

# Floods in Germany (June 2013)

Post-flood field investigation, July 2&3, 2013

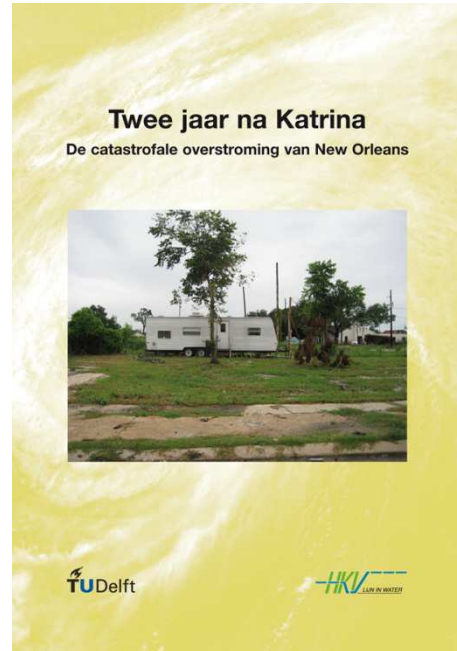
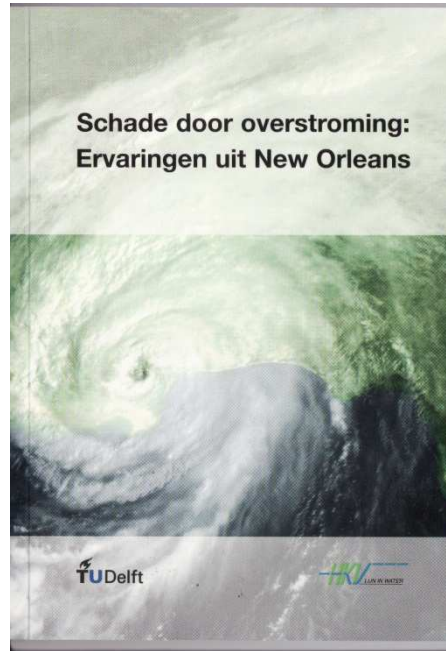
Preliminary Findings

Bas Jonkman, Timo Schweckendiek, Guy Dupuits (TU Delft);  
Torsten Heyer (TU Dresden); Joop de Bijl (STOWA); Astrid Labrujere (RWS)

in collaboration  
with:



## New Orleans, 2005



## Xynthia, Frankrijk, 2010



## Japan, 2011



## Thailand, 2011



# Objectives and scope

- Post-flood field investigation July 2 & 3
- Focus on dike breaches and emergency measures
- Team:
  - Torsten Heyer (TU Dresden)
  - Bas Jonkman (TU Delft, Rijkswaterstaat, ENW)
  - Timo Schweckendiek (TU Delft, Deltares, ENW)
  - Joop de Bijl (STOWA, Waterschap Aa en Maas)
  - Guy Dupuits (TU Delft)
  - Astrid Labrujere (Rijkswaterstaat)
  - July 2, Reinhard Pohl (TU Dresden)
  - July 3, Koos Wieriks (Dutch Embassy in Berlin)



# Deichbruch

**Achtung allgemeine Gefahrenstelle !**

**Das Betreten des Deiches durch Unbefugte ist  
untersagt !**

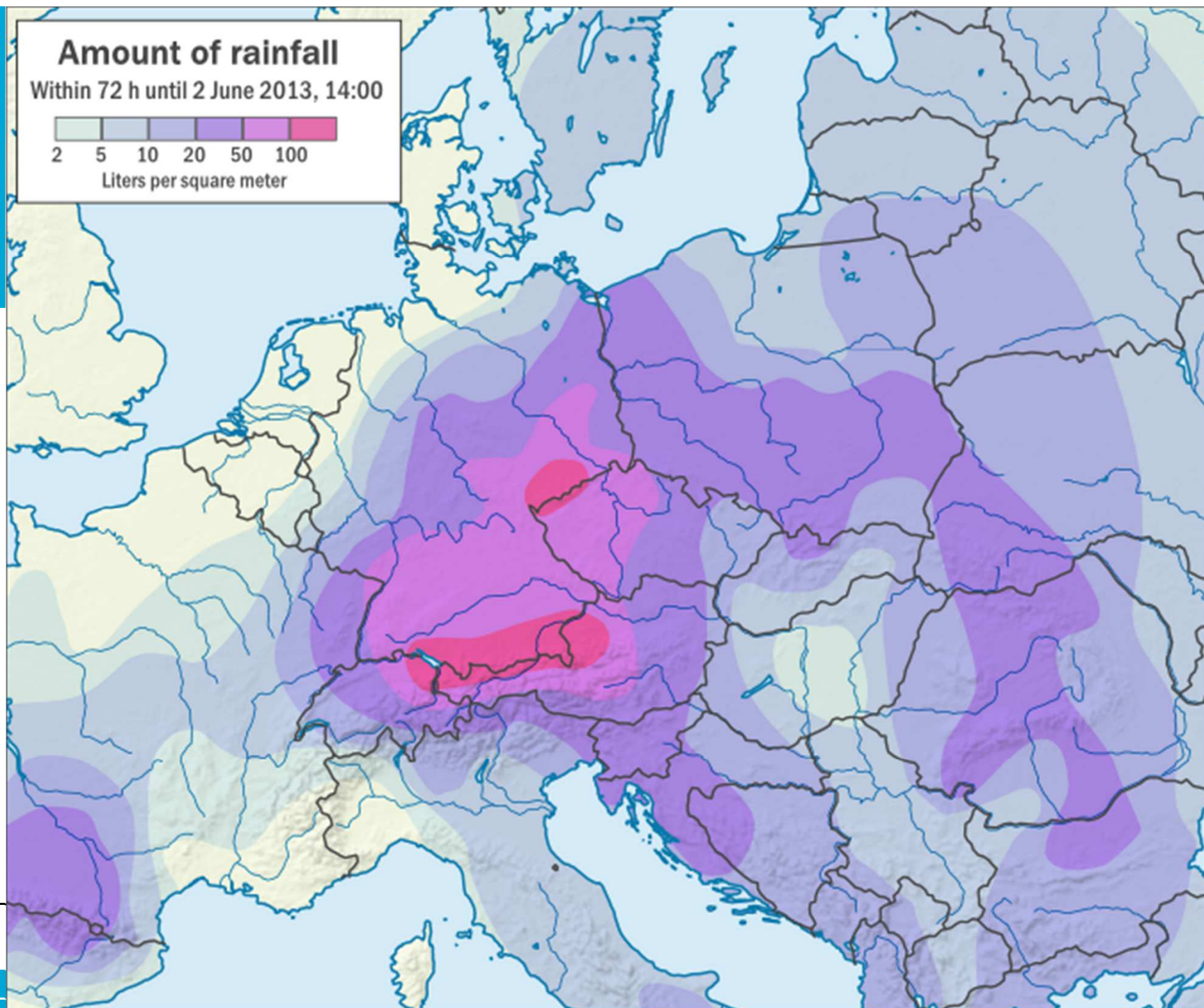
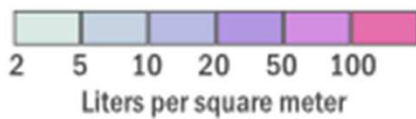
Landestalsperrenverwaltung des  
Freistaates Sachsen  
Betrieb Elbaue/Mulde/Untere Weiße Elster  
Flussmeisterei Bad Dübén  
Tel. 034243 / 333 00

Flussmeisterei Bad Dübén  
Tel. 034243 / 33300



## Amount of rainfall

Within 72 h until 2 June 2013, 14:00

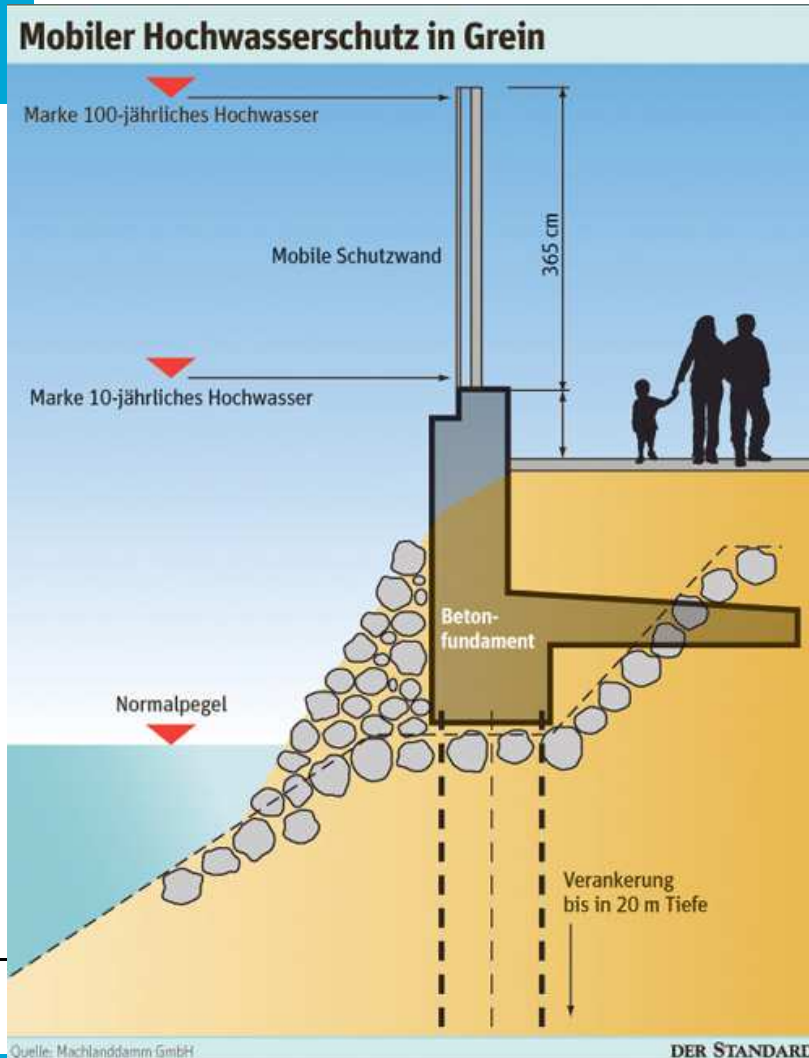




- Large flood event:
  - Return period 50 – 500 year depending on location / river
  - At some places larger than 2002 flood event

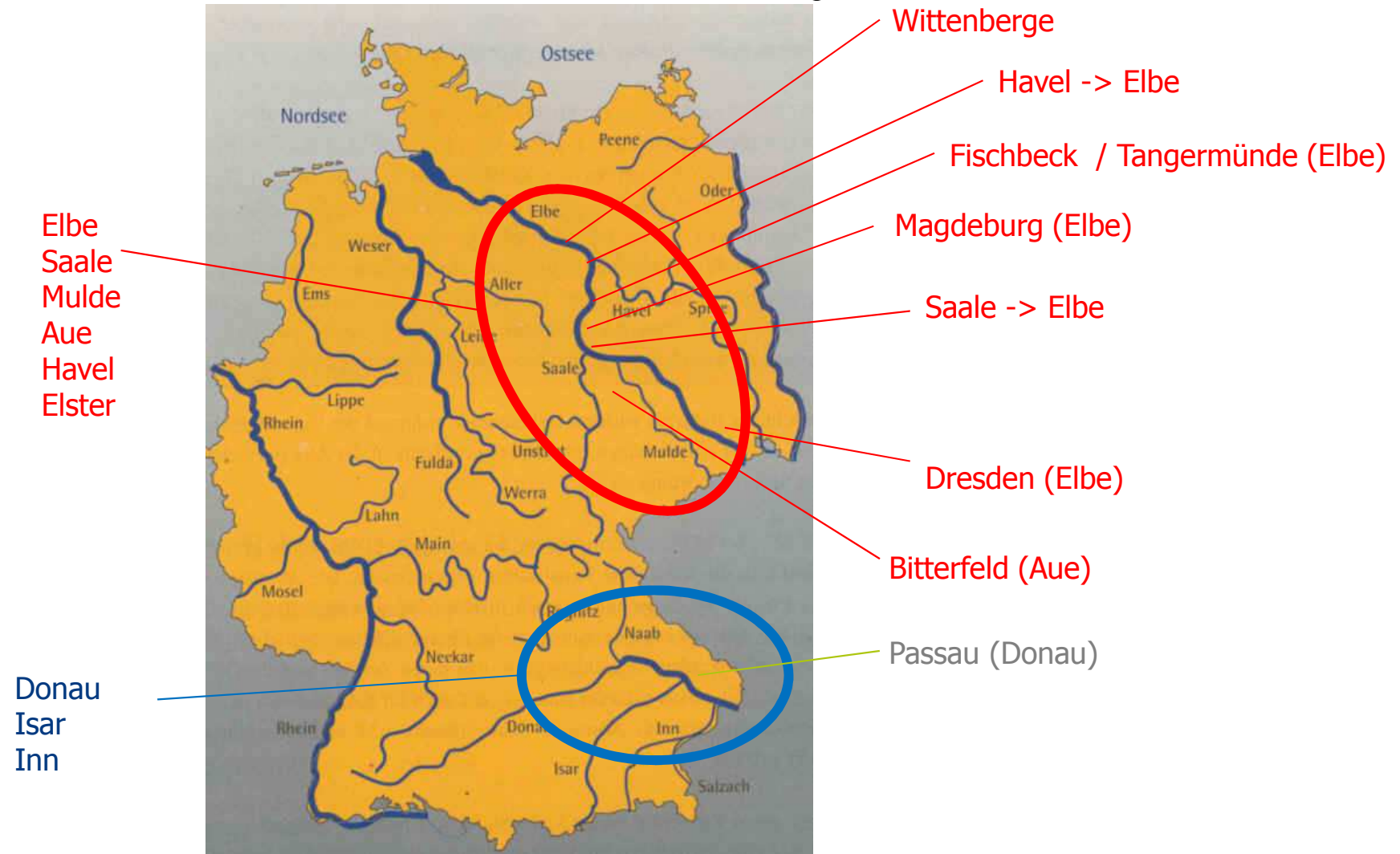


# Temporary flood defence (Grein, Austria)



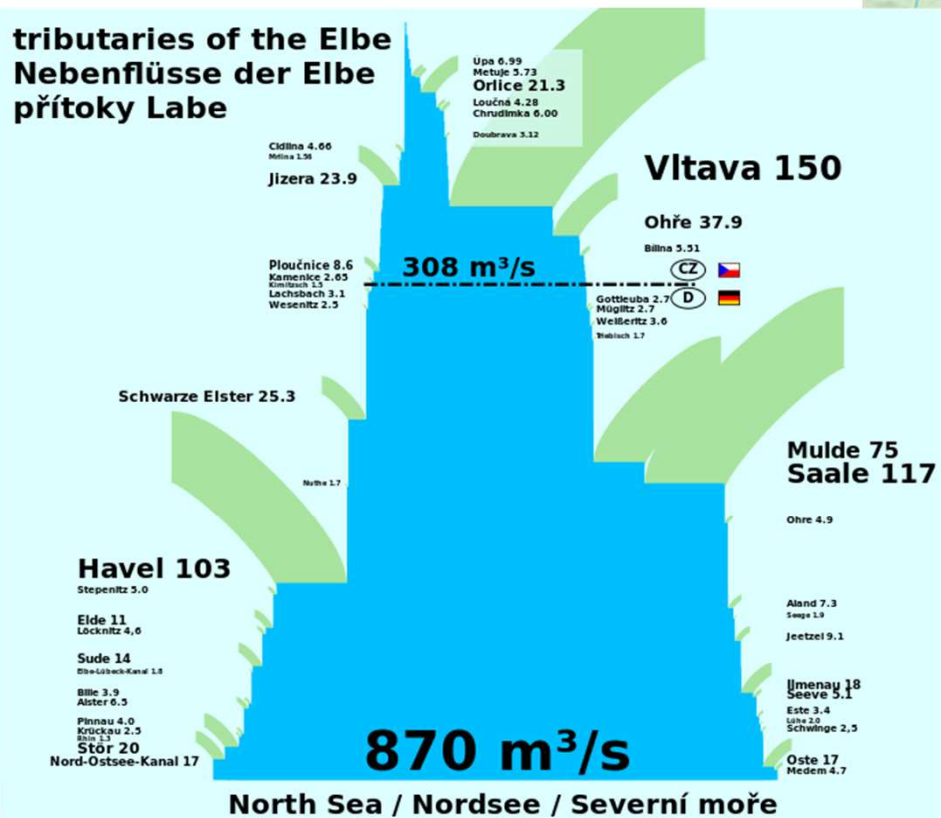
Field investigation (2-3 July 2013)

# Affected areas Germany





## tributaries of the Elbe Nebenflüsse der Elbe přítoky Labe



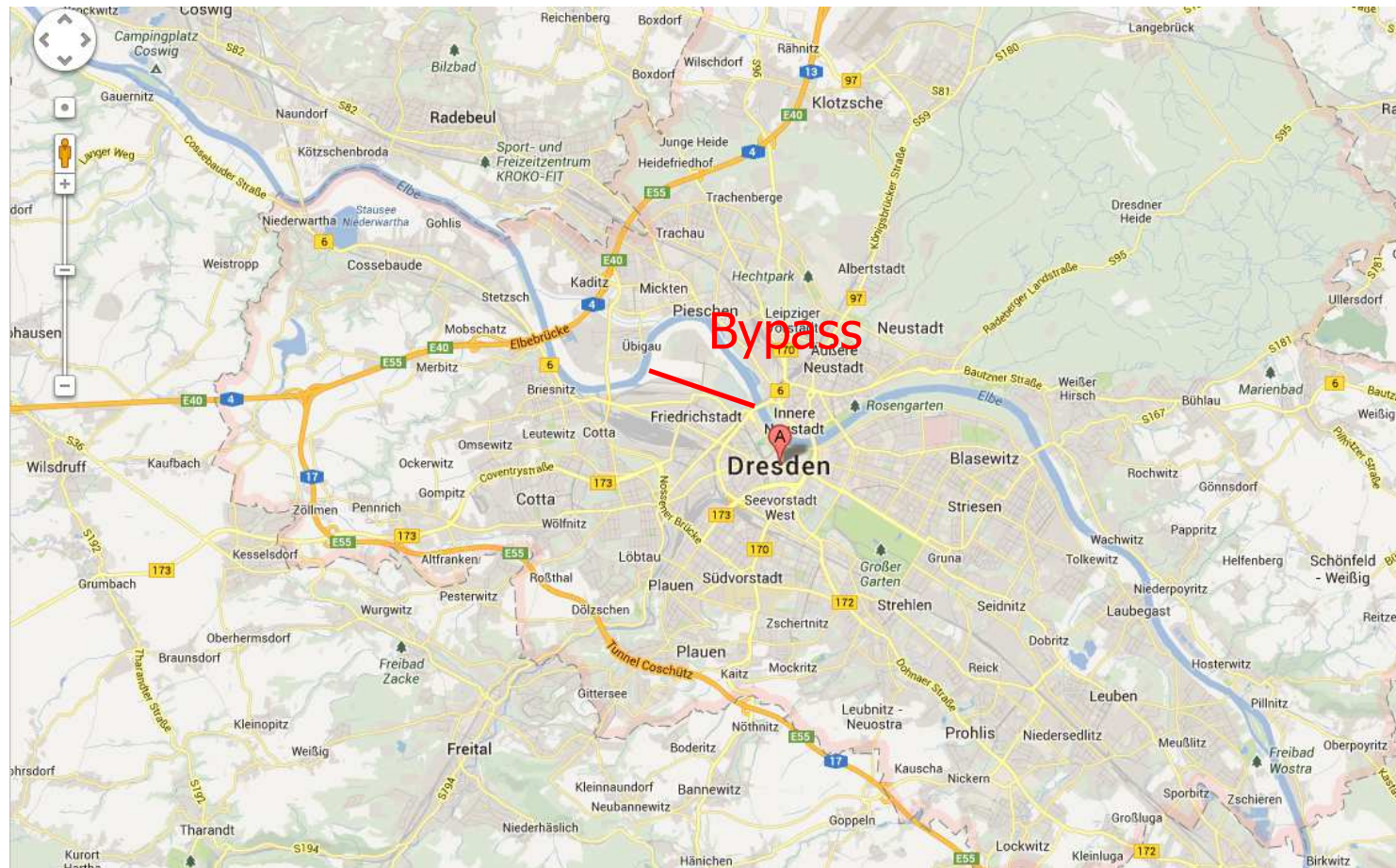
n (2-3 July 2013)

# Overview of investigated sites





# Dresden – overview





# Dresden – facts and figures

- 2002 flood event:
  - +9.40 meter water level in the Elbe (1/200 per year event), 1000 million euro in damage
- Various measures were taken after this event: floodgates, mobile flood protection, improvement of hydraulic roughness, increasing protection to at least 1/100 per year
- 2013: +8.77 m water level Elbe (1/50 per year event)

# Dresden – impressions



2013 - Picture taken by Reinhard Pohl

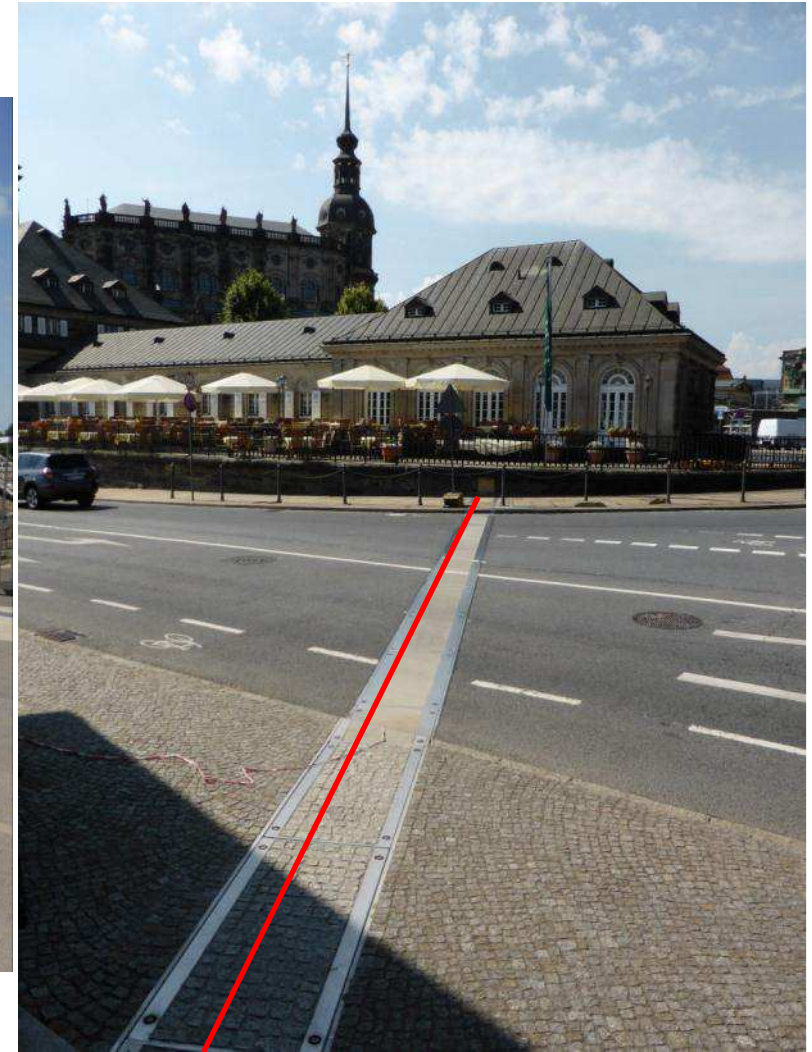
# Dresden - impressions



2013 - Picture taken by Reinhard Pohl



# Dresden – flood gates





# Dresden bypass





# Dresden – erosion



unexpected erosion next to the Marienbrücke in the bypass (after removing obstacles downstream)





# Overview of investigated sites



# Bitterfeld - situation

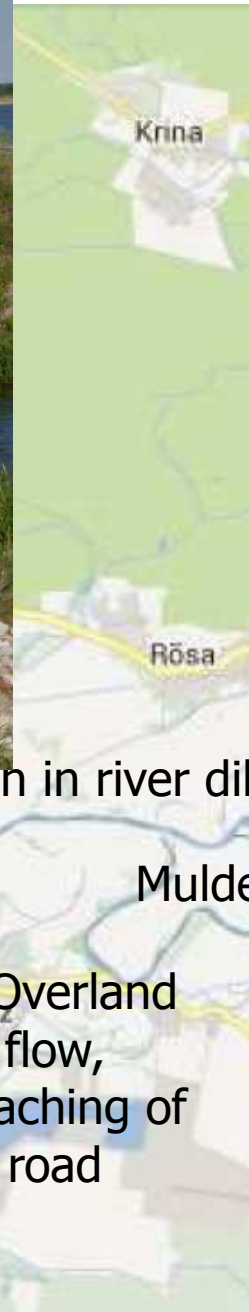
- Coal mining, leaving pits of 60 meters deep
  - Mining activities have stopped
  - Turned into a recreational area with shipping harbour
- Concentration of chemical industry in the area
- City of Bitterfeld
  - On the border between Sachsen en Sachsen-Anhalt
  - Thousands of people were evacuated because of threat from lakes

# Bitterfeld (pre-breach situation)



© Jens Wolf/dpa





(lower water level)

$\Delta H_{\text{normal}} = 3\text{m}$

$\Delta H_{\text{flood}} = 9\text{m}$

3. Double breach

pumps

canal

1. Breach in river dike

Mulde

2. Overland flow, breaching of road

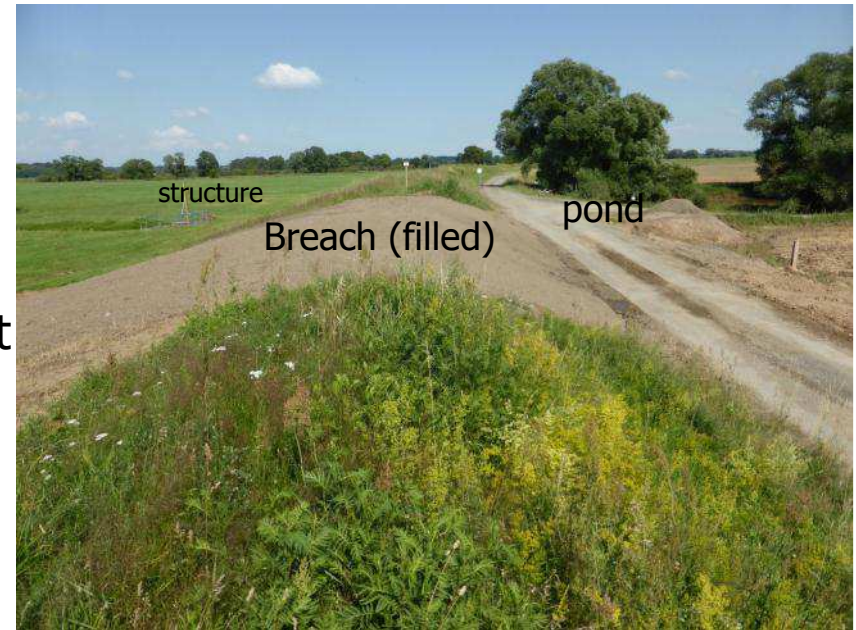
Seehausener See (higher water level)

# 1. Bitterfeld – Mulde breach

- Breach on the Mulde river, one of multiple breaches
- 25 m wide breach, relatively high on slope
- Wells on the inside of sandy material, possibility of piping mechanism
- Highest water about 1m (?) below crest

## Context:

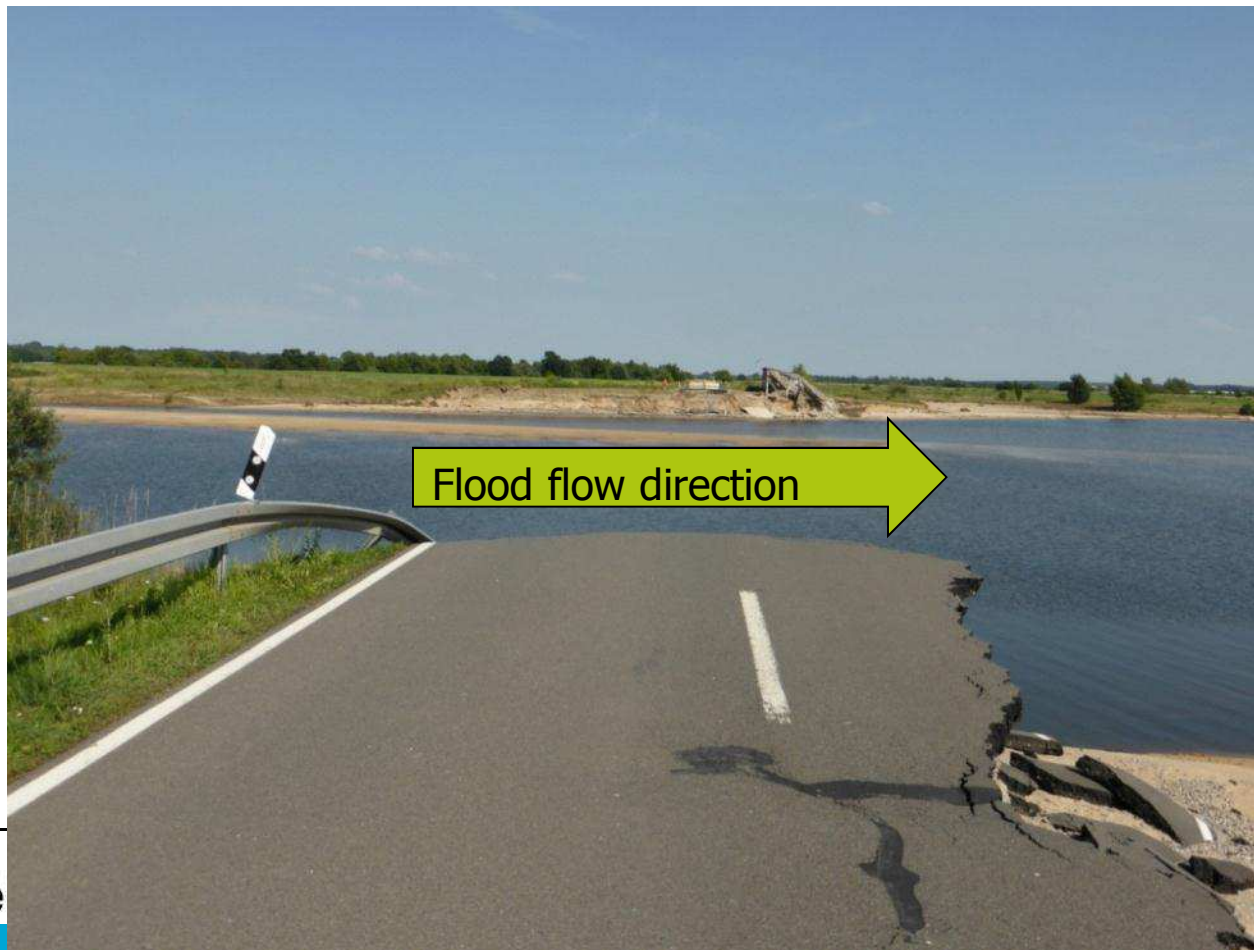
- Next to small dewatering structure and small pond
- In 2002 a breach occurred in the same area, a few hundred meters upstream from the current breach.





## 2. Bitterfeld - Breaches in Road Nr. S12

- Large breach in road (200m or more)
- Overtopping and erosion of road and bike path



### 3. Bitterfeld, Breaches in Channel embankments between lakes

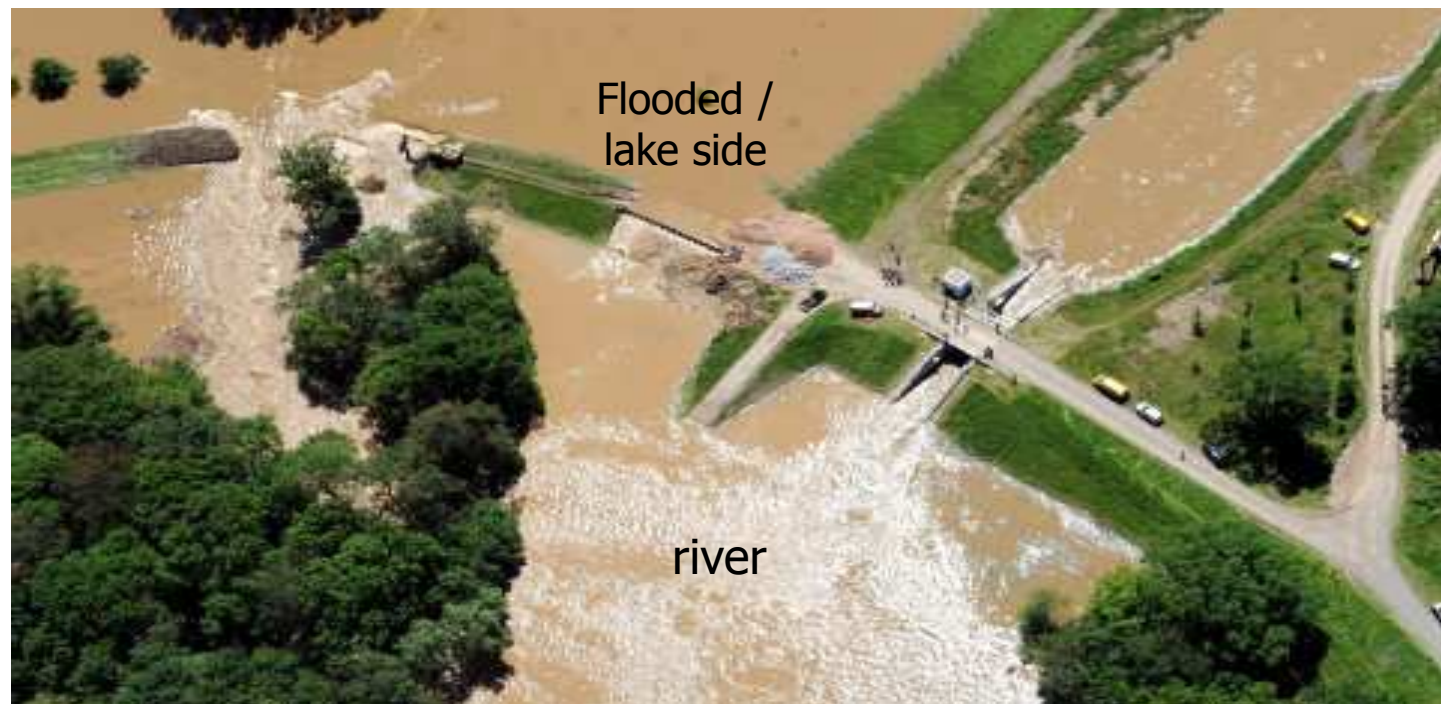
- Seelhausener Lake fills due to breach (several meters)
- Overflow and breaching of adjacent canal dikes
- Unsuccessful attempt to close breaches with bigbags by helicopters
- Cascading effects to Grosse Goitscherzee, threatening city of Bitterfeld





# Bitterfeld – dewatering

- Breaches created with dynamite for dewatering



Source???

# Overview of investigated sites





# Breitenhagen - levee breach



DPA / Salzlandkreis

# Breitenhagen - inner slope failure



Reuters



# Breitenhagen

- Located on Elbe river, water levels about 1~1.5m below crest
- Trees located in front of dike
- Dikes consisted of clay, slope about 1:2.5 to 1:3
- Slip circle occurred on inside, on landside of the road
  - Part of the dike remained for 10 hrs, then breached
  - 150m breach
- Dike reinforcement plan was available, but not yet implemented
- Emergency measures:
  - First round of bigbags delivered by helicopters
  - After that no army assistance available anymore
  - For dewatering:
    - Explosions were not effective to blow up dike
    - Breach opened by equipment for dewatering
    - Pumps installed to dewater the urban area

# Overview of investigated sites





# Fischbeck (levee breach)



Foto: REUTERS/Thomas Peter

# Fischbeck dike breach - general

- breach location located at “corner”
- Western side of the Elbe,
- water level below crest (0.2m ~ 0.4m)
- dike: about 5m high, moderate/steep slope (about 1:3?), no berm
- dike body: clayey sand (sandy clay in lower part)



# Fischbeck dike breach

Failure process (according to eye witnesses)

- cracks in crown, stage-wise settlement of the inner slope
- heavy flood fighting to prevent breach (sand bags, big packs)
- breach occurred around midnight (Sunday 9 June around 00:01 AM)
- inner slope sliding/breach occurred fast (10 ~ 20s)
- initial width 50m, growth to 100m within hours, 2-3m deep scour hole
- estimated inflow up to 700-1000 m<sup>3</sup>/s (different figures in BfG report)
- Water was within town of Fischbeck (~ 2km) within 5 minutes
- Fischbeck had been evacuated previously
- flooding extended in a wide area (up to the Havel river, tens of km)

# Fischbeck - post-breach



modified after dpa photo



# Fischbeck breach emergency



[dpa](#) / [dpa](#)

- Three barges sunk in front of the breach using explosives
- inflow reduced significantly
- breach finally closed when water was levelled out
- Temporary flood defence:
  - Sheet pile in the breach (8 ~ 11m)
  - Earthen dike / roadway in front
  - Ships are being removed, new dike will follow different alignment





# Fischbeck breach emergency repairs



Photo: Doreen Jonas / MDR



breach

barges

river

Temporary  
dike &  
sheetpile





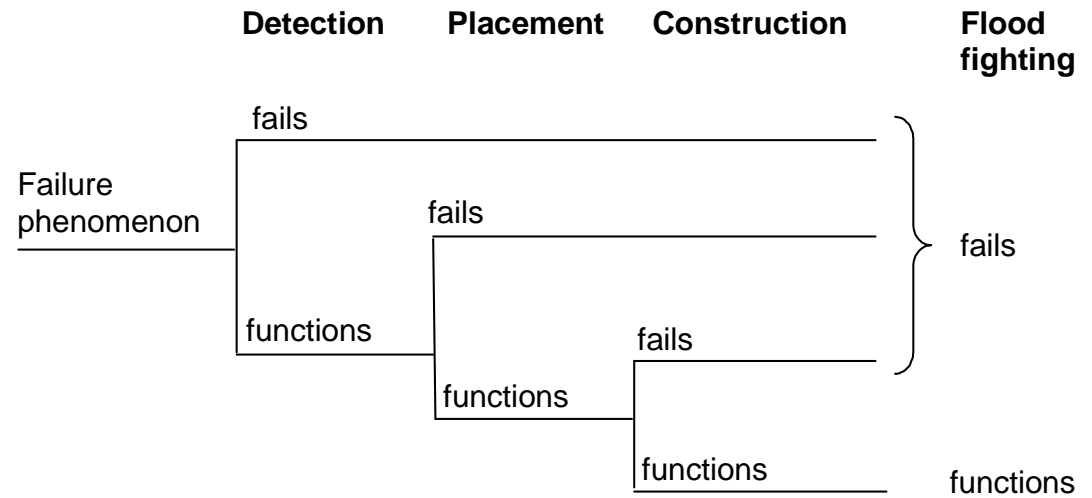
# Fischbeck - local instability

- Few hundred meter from breach site
- Seems initiation of slip circle over about 25 ~ 30m
- Sheet pile in dike and bigbags on slope implemented as emergency measures





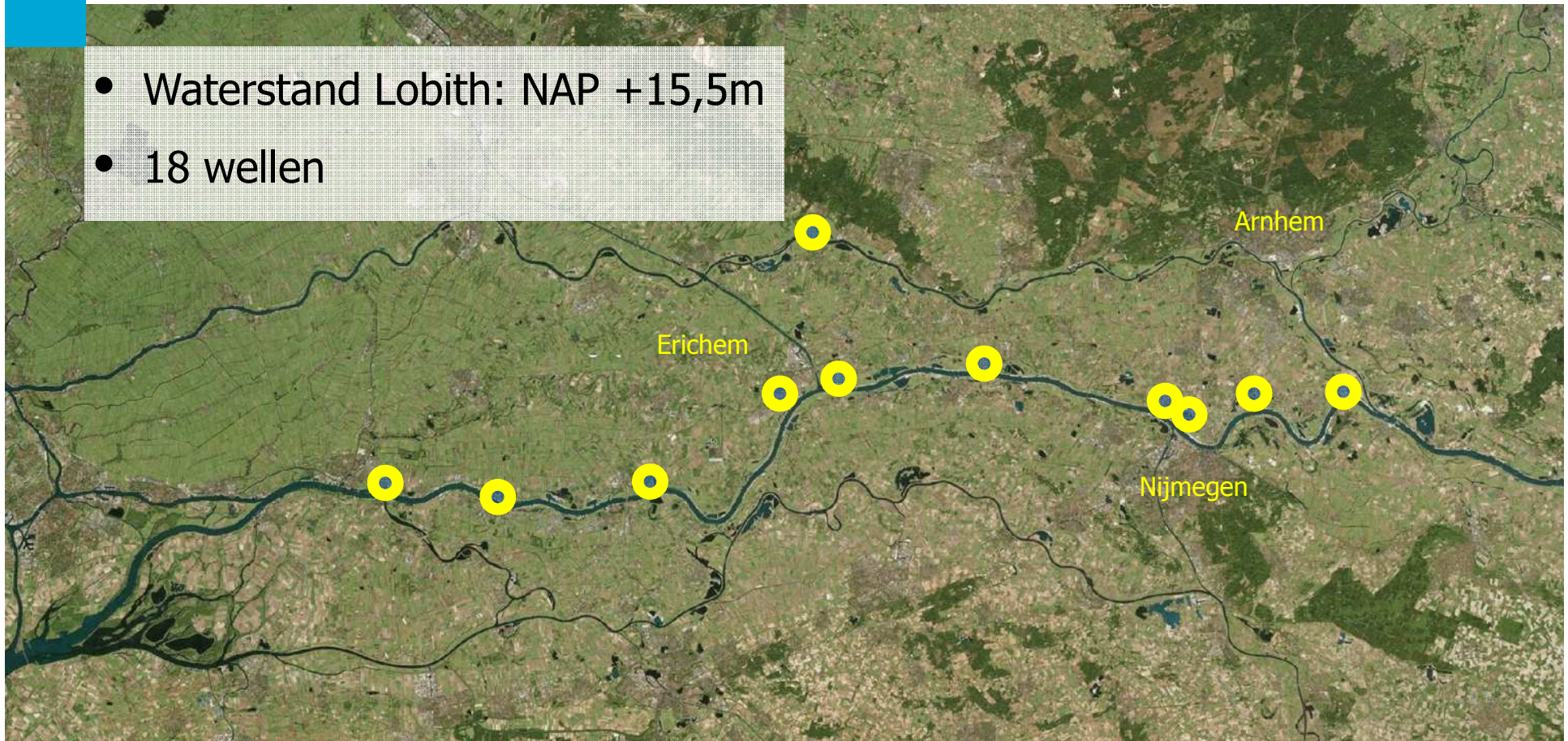
# Nood- en beheermaatregelen





# Pipinglocaties hoogwater 2011

- Waterstand Lobith: NAP +15,5m
- 18 wellen





# Concluding remarks

- Large flood event:
  - Return period 50 – 500 year depending on location / river
  - At some places larger than 2002 flood event
- Water levels mostly close to the crest of dikes (no overflow)
- Several dike failures
- Visited failures were due to geotechnical mechanisms at several sites
  - Instability at Fischbeck and Breitenhagen
  - Possibly piping at Bitterfeld river dike breach, and overflow for canal and road breaches
- Complex system / cascading effects at Bitterfeld
  - Dike failure -> road breaching -> lake fills -> canal dikes fail -> Second lake fills up, threatens town of Bitterfeld
- Breaches could not be closed by emergency measures (barges, bigbags etc.)

# Recommendations / follow-up

- Analyze and hindcast dike failures (data collection, stability and piping analysis)
- Evaluate performance of emergency measures
- Evacuations and emergency response
- Further analysis of other topics:
  - Hydrological system performance (incl. cascades and retention)
  - Damage
  - Risk management / multi-layered safety
- Second mission in Autumn (?)
- For the Netherlands:
  - Geotechnical failures! (multiple)
  - Use and effectiveness of emergency measures
  - Plans for dewatering and breach closure?

# Acknowledgements







# Bedenkt u het nieuwe grote waterbouwkundige project voor Nederland?

Doe mee en meld u aan!

