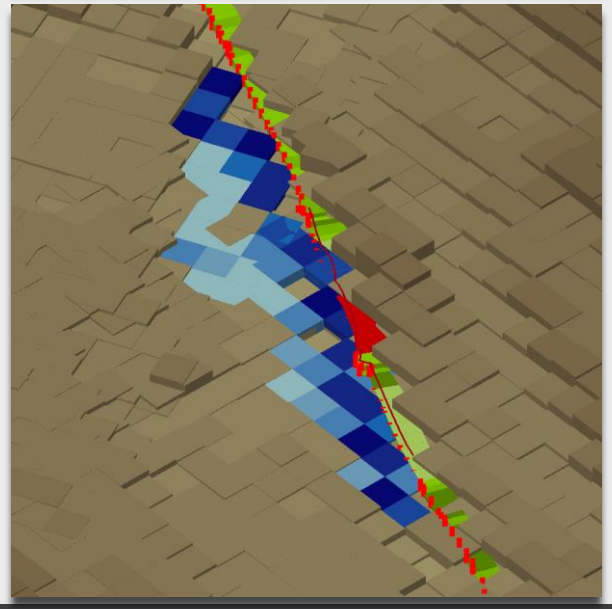
SYSTEM-RISK final conference, Potsdam 2019

Reduction of dike height

– A flood mitigation measure?

Bachmann, D.[1]; Johann G.[2]; Schruff, T.[3]; Schüttrumpf, H.[3]

[1] University of applied sciences Magdeburg-Stendal
[2] Emschergenossenschaft / Lippeverband
[3] RWTH Aachen University



1. Brief look to history of flood protection

Source: wikipedia

Noachian flood

Period until 19th C.

1. Brief look to history of flood protection

Period until the 19th C.

- From a German universal encyclopaedia (1746)
- Translation: **Flooding = divine punishment and a rood of god against the godless**

Ueberschwemmung oder Ueberlauff des Wassers (1746)

Da wir nun die Unglücksfälle; welche in der Natur sich ereignen; als **Göttliche Straffen und Züchtigungen** ansehen können, nehmlich als Straffen für diejenigen, so Böses thun, als Züchtigungen für die, welche ins künfftige zum Bösen abweichen würden; so sehen wir hieraus; **wie GOTT die Ueberschwemmungen auch zur Ruthe wider die Gottlosen**, und als ein Mittel die Menschen zu verbinden, daß sie vom Bösen abstehen, und Gutes thun, gebrauchen kann. *(Großes Universal-Lexikon Aller Wissenschaften und Künste, welche bishero durch menschlichen Verstand und Witz erfunden worden. Bd. 48. Leipzig, 1746)*

What was the best flood mitigation measure?

- **To pray!**

1. Brief look to history of flood protection

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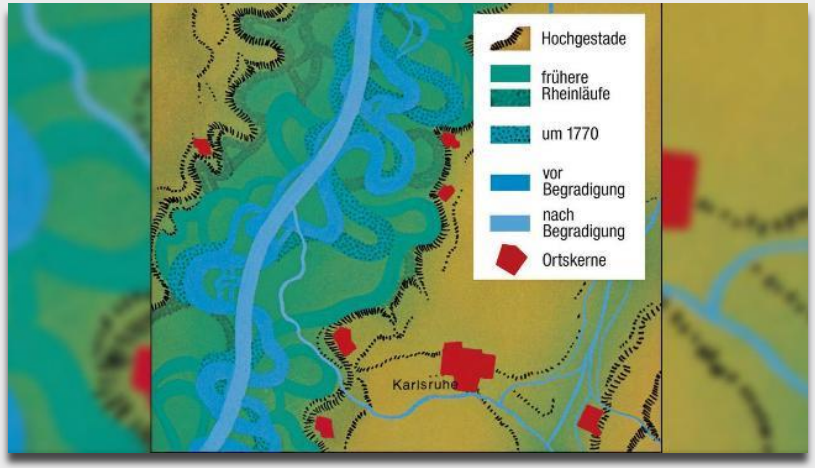
Noachian flood



Source: http://www.swr.de

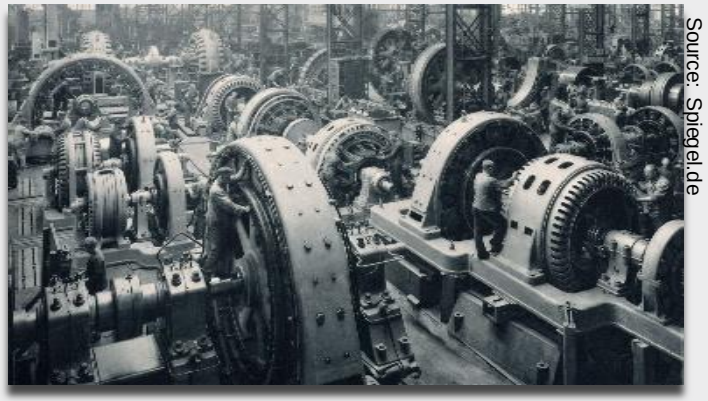
Straightening of the Rhine river (19th C.)

Period until 21st C.

1. Brief look to history of flood protection

Period until the 21th C.

- Starting with the industrial revolution:
  - **Believe in technical power**
  - **Philosophy of safety:** “this dike is safe!”



Source: Spiegel.de

- Example**:** Idea of **Atlantropa**, a dam at the Strait of Gibraltar to regulate / controll the Mediterranean Sea (early 20th C.)

Source: wikipedia

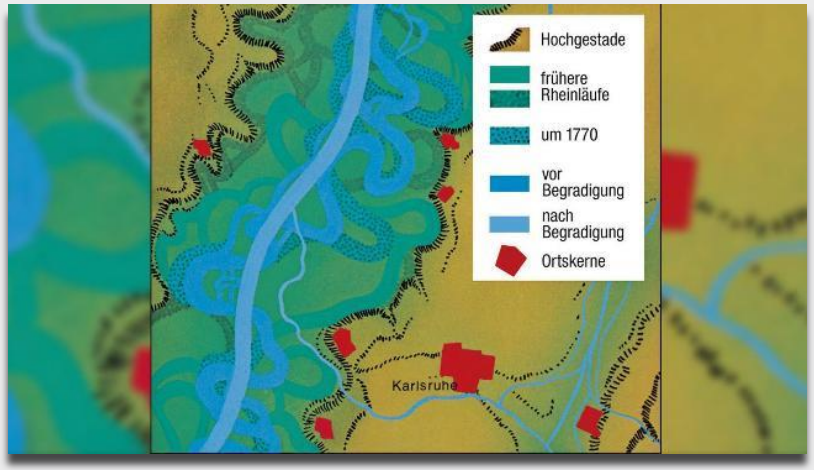
- **All is possible** with technical power!

1. Brief look to history of flood protection

Period until the 21th C.

- Starting with the industrial revolution:
  - **Believe in technical power**
  - **Philosophy of safety:** “this dike is safe!”

What was the best flood mitigation measure?



River Engineering

Barriers

- **Technical measure will solve all problems!**
  (higher, bigger, faster)

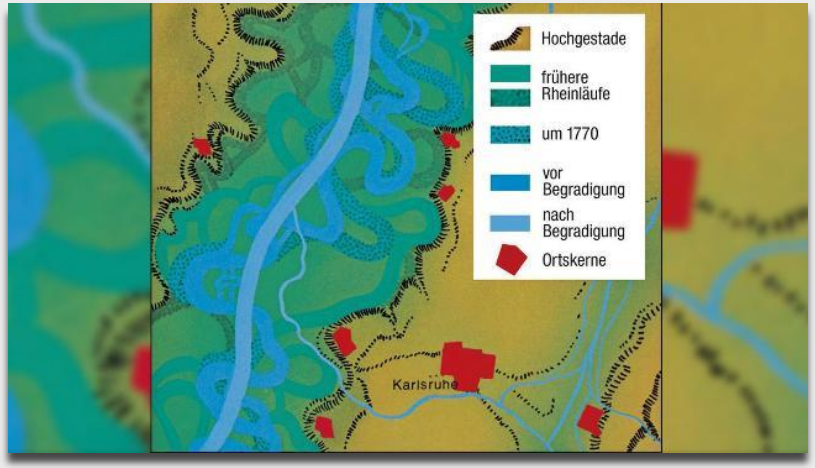
Reservoirs

Dikes

1. Brief look to history of flood protection

Source: wikipedia

Noachian flood



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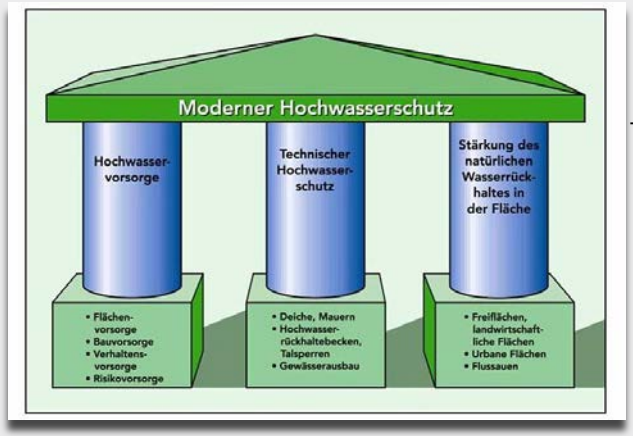
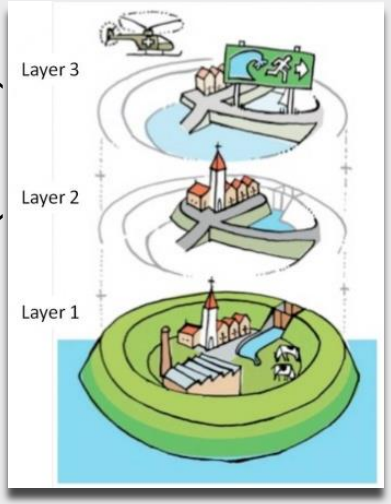
Straightening of the Rhine river (19th C.)

3-pillar concept Germany (21st C.)



Source: http://mule.sachsen-anhalt.de

3-layer concept Netherlands (21st C.)



Source: http://www.mare-portal.eu

1. Brief look to history of flood protection

Nowadays

- Due to some major flooding in Central Europe (an eye-opener)
  - **Technical measures can not solve all**
  - **Switch to a philosophy of risk**

What is now the best flood mitigation measure?

Cologne
Rhine river (1995)

Source: steb

Dresden
Elbe river (2002)

Source: dnn

Magdeburg
Elbe river (2013)

1. Brief look to history of flood protection

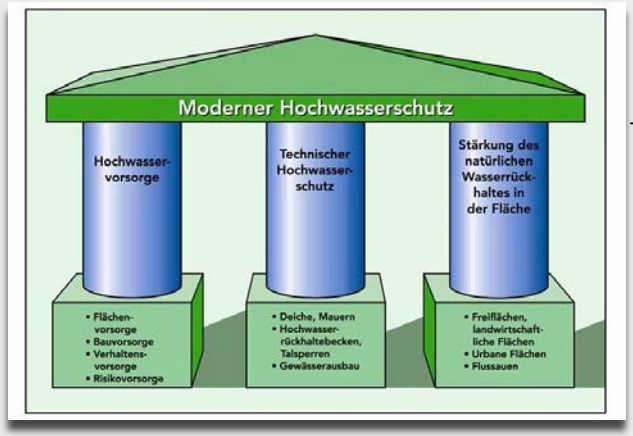
Nowadays

- Due to some major flooding in Central Europe
  - **Technical measures can not solve all**
  - **Switch to a philosophy of risk**

What is now the best flood mitigation measure?

- A well-balanced mix of **technical, precaution and nature-based** measures

3-pillar concept Germany (21st C.)



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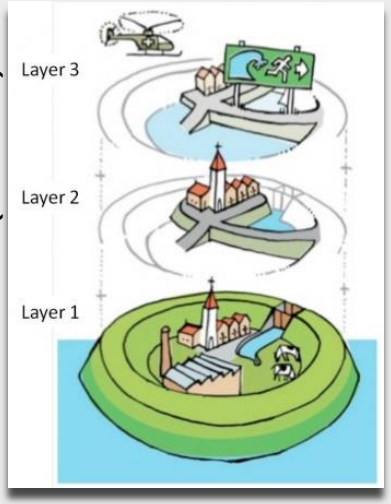


Source: http://www.mare-portal.eu

1. Brief look to history of flood protection

Nowadays: Examples of flood mitigation measures

River Engineering

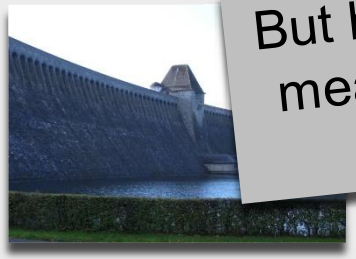
Barriers

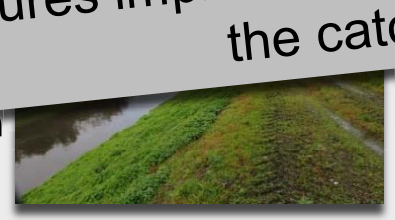
Adapted construction

Information

Afforestation

Reservoirs





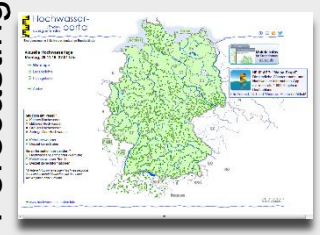
But how to **compare** all these **different kind** of measures implemented in **different places** of the catchment?

Reactivation of flood plains

Mobile systems

Higher ground

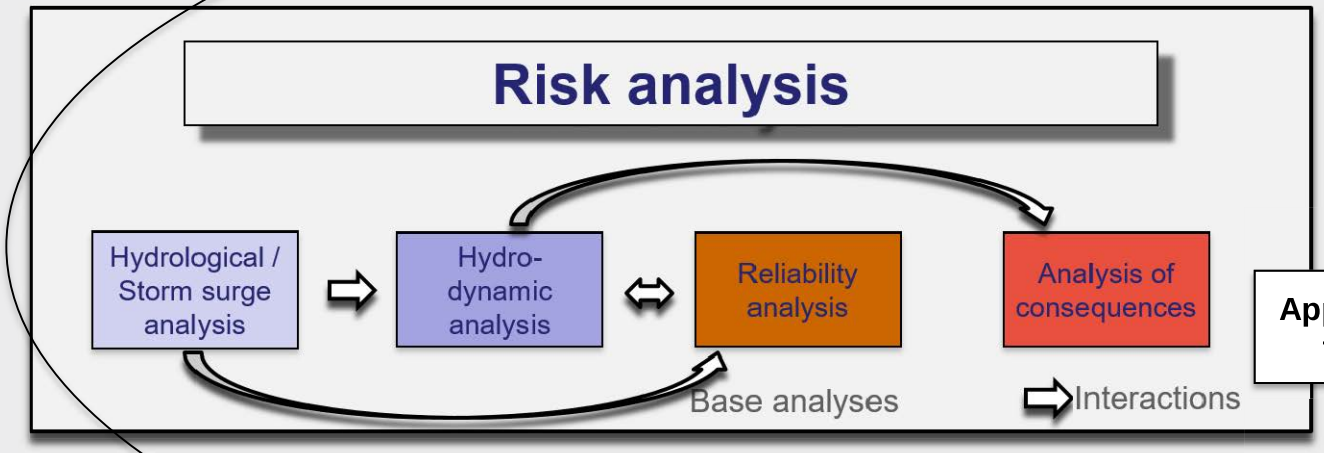
Forecasting



2. New modelling techniques required

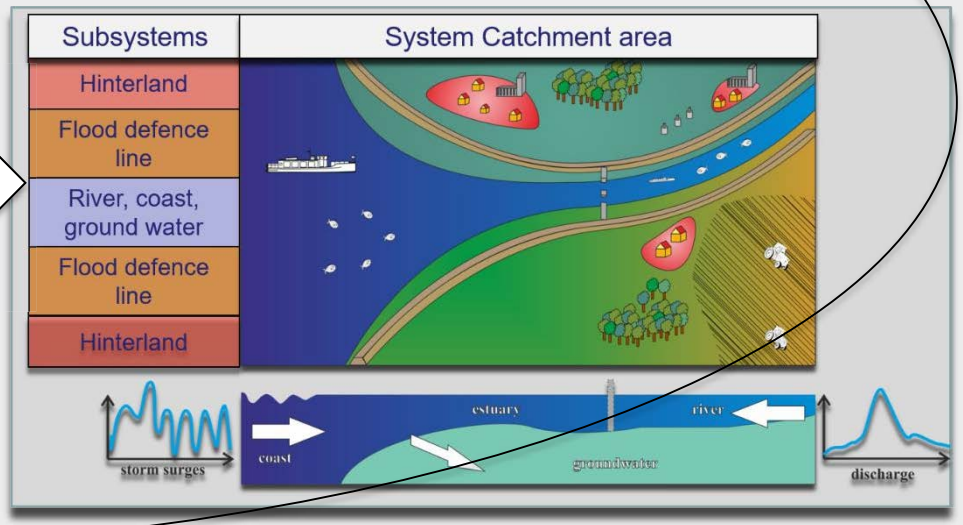
SYSTEM RISK

Full integrated approach with focus on risk analysis including the relevant base analyses



Applied to

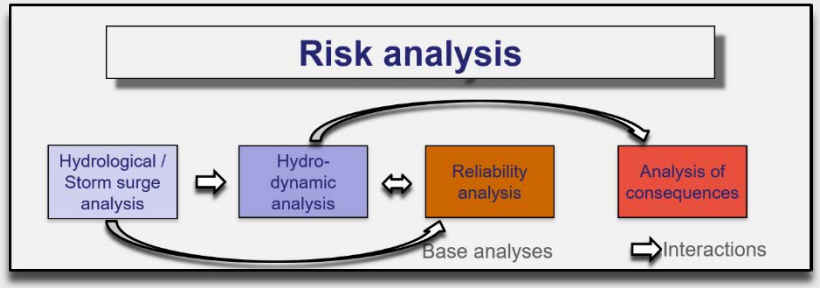
System based approach applied on (sub-) catchment scale



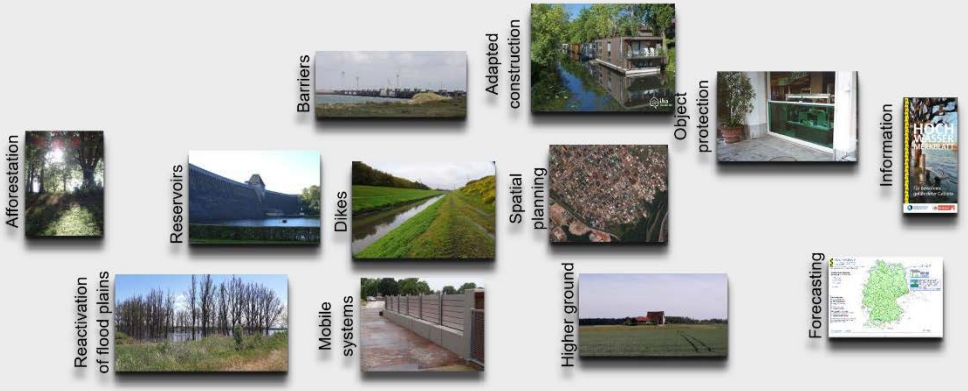
2. New modelling techniques required

Why focus on risk?

- **Change of flood risk** due to a measure is a very good value to describe its **effectiveness**
  - Not change of discharge, water level or safety factor



- Different kind of measures get **directly comparable by change of flood risk**
  - Not by change of discharge, water level or safety factor

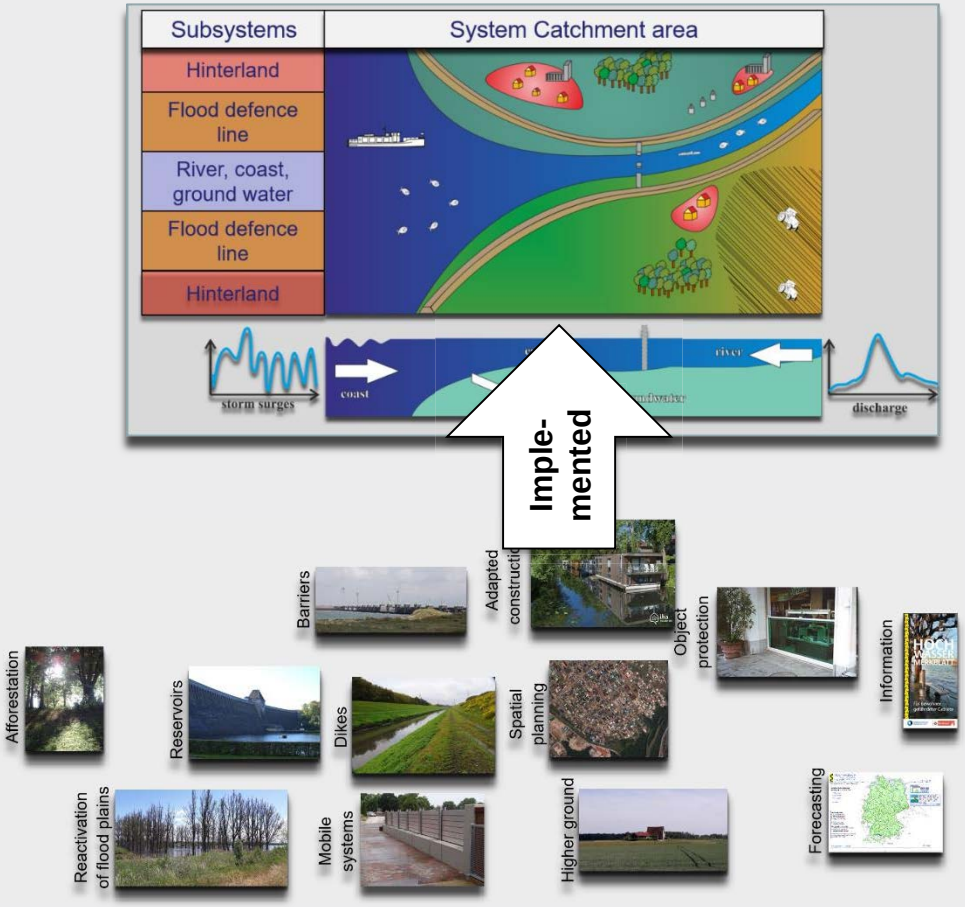


2. New modelling techniques required

Why a system-based approach?

- Different kind of measures are implemented in **different parts of the catchment**

- Measure can have local but also **system-wide effects**



2. New modelling techniques required

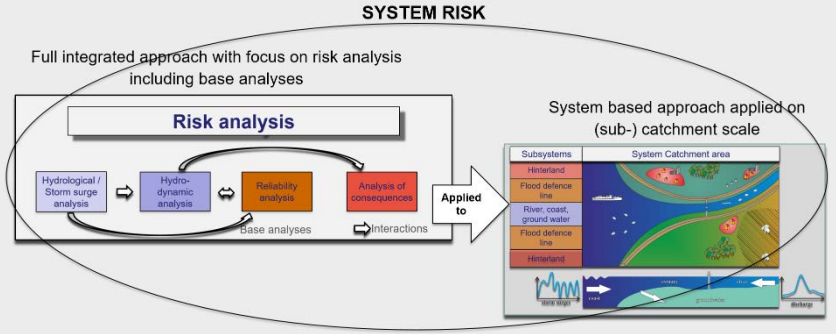
Example: Measure with system-wide effect

Reduction of dike height

- It is a quite **progressive** flood mitigation measure
- Difficult to communicate, a very hot topic!
  (if you do not think in a System-Risk approach)

- It will always show a **negative effect** by a **local** point of view

- It can have **positive effects** by a **system** point of view
  => **System-Risk** approach required!



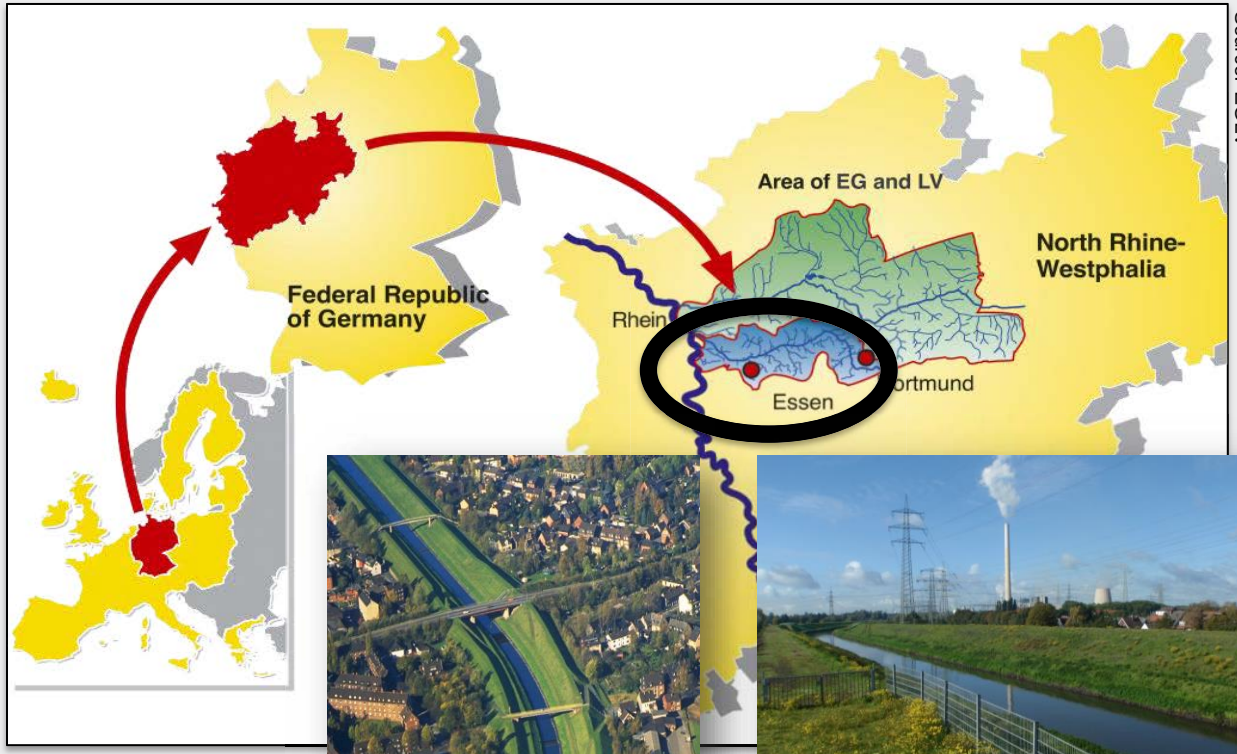
3. Dike height reduction at the Emscher river

Study area

- Catchment of the Emscher river
  Tributary to the Rhine river

- Located in the Ruhr-area
  Densely populated

- **Strongly protected** by dikes



Source: EGLV

Source: EGLV

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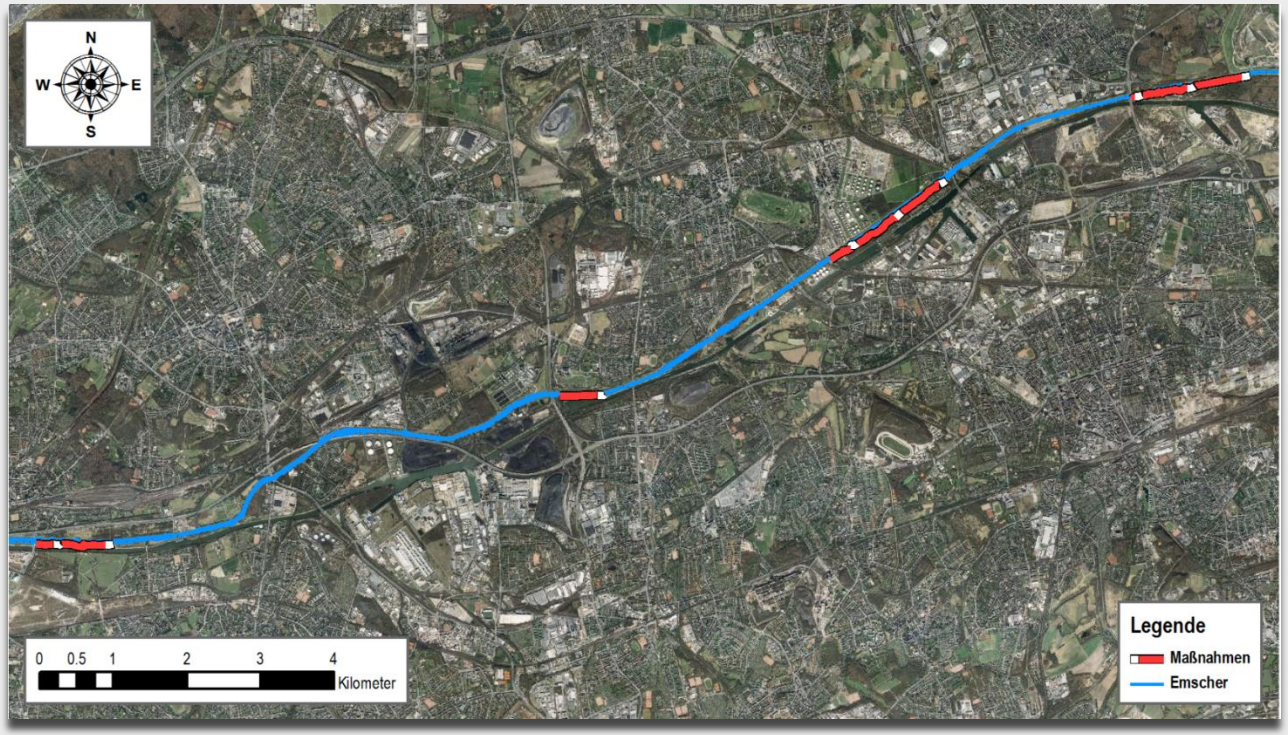
3. Dike height reduction at the Emscher river

Objective of the study

Risk-based evaluation of dike height reduction in 4 pre-selected dike locations

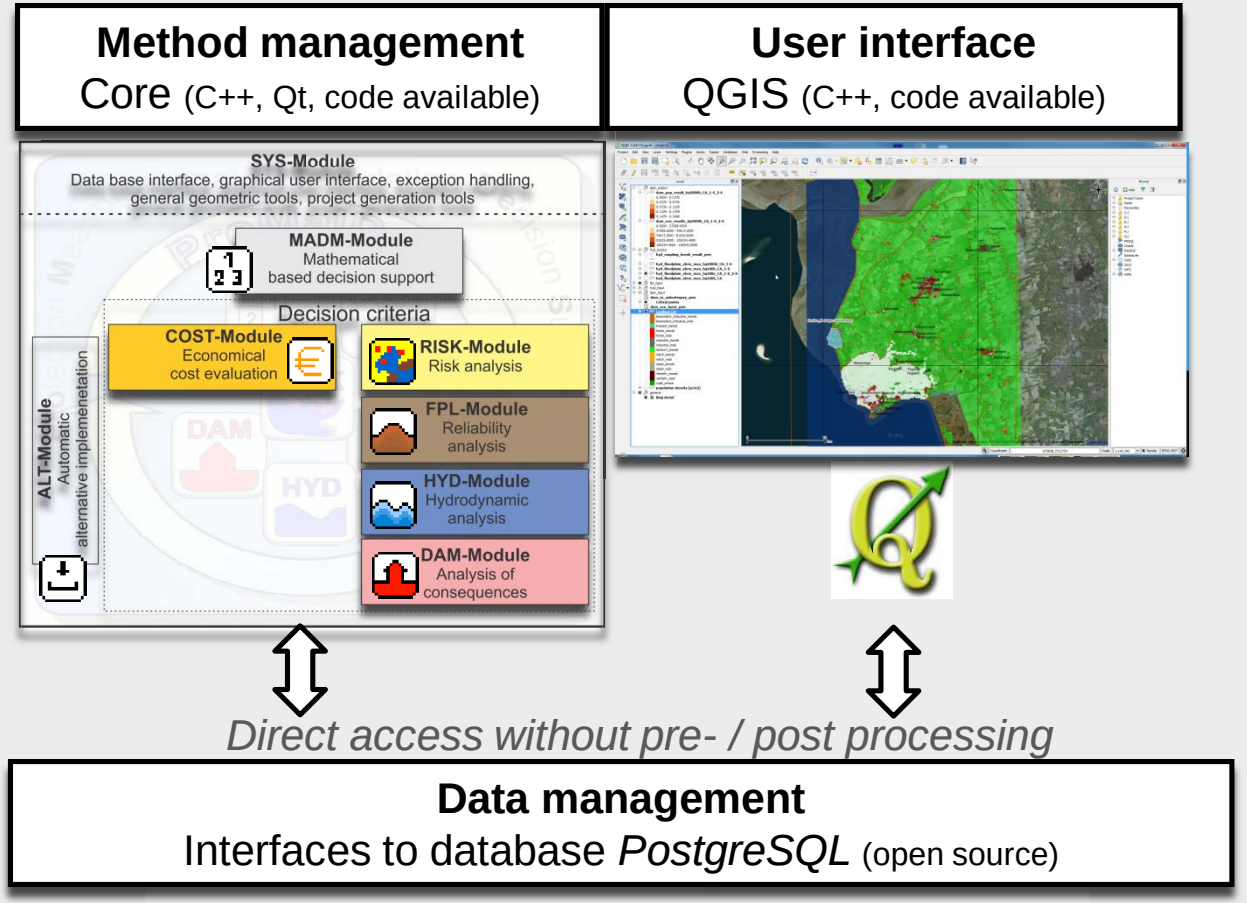
- 4 reduction steps:
  -10, -20, -50 and -100 cm
- Combinations of locations
- => **60 measures** were **risk-based** analysed



3. Dike height reduction at the Emscher river

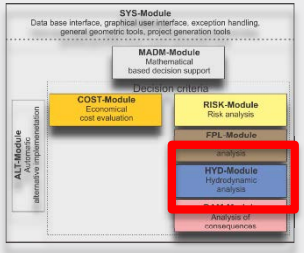
Tool ProMaIDes (**Pro**tection **M**easures **a**gainst **I**nundation **De**cision **s**upport)

- **Free software** for a risk-based evaluation of flood mitigation measures
- **Modular** designed
- Approaches for the **flood risk analysis** and their **base analyses** are available
- Direct connection to **QGIS** via database



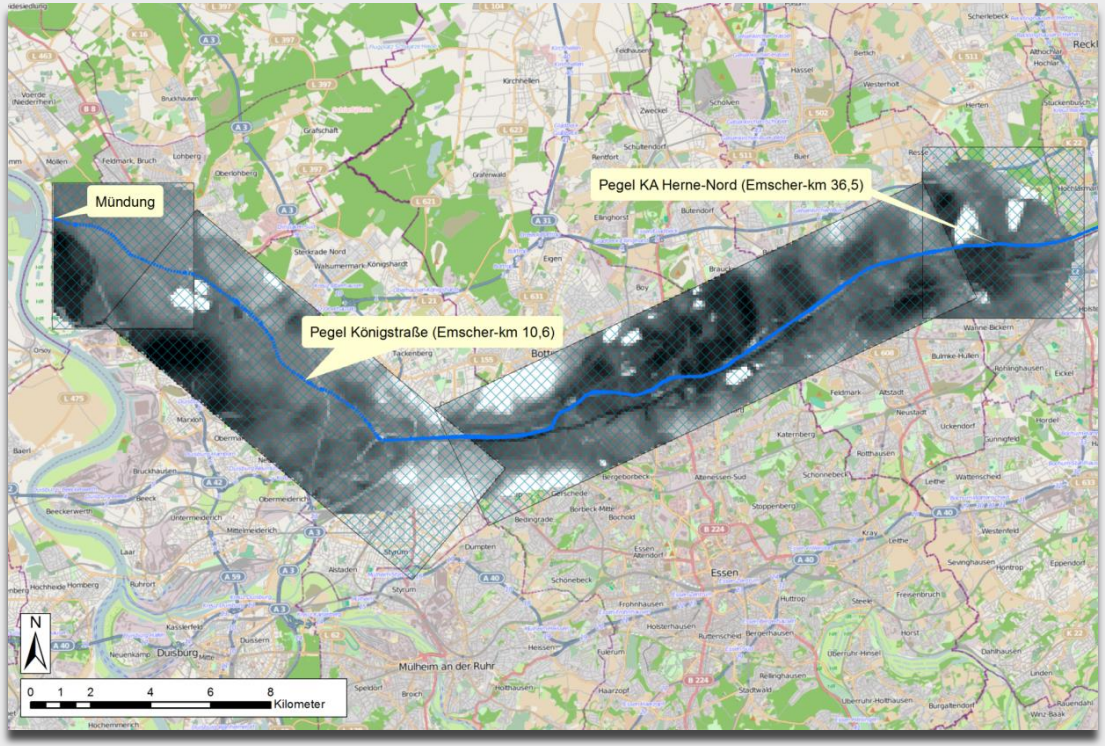
3. Dike height reduction at the Emscher river

Model set-up: hydrodynamic analysis



1d-2d coupled hydrodynamic model

- 1d river model Emscher:
  - 43 km river
  - 1200 profiles (standard, bridges and weirs)
- 2d floodplain model:
  - 20000 elements
  - 100 x 100 m
  - 200 km² floodplain



Boundary conditions

(from hydrological /statistical analysis)

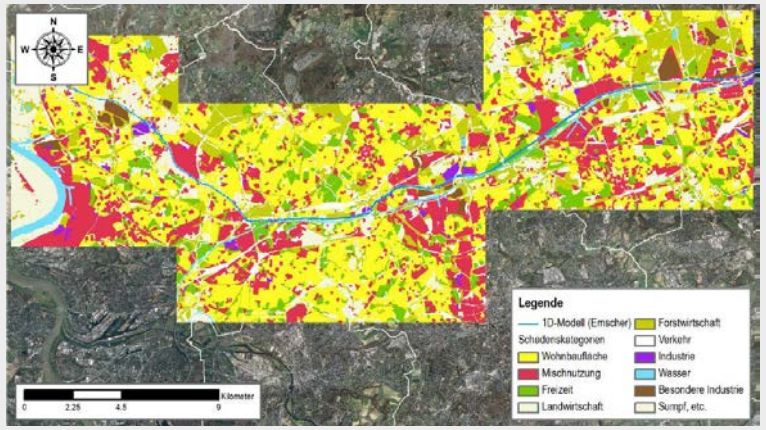
- 3 scenarios (100-, 200-, 1000- year flood event)

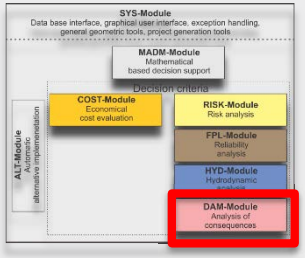
3. Dike height reduction at the Emscher river

Model set-up: analysis of consequences

Direct economic damages

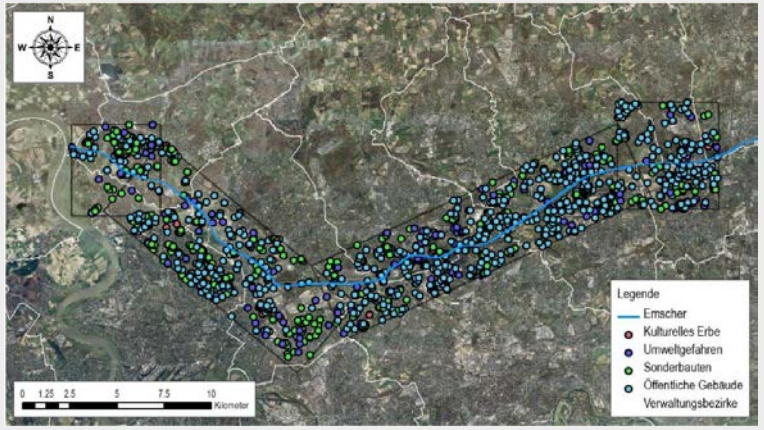
- Spatial distribution of 8 land-use categories in 4 raster (25 x 25 m) and stage-damage functions (housing, industry etc.)
- Spatial distribution of stock-values





Affected and endangered persons

- Spatial distribution of population density in 4 raster (25 x 25 m)

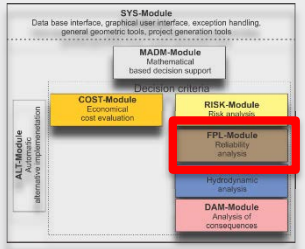


Special objects at risk

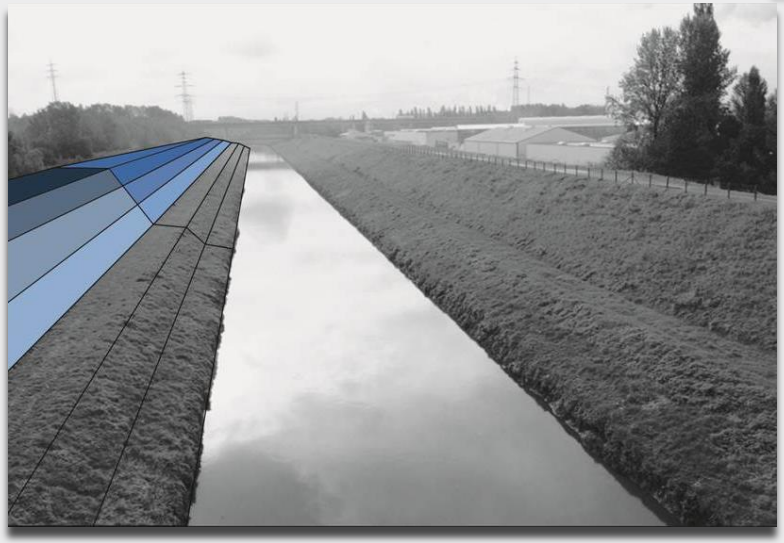
- 4 categories (public buildings, cultural heritage etc.)

3. Dike height reduction at the Emscher river

Model set-up: reliability of dikes



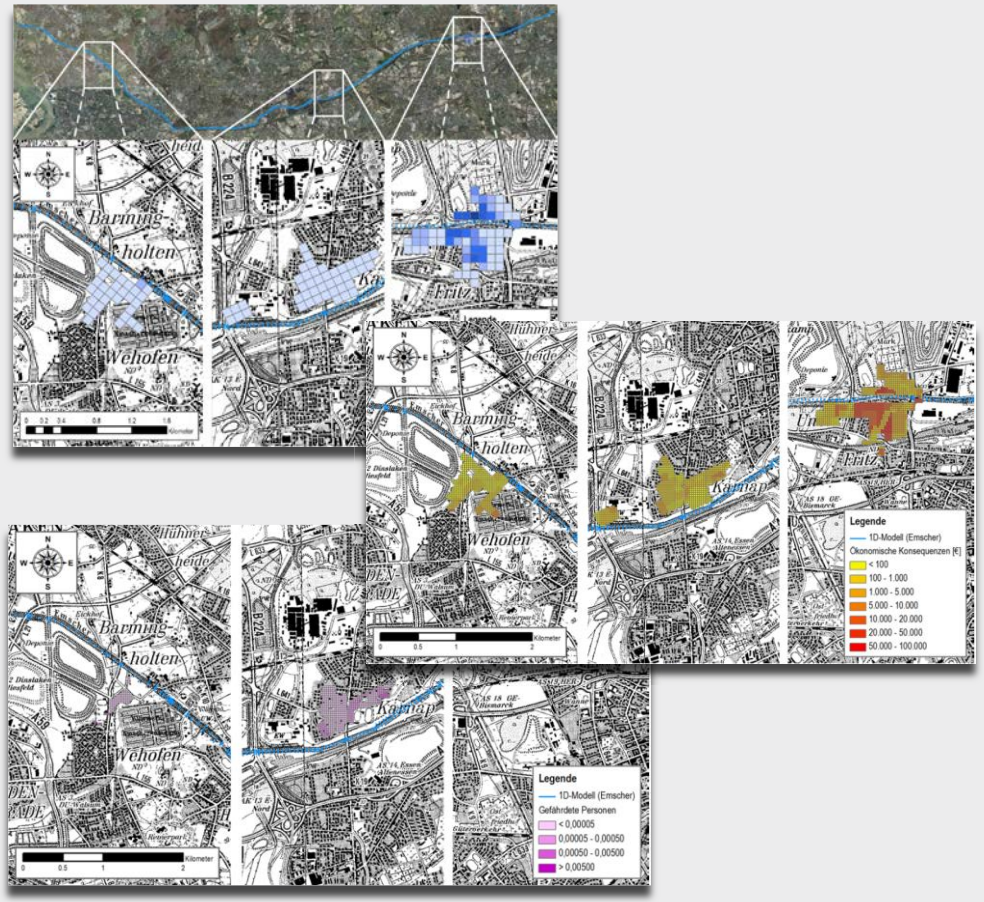
First assumption: **no dike failure!**



3. Dike height reduction at the Emscher river

Results: Flood risk current state (M0)

- **A lot of information** gets available**:**
  - Flooded area and water levels
  - Damages to economy
  - Damages to people



3. Dike height reduction at the Emscher river

Results: Flood risk current state (M0)

- **A lot of information** gets available**:**
  - Flooded area and water levels
  - Damages to economy
  - Damages to people

- **Summarized in flood risk** per category for the Emscher area

- **Risk is quite low** for current state (under assumption of no dike failure!)

Category	Risk
Economical risk [€ / a]	
Immobile	20.660
Mobile	10.771
Sum	**31.431**
Risk to persons [P / a]	
Affected	7,2960
Endangered	0,0049
Special risk objects [Score / a]	
Public buildings	0,150
Environmental risk	0,128
Cultural	0,015
Person risk	0,045

3. Dike height reduction at the Emscher river

Results: Ranking of alternatives

- **No effect** just numerical differences:
  - Dike height reduction to low
    => no overflow
  - Adjacent flood plain to high
    => no storage

- **Current state**

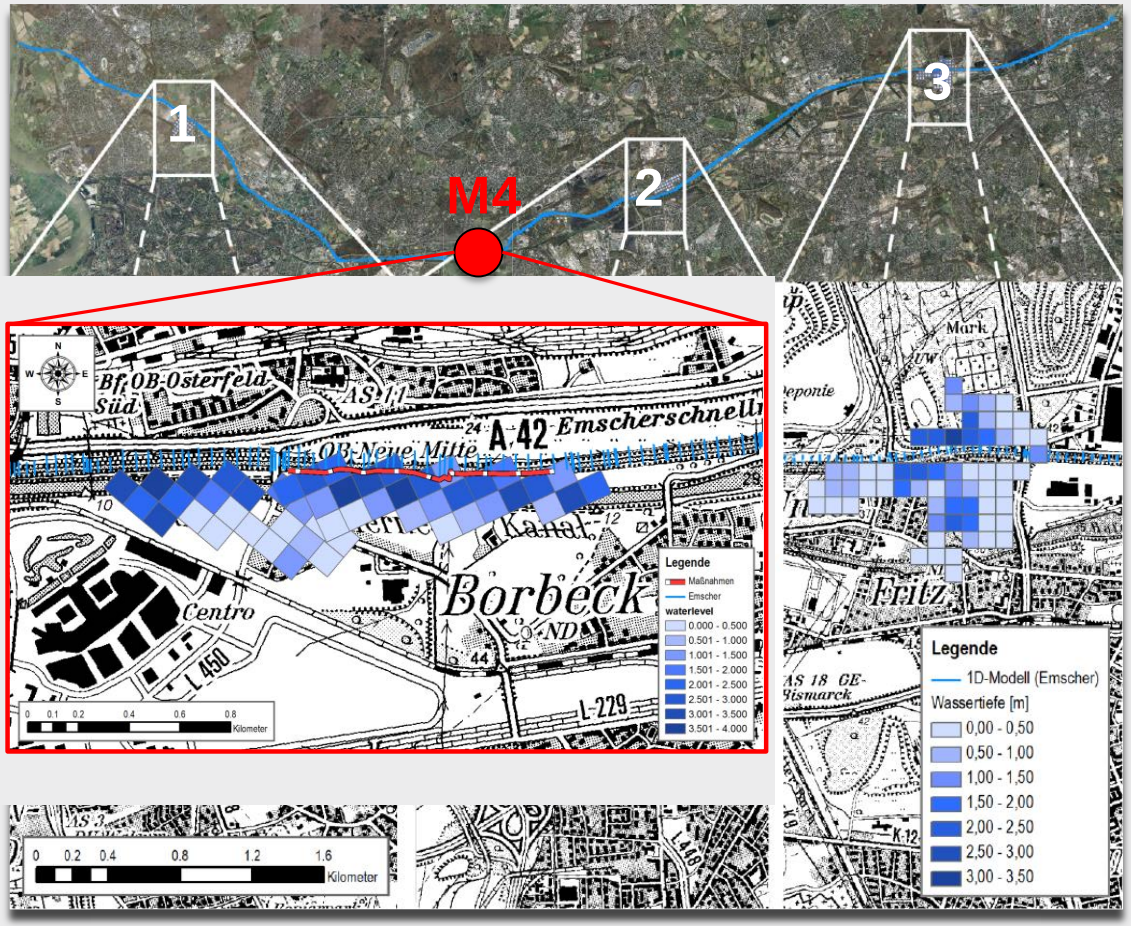
- **Increase of flood risk**

Rang	Name
1	M134-50
2	M1234-50
3	M14-50
4	M12-100
5	M234-50
6	M124-50
7	**M0**
…	…
58	M123-100
59	M23-100
60	M13-100
61	M3-100

3. Dike height reduction at the Emscher river

Results: Measure M4-100

- **3 flooded area for current state** (1000-yearly)
- **100 cm** dike height reduction (M4-100)
- **=> no flooding** in 1 and 2
- => **new flooding** in M4
- **Successful** from **hydraulic** point of view **but**…

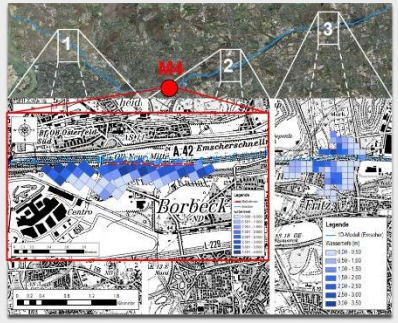


3. Dike height reduction at the Emscher river

Results: Measure M4-100

- …**not** from **a risk** point of view

- Increase of flood risk due to increased damages



Rang	Name
1	M134-50
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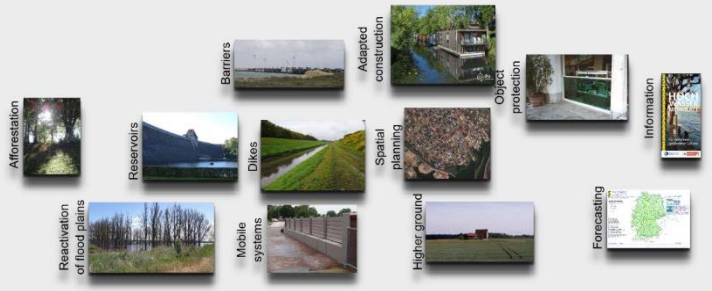
4	M12-100
5	M234-50
6	M124-50
7	**M0**
…	….
17	**M4-100**
…	…
58	M123-100
59	M23-100
60	M13-100
61	M3-100

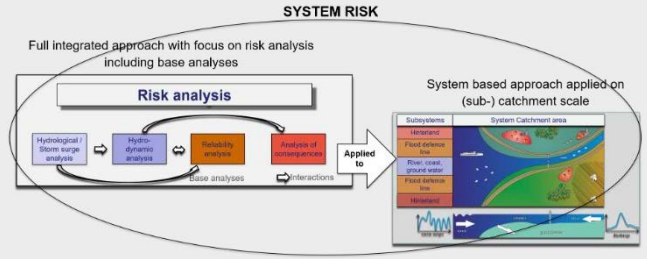
4. Conclusion

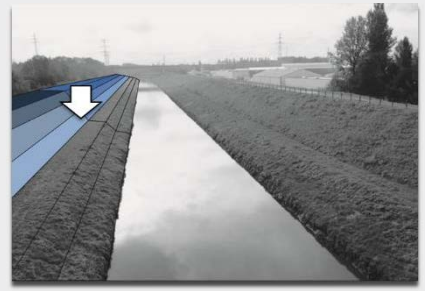
- **Risk philosophy** and **well-balanced mix** of various flood **mitigation measures**
  => we are **much further** than 20 years ago

- **New model techniques** are required
  => focus on risk and on the system
  (**System-Risk approach**)

- **Dike height reduction** measures are a quite **progressive flood mitigation measure**, which **can** be **effective**



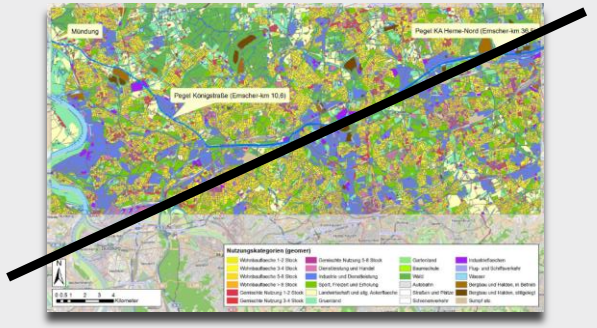




5. Outlook

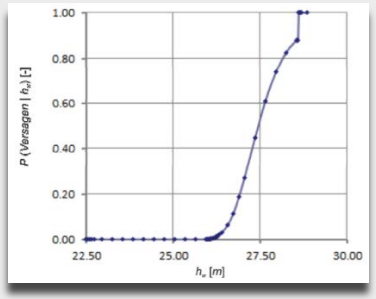
General

- Analyse dike height reduction as flood risk mitigation measure in less populated catchments

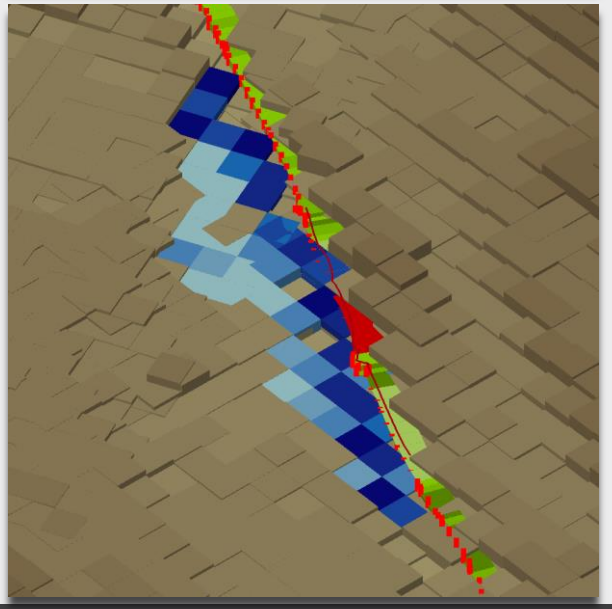


Emscher river

- Include dike reliability in the risk analysis (e.g. by fragility curves)



Thanks for your attention!



SYSTEM-RISK final conference, Potsdam 2019

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