Transboundary effects of flooding and flood reducing measures along the Rhine in North Rhine-Westfalia (Germany) and Gelderland (the Netherlands)

A project initiative of
- Provincie Gelderland (NL),
- Ministerie van Verkeer en Waterstaat (NL)
- Ministerium für Umwelt, Naturschutz, Landwirtschaft und Verbraucherschutz (North Rhine-Westphalia, Germany)
1. aim of the project
2. methods
3. results
4. outlook
   a. statistical value of design discharges?
   b. rules for and effects of retention areas?
Background

- floods 1993, 1995
- Declaration of cooperation in flood control between NRW, Province of Gelderland, Rijkswaterstaat 1997
- Fondation of the German-Dutch workgroup for flood management
- Project “Transboundary effects of extreme floods along the Lower Rhine”; 2001-2004
Transboundary effects of flooding and flood reducing measures along the Lower Rhine

aim: answers to the questions

➡️ Question 1
   How much discharge can result in the catchment of the river rhine?

➡️ Question 2
   What happened at extreme discharge along the Lower Rhine?

➡️ Question 3
   Which impacts have flood reducing measures?

➡️ Question 4
   Effects of climate change?
Detail research
Lower Rhine and Rhine branches downstream of Gauge Andernach

Hydrologic Calculation of the whole catchment area of the River Rhine

Scenarios 2002 and 2020
- reinforcement of dikes
- flood reducing measures

Dike damage only when dikes overflow
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Calculations for the catchment area of the River Rhine

Stochastic Rainfall generator (KNMI)

Time series ~1000 year P and T

Rainfall-runoff model (HBV)

Transformation to discharge

1000 year synthetic discharge waves

Selection of 16 highest discharge waves

Flood routing (SOBEK, SYNHP)

16 discharge waves at Andernach

Flood routing with retention and floodings along the Upper Rhine
Calculations beginning at Gauge Andernach

Extreme discharges from Rhine catchment

Selected discharge waves at Andernach

Flooding at Lower Rhine and Gelderland (Delft-FLS)

- Flooding protected area
- Knowledge on inflow to protected area / loss of discharge in river

Discharge Lower Rhine – Rhine Branches (SOBEK)

- Effects of flooding on discharge waves
- Effect of flood reduction measures
content

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Answers to Question 1:
How much discharge can result
in the catchment of the river Rhine?

Very large floods are possible!

Highest calculated peak discharges at Gauge Andernach:

- With infinitely high dikes at the upper Rhine: 17,800 m³/s
- With dike overflowing at the upper Rhine: 15,300 m³/s
Discharge peaks at gauge Andernach
with and without considering dike overflowing at the Upper Rhine
-> how extreme are the peak discharges?

Annuality of design discharges,
Peak of flooding 1995
Question 2
What happened at extreme discharge along the Lower Rhine?

Extreme discharges of the project will lead to overflowing of dikes or high banks!
Flooding at the southern part of the lower rhein
Example: project flood HW 824
Peak Discharge at Gauge Lobith
with and without considering dike overflowing
at the Upper and Lower Rhine

Annually of design discharges,
Peak of flooding 1995

Dike overflowing in NRW
leads to reduction of peak discharges at Gauge Lobith.
Answers to question 3: Effects of flood reducing measures?

- Dike overflowing and flood reduction measures together reduce peak discharges.

- Retention areas have different effects in condition to shape and peak of the calculated discharge waves – these waves are influenced by dike overflowing.

→ in an area with changing flood design levels along the river the effects of flood reduction measures must be seen in combination with the effects of dike overflow upon the discharge and water level.

→ It is not allowed to say: „Measure A reduces floods at B centimeters.“
content

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Influence of dike overflowing to peak discharges

Peak discharges in longitudinal profile with infinite high dikes

infinitely high dikes
(= no dike overflowing)
Influence of dike overflowing to peak discharges

⇒ Reduction of peak discharges in the river pipe

Infinitely high dikes
(= no dike overflowing)

Sections with reflowing to the river pipe

Sections with dike overflowing

Calculation with dike overflowing
Influence of dike overflowing to peak discharges

- Comparison: Year 2002 (without dike reinforcement)

- In Scenario 2002, more water flows over the dikes and the streams behind the dikes are larger.

- In 2020, the reinforced dikes will reduce the overflows.
Outlook

Impact of flooding and flood reduction measures upon extreme floods is very big

⇒ This should be taken into account in flood statistics.
Grenzüberschreitende Auswirkungen von extremem Hochwasser am Niederrhein

Grensoverschrijdende effecten van extreem hoogwater op de Niederrhein

Questions to discuss:

What about statistical value of design discharges?

What about rules for and effects of retention areas, when dike overflowing happens upstream?

Main message: Understand the hydraulic processes!
Sandbags are able to influence our extrem value statistics!

Sandbags are able to influence the impact of our retention areas!