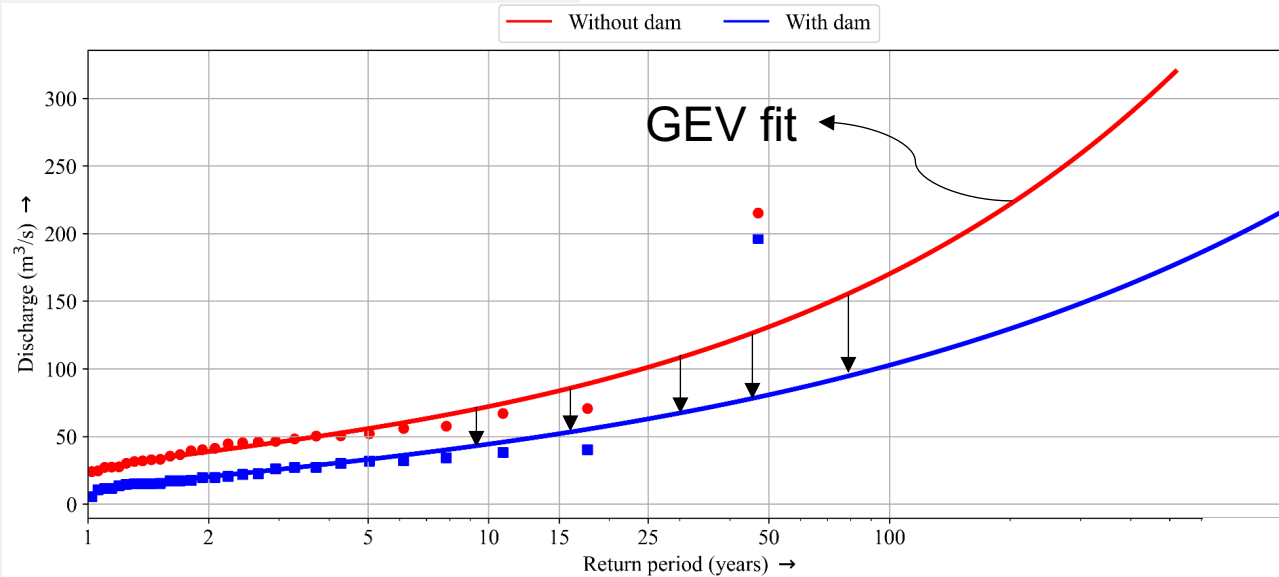
# Peak delay

## What is determining the peak-delay of an incoming flood wave?

- Significant **direct correlation** between **relative peak delay** & **volume ratio**
- Indicates operational perspective
- **Outliers** characterised by simultaneous occurrence of **high volume-ratio** and **high peak inflow**



# Flood frequency analysis

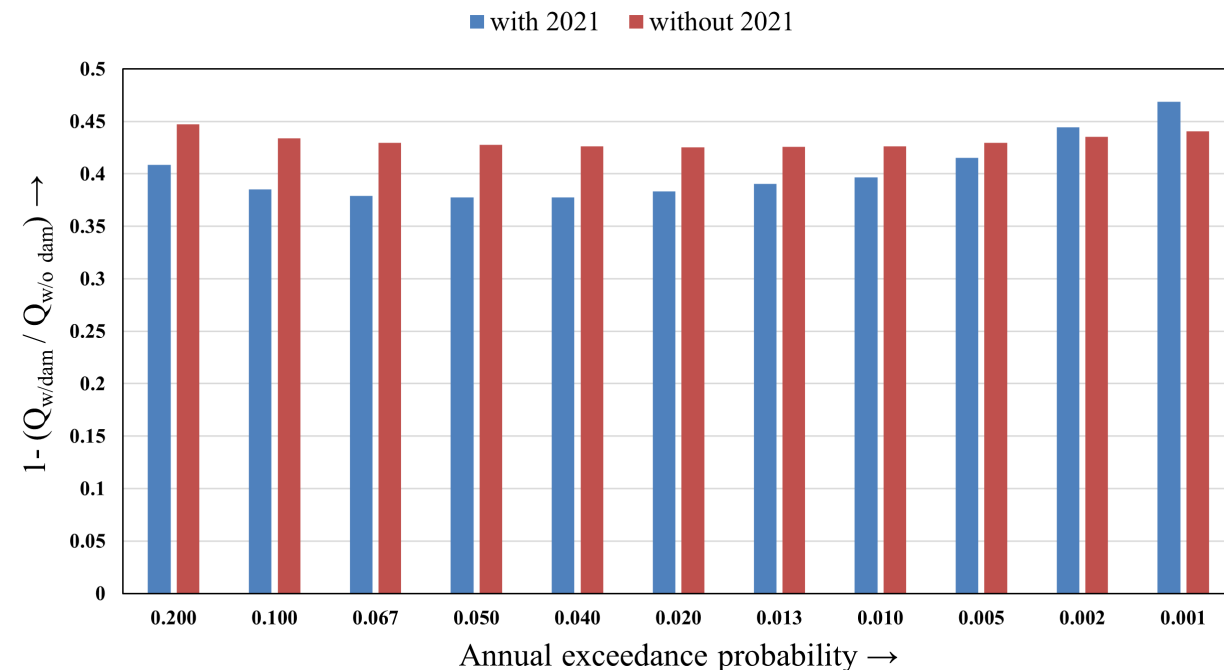


→ Sensational July 2021 floods

→ Consistent peak value reduction by dam across different return periods

Dam reduces the magnitude of floods of different return periods by **38-47%** (40% - Mei et al. [2017])

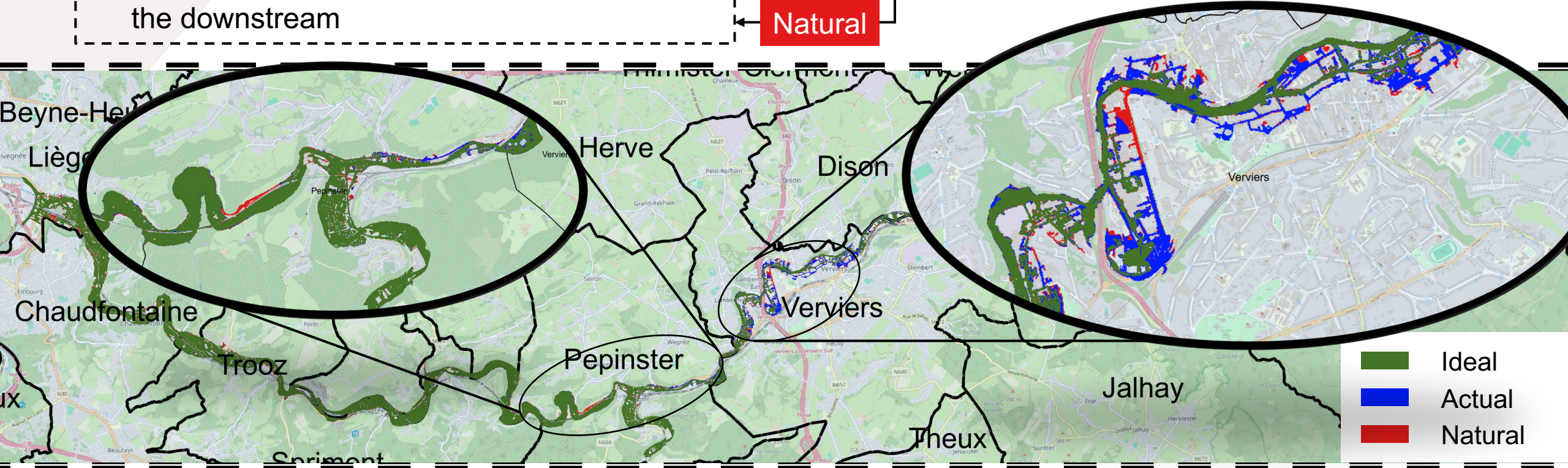
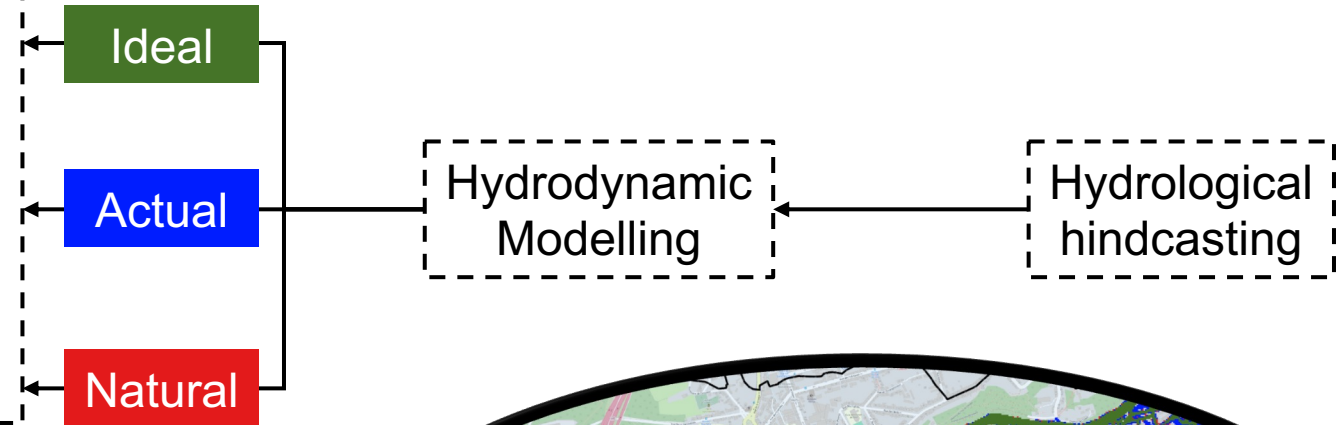
Inclusion/exclusion of data from July 2021 in the EVA does not alter outcomes very significantly



# The Eupen dam & the 2021 mega-flood

## Major inferences:

1. Dam performed closer to 'no-dam'/'natural' situation than 'infinite'/'ideal' dam scenario.
2. Effect of dam wanes progressively towards the downstream





# Q&A



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