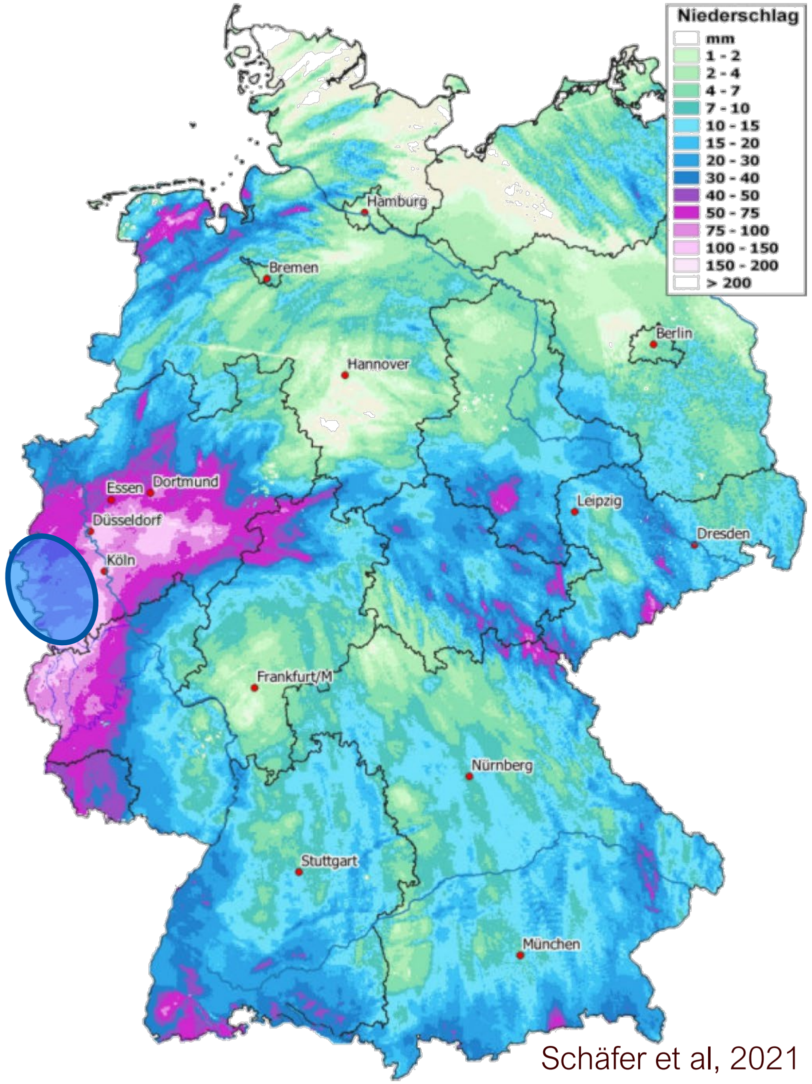
The “Stresstest Rur”

The What, the Why, the Where

10.09.2024 | Bernhard Becker Stefanie Wolf

The Flood of Mid-July 2021

- Areas in Germany, Belgium, the Netherlands and Luxembourg were affected
- Precipitation: more than 100l/m² in 72h
- Regionally more than 200 l/m² in 24h (≈ 25% of annual rainfall)
- Heavy rainfall is assigned a probability of occurrence of 1 in 400 years (Tradowsky et al. 2023)
- Low mountain regions were predominantly affected
- A lot of debris was transported with the flood wave
- Consequences:
  - Injuries (physical and psychological)
  - Damage to infrastructure (roads, public transport, energy supply, critical and sensitive infrastructure)
  - Damage to buildings
  - Erosion, sediment deposition, contamination



Schäfer et al, 2021

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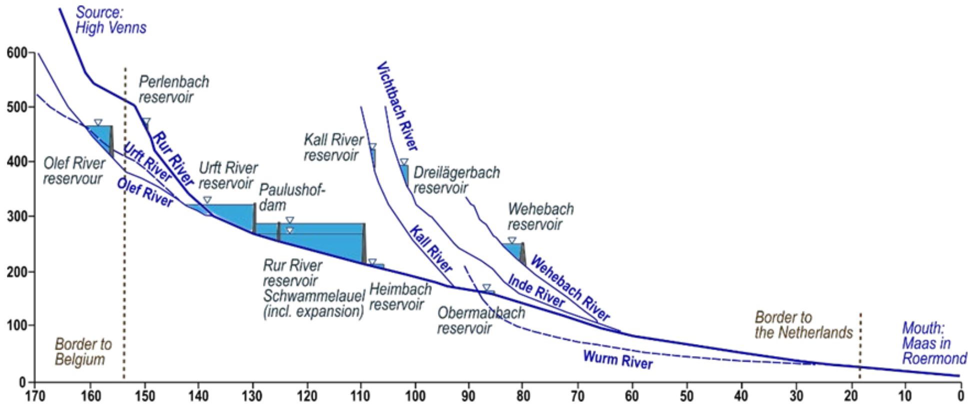
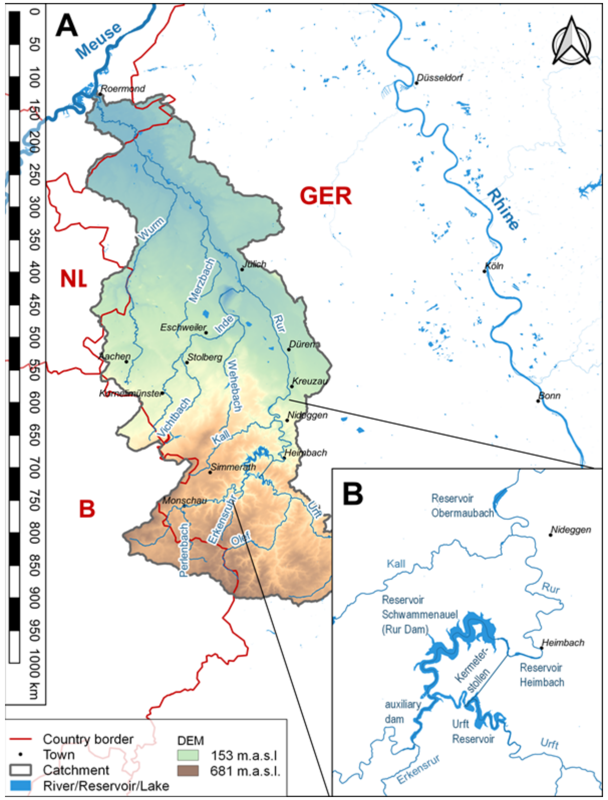
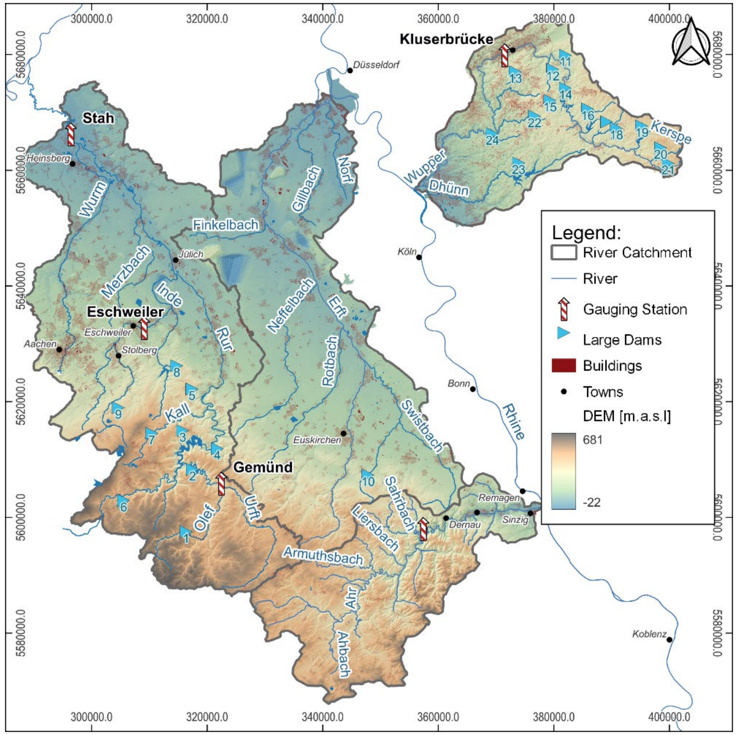
The Flood of Mid-July 2021

- There are a total of 24 dams in the affected catchments
- 9 dams in the Rur catchment



Wolf 2023





Wolf, S., Klopries, E.-M., Schüttrumpf, H., Carstensen, D., Gronsfeld, R., & Fischer C. (2023). Design values for dams exceeded: Lessons learnt from the flood event 2021 in Germany. In R. M. Boes, P. Droz, & R. Leroy (Eds.), Role of dams and reservoirs in a successful energy transition: Proceedings of the 12th ICOLD European Club Symposium 2023 (ECS 2023, Interlaken, Switzerland, 5-8 September 2023). CRC Press. https://doi.org/10.1201/9781003440420-47

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The Flood of Mid-July 2021

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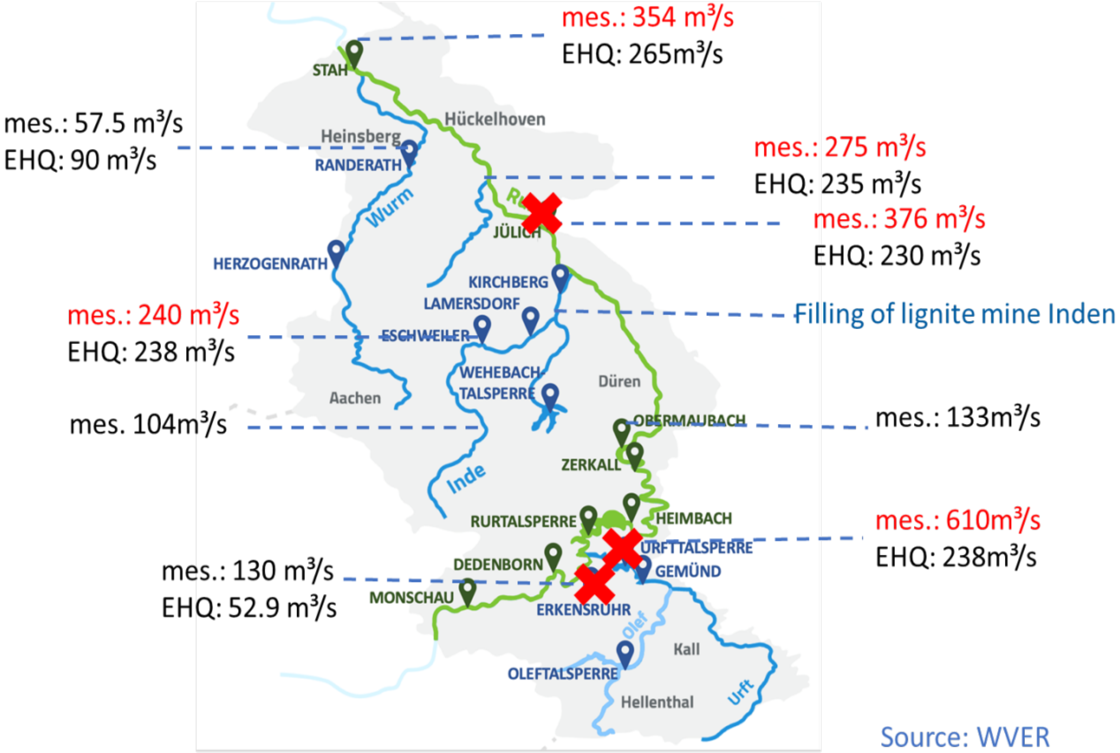
- There are a total of 24 dams in the affected catchments
- The dams survived their design event without damage
- The retention by the dams was successful
- Large upstream reservoirs protect the downstream regions
- Inflow dam system: 760 m³/s
- Discharge at the border D-NL: 354m³/s
- Without dams: approx. 1,000 m³/s !!!



Source: WVER

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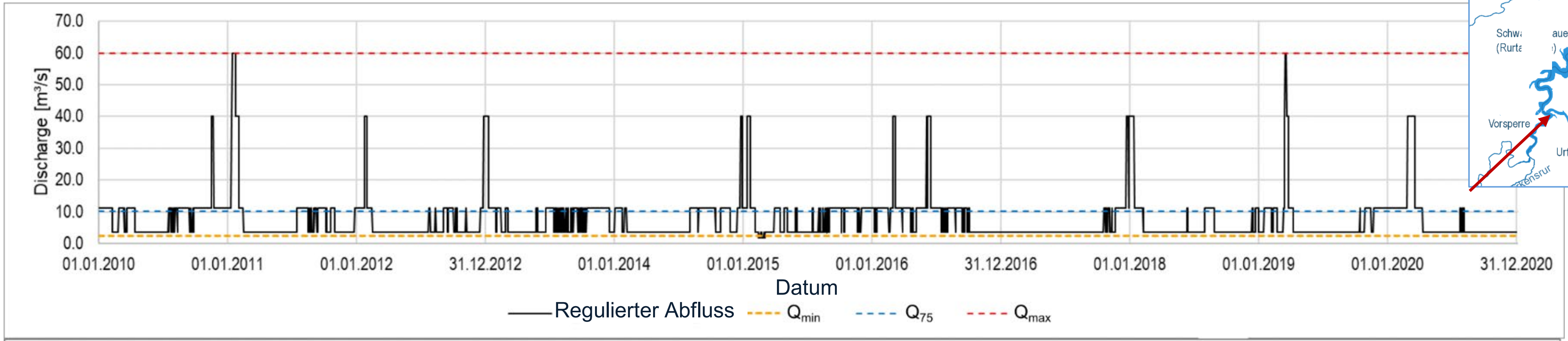
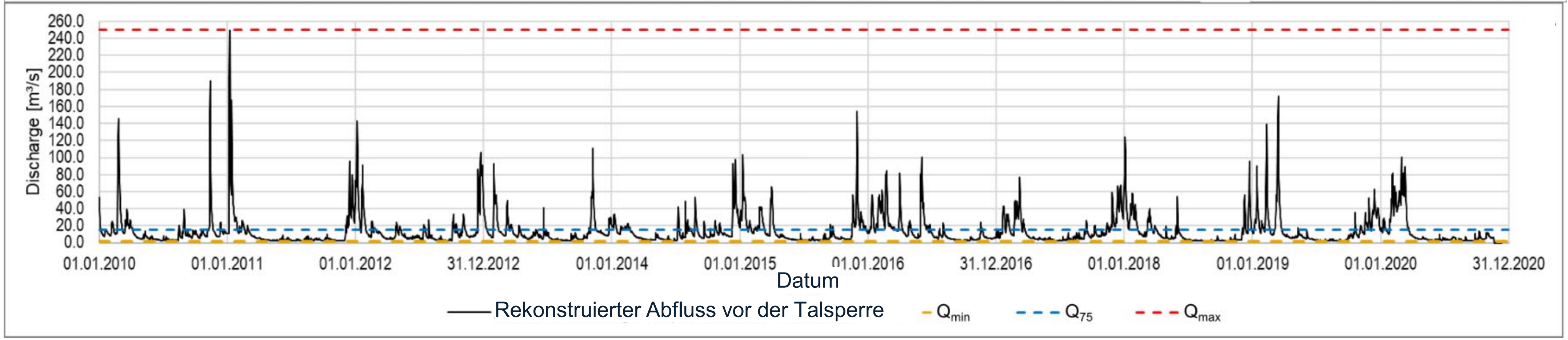
Impact of the Urft-Rur-Dam System





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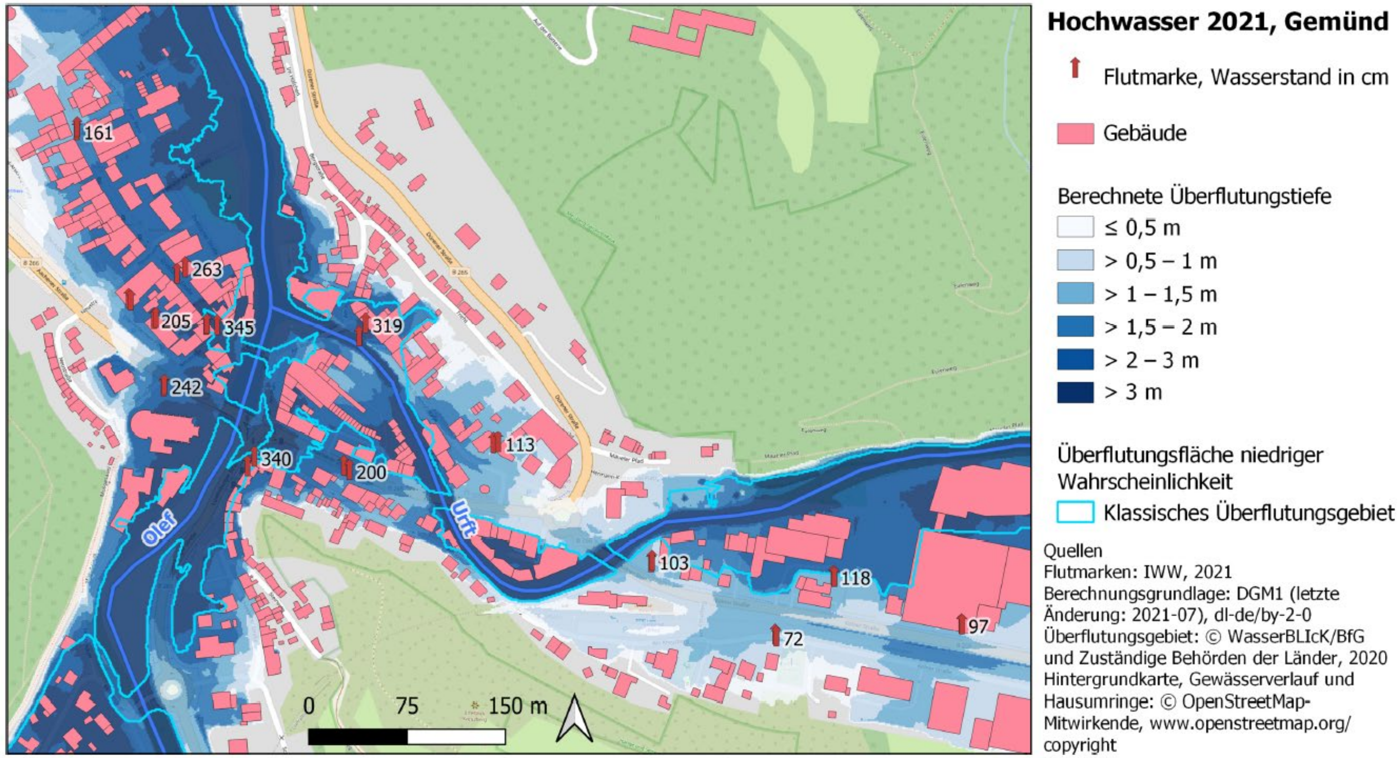
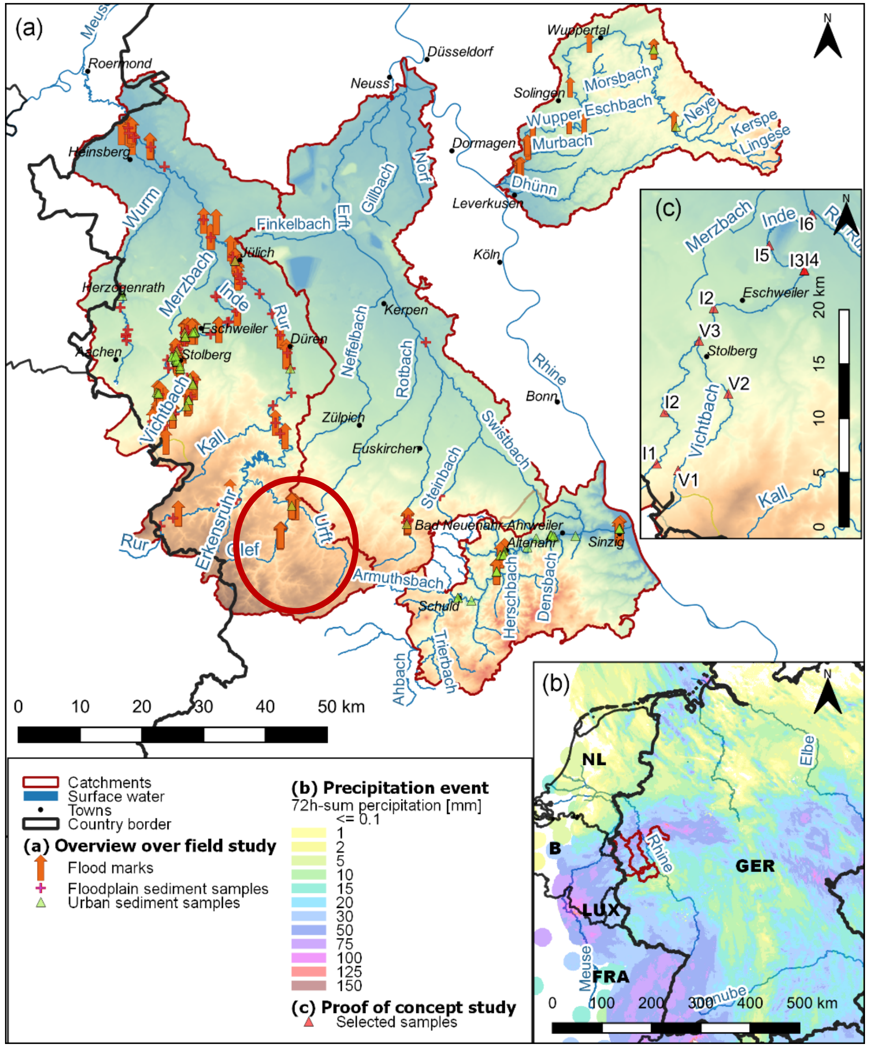
The Urft Catchment



Elisabeth Kisseler (2022)



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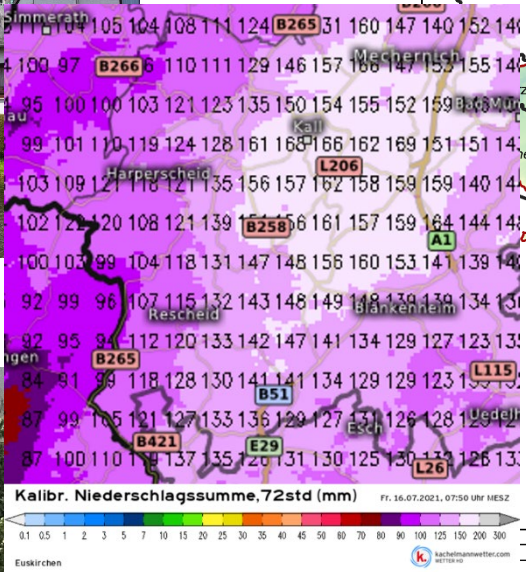
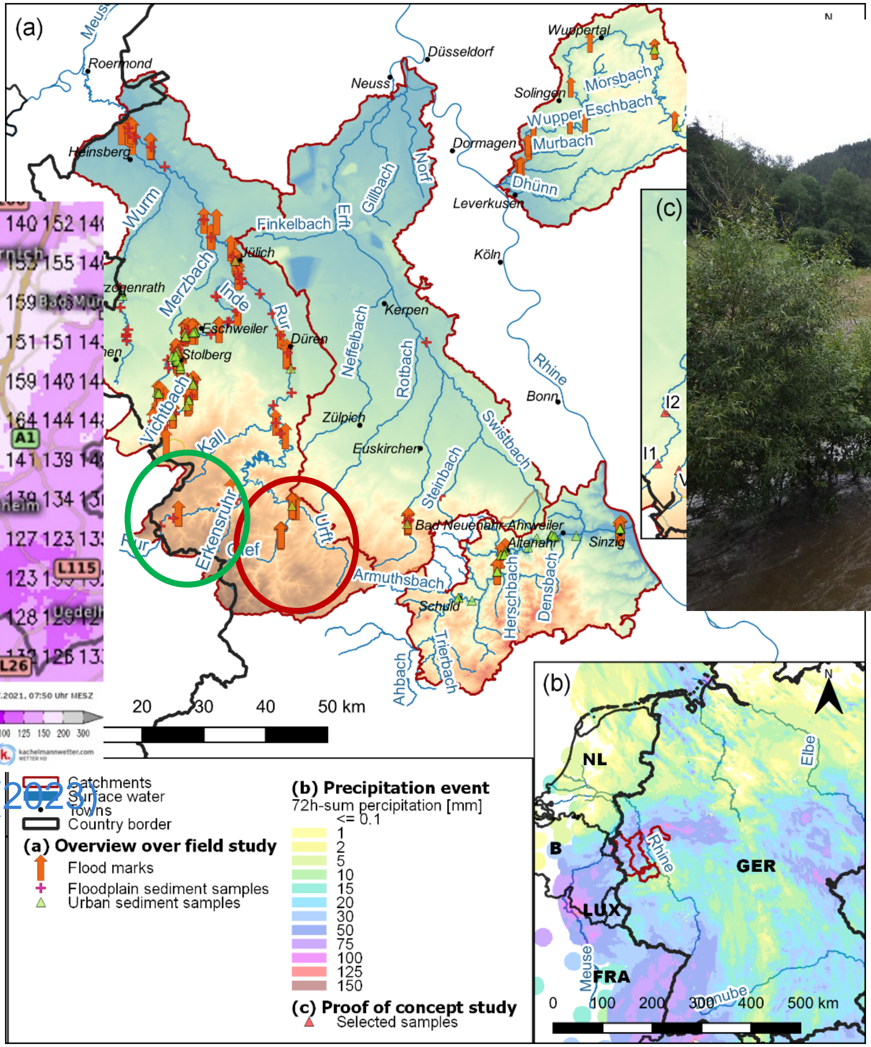
The Urft Catchment

Wanderatlas Verlag GmbH (2023)



Kachelmann Wetter (2023)

Aktion Deutschland hilft (2021)



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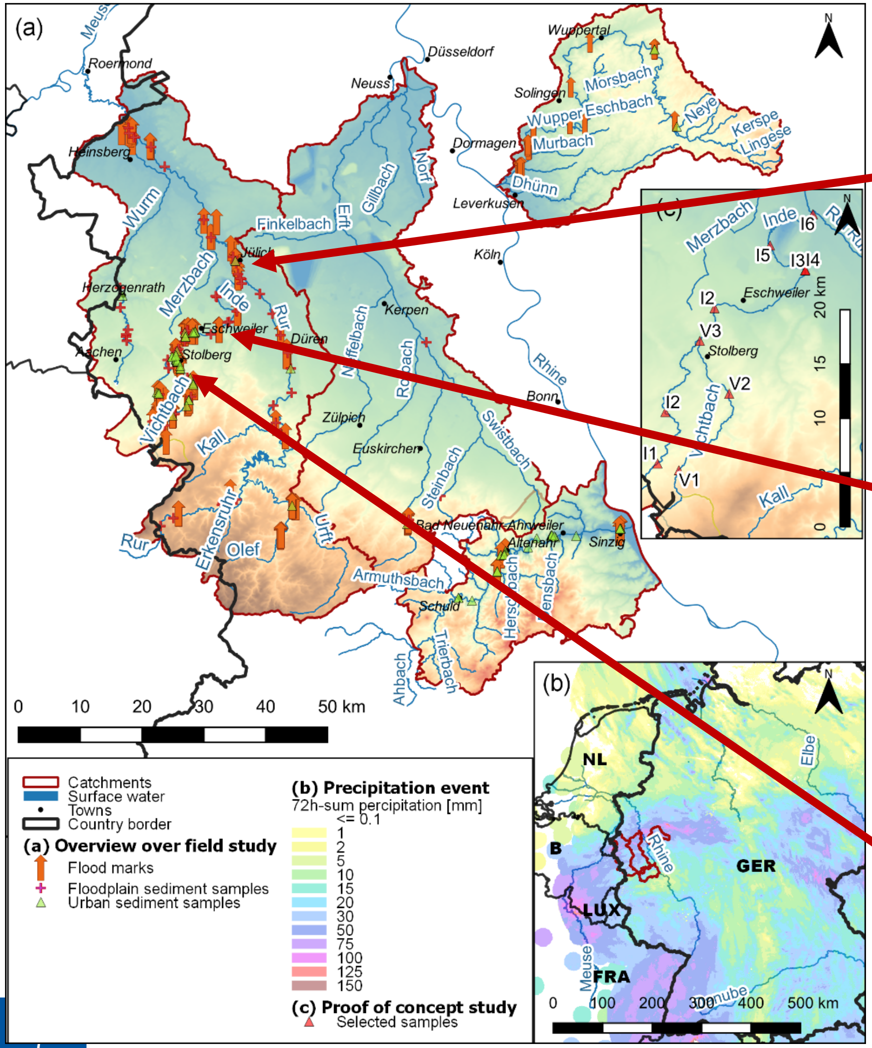
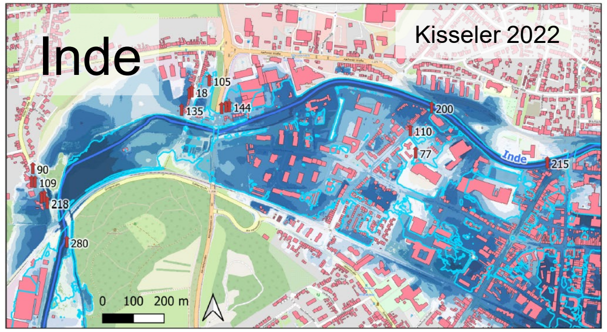
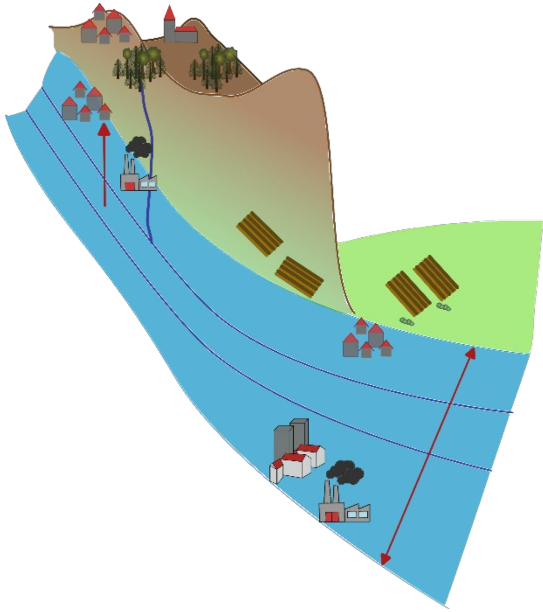
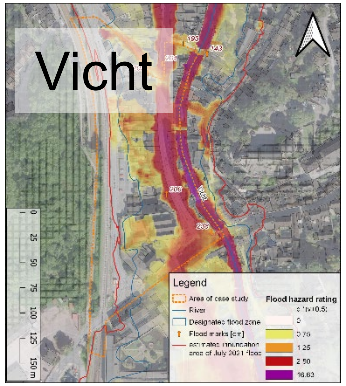
The Flood of Mid-July 2021 in the Inde Catchment









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Open Pit Mine Inden in July 2021

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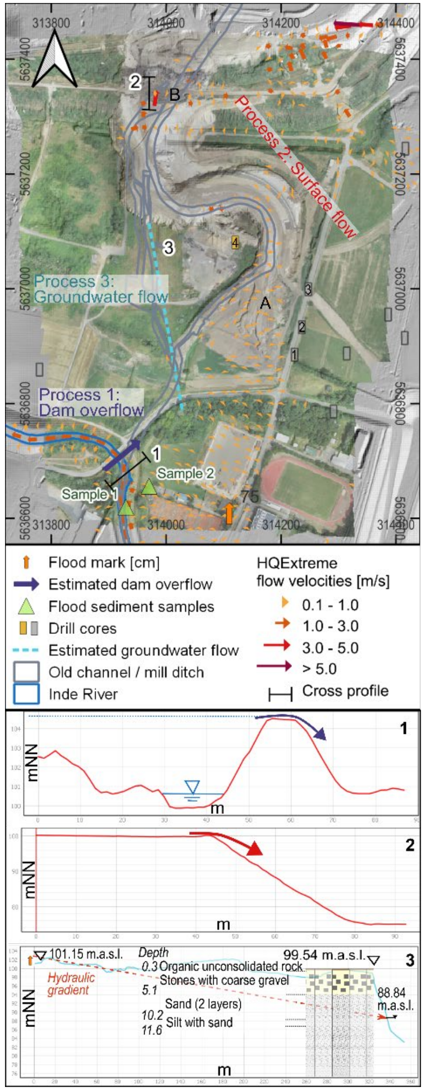

Keßels, Wolf, Römer, Dörwald, Schulte, Lehmkuhl (2024): Enormous headward erosion in the floodplain areas of open-cast mining sites during the flood of July 2021 in Germany, ESEU, Under Review

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Joint Cooperation programme for Applied scientific Research

Accelerate Transboundary Regional Adaptation to Climate Extremes

Joint structural policy-relevant research on flood and drought risk management in regional river basins

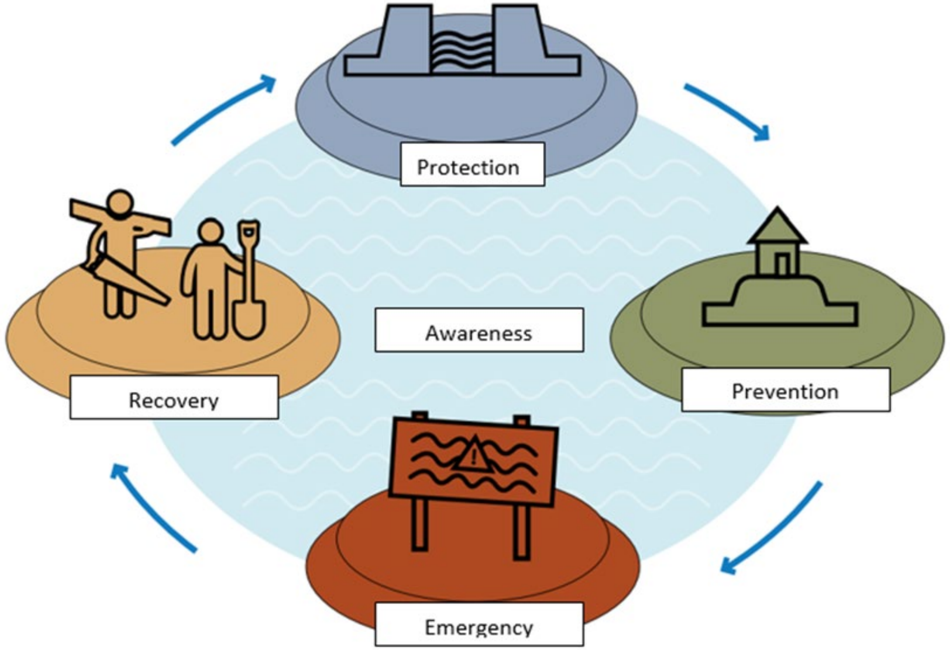
Main objectives

Objective 1: Preparing for Future Water Challenges

- Facilitate European regional governments on transboundary flood and drought risk management of smaller regional river basins;
- Enhance integrated planning, development and management.

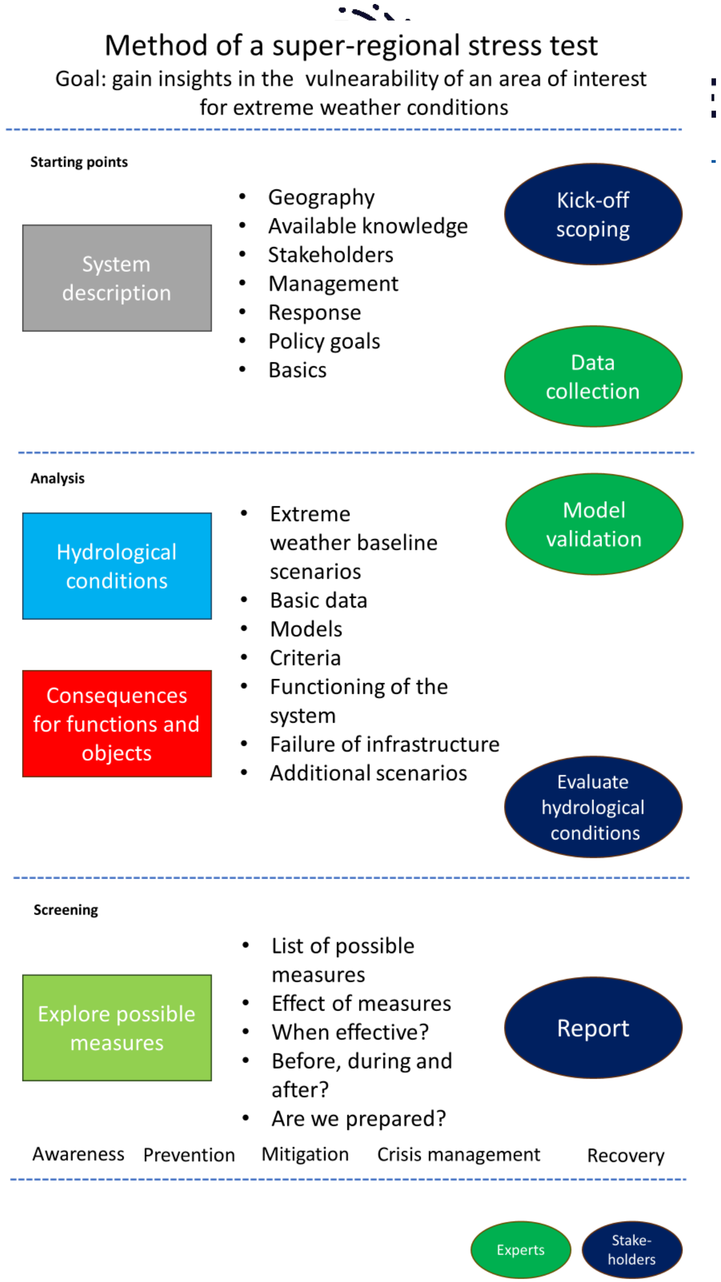
Objective 2: Knowledge cooperation

- Support the development of an international expert community on flood and drought risks in regional river basins;
- Fostering long-term partnerships between European knowledge institutes and enhance the knowledge base to inform strategies on mitigation and adaptation



The stress test

- It could have been worse then July 2021 …
  - What happens, if the upper Rur River experiences similar precipitation sums to the Urft and Olef rivers?
  - What happens if the Rur reservoirs
  - What happens in the case of a dam failure?
- What is a stress test?
  - How does the system react under extreme conditions?
  - When does the system fail?
  - What are consequences?
  - What are thinkable mitigation measures?



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Starting points: system description

- Catchment
  - System description
- Stakeholders (fact sheets)
- Water infrastructure and water usage

Country	Name of the dam and the lake where applicable	Impounded water	Volume of the reservoir lake (Mio m³)	Surface area (ha)
Germany	Dreilägerbachtalsperre	Dreilägerbach, Vicht	4.280	40.0
Germany	Kalltalsperre	Kall	2.100	18.0
Germany	Oleftalsperre	Olef	20.300	110.0
Germany	Perlenbachtalsperre	Perlenbach	0.900	15.0
Germany	Paulushofdamm; divides the Rursee into the Obersee (forebay) and the Hauptsee (main lake)	Rur		
Germany	Rurtalsperre Schwammenauel with and reservoir lake Rursee	Rur	202.600	783.0
Germany	Stauanlage Heimbach Staubecken Heimbach	Rur	1.430	34.6
Germany	Stauanlage Obermaubach	Rur	1.650	55.4
Germany	Ufttalsperre	Urft	47.750	216.0
Germany	Wehebachtalsperre	Wehebach	25.060	162.0
Netherlands	Cranenweyer	Anstelerbeek		20.0

<table>
<tr><th>Actor's Name</th><th>Wasserverband Eifel-Rur
https://wver.de/</th></tr>
<tr><td>Type and structure</td><td>Sondergesetzlicher Wasserverband according to the Eifel-Rur-Verbandsgesetz; Members are municipalities, districts, industry, drinking water supply companies</td></tr>
<tr><td>Responsibility and purpose</td><td>Water management (including dam operations)
Wastewater treatment
Responsibility for maintenance of water courses
Responsibility for flood protection in the whole operational area, except some municipalities in the Obere Rur.</td></tr>
<tr><td>Region of responsibility</td><td>Rur catchment

</td></tr>
<tr><td>Interest, task, roles, mandate</td><td>Flood protection, sufficient water for their members</td></tr>
<tr><td>Challenges and conflicts</td><td>Operation under climate change, balance flood and drought management with reservoirs</td></tr>
<tr><td>Ressources</td><td>Reservoir lakes with very large storage capacity, flood control volume</td></tr>
</table>

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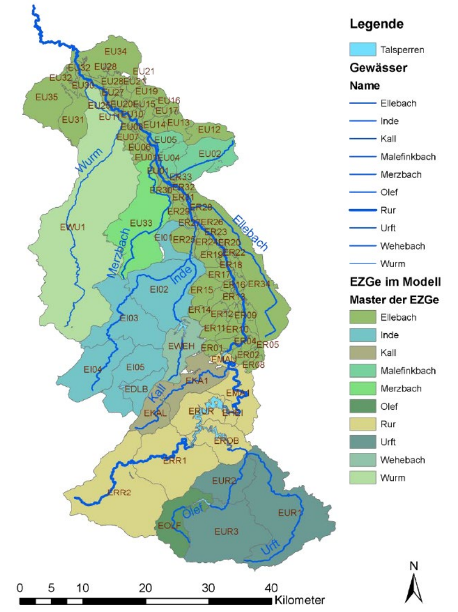
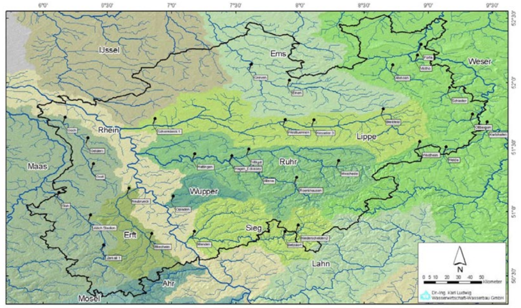
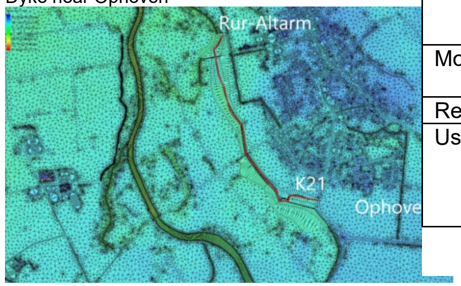
Starting points: available knowledge

- Model inventory (fact sheets)
  - 2 Weather generators
  - 11 hydrological models
  - 8 hydraulic models
  - 3 reservoir models
  - Sediment models
  - Machine learning models
  - 4 forecasting systems

Model name	Talsim-Model of the Rur
Software	NASim ((Hydrotec GmbH 2015c)), Jabron ((Hydrotec GmbH 2015b))
Category	Hydrological model, flood routing. Wave propagation is described with the help of parameters ("Hochwas-sermerkmale"), e. g. parameters for translation and re-tention. The parameters are derived from statistical analysis of historic data.
Purpose of the model	Climate change analysis for floods
Model owner	WVER
Model developed by	SydroConsult GmbH
Modelling area	Rur catchment until the Dutch-German Border  ((Demny and Lohr 2014))
	86 sub-catchments
	(Demny and Lohr 2014)
nce	Model has been developed within

Model name	Operational hydrological models LARSIM
Software	LARSIM (Large Area Runoff Simulation Model, (LAR-SIM 2024))
Category	Hydrological model
Purpose of the model	Operational flood forecasting
Model owner	LANUV
Model developed by	Dr. Karl Ludwig (Consulting Engineer)
Modelling area	All sub-catchments within the area of Nordrhine-West-falia 
Model resolution	Time: hours Space: 10 km
Reference	(Richter et al. 2009)
Usage and state of maintenance	Models have been built in 2009 for climate change stud-ies. Multiple LARSIM models have been integrated in a flood forecasting system, this is being made operational (Feb. 2024)

Model name	HydroAs2D model Untere Rur
Software	HydroAs2D ((Hydrotec GmbH 2015a))
Category	Hydrodynamic numerical model
Purpose of the model	2D flood modelling, polder study
Model owner	RWTH Aachen University, IWW
Model developed by	Nico Schmitz
Modelling area	Dyke near Ophoven 
Model resolution	Time: Space: ~ 105 km² Resolution: ~ 150 m²
Reference	Master thesis Nico Schmitz in collaboration with the WVER
Usage and state of maintenance	Heleen Urbach, MSc. Thesis

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Starting points: Glossary in multiple languages

- One-directional from English to German, Dutch, French
- Sources
  - Standardizations
    - German standards (DIN) contain translation tables to English
    - Wikipedia (.de, .nl, .fr, .org)
    - Professional practice and experience
- Lost in translation …
  - A polder in the Netherlands or Northern Germany is not the same as a polder along the Rhine or the Rur (planned)
  - Charles Antoine François Poirée invented the needle weir with thin vertical beams (“barrage à aiguilles”), but in Dutch this term is used for a weir with large horizontal beams …
  - a barrage in French can be a (large) dam or a weir
  - and we have sills (French: seuil, German: Sohlschwelle), a Seul can have a movable crest, but (usually) not a sill …
  - And what is the “Kreisebene” (German) and how does this relate to district, gemeente and arondissement in other countries?

Term (English)	Language	Term	Definition (by authors for the scope of this document if not specified otherwise)
Catchment, basin	German Dutch French	Einzugsgebiet Stroomgebied bassin versant	
Dam (large dam)	German Dutch French	Talsperre Stuw (grand) barrage	A barrier that stops or restrict the flow in a surface water course. Barrage
Detention basin (rain)	German Dutch	Regenrückhalte-becken regenwaterbuffer	A basin to store rainfall water temporarily. Often the outlet is uncontrolled. Under normal condition the detention basin is empty.
Detention basin (stream)	German Dutch	Hochwasserrückhalte becken Polder (lateral detention basin)	A basin to control the discharge of a stream under flood conditions. Under normal conditions the basin is empty. It can be installed laterally to the stream, then often an excavated area or enclosed with dikes, or longitudinally, then often realised with a single-purpose dam. The latter can be designed with controllable or uncontrollable outlet.
District	German	Kreis, Landkreis, kreisfreie Stadt	Administrative subdivision higher than a municipality.
Governmental district	German	Bezirk, Regierungsbezirk	Regional mid-level local government units in four of Germany's federal states, including Nordrhein-Westfalia
Run off potential (natural or artificial)	German	Vorflut	The potential for water to run off by gravity flow (natural, "natürliche Vorflut") or artificial drainage ("künstliche Vorflut).
Minimum release	German Dutch	Mindestabgabe Minimale afvoer	The operational minimum release from a reservoir that the operations should aim to maintain according to the operational protocol
Municipality	German Dutch	Gemeinde gemeente	Lowest level of territorial division.
Polder	German Dutch	Polder polder	A catchment that has no natural drainage by gravity flow. Polders are typically drained with the help of pumps. Note that the German term "Polder" is used also for detention basins lateral to a river or stream.
Reservoir lake	German Dutch French	Stausee stuwmeer lac	A lake created by a dam. Multi purpose reservoirs suppress floods and provide water for human consumption, irrigation, industrial use, recreation, hydropower or ecological functions.
Spillway	German Dutch	Hochwasser-entlastungsanlage overlaat	A structure to provide the controlled release of water from a dam or levee under flood conditions.
Volume-release plan	German	Lamellenplan	An operational protocol for a reservoir that specifies the reservoir release in dependence of the time in the year and the current volume of water in the reservoir.
Receiving water	German	Vorfluter	The water that enables gravity flow potential, typically a water course, but also groundwater or lakes.

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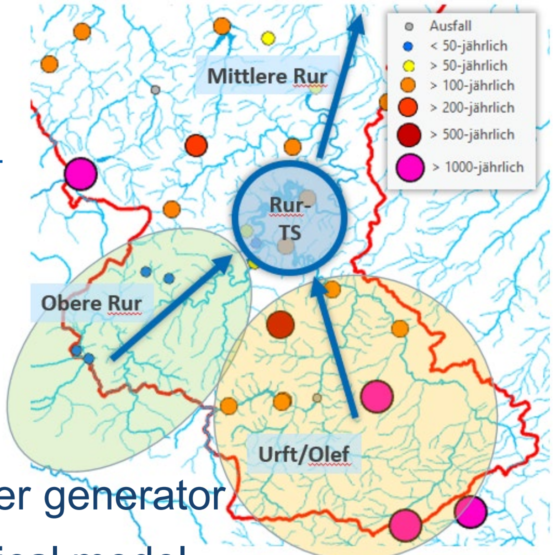
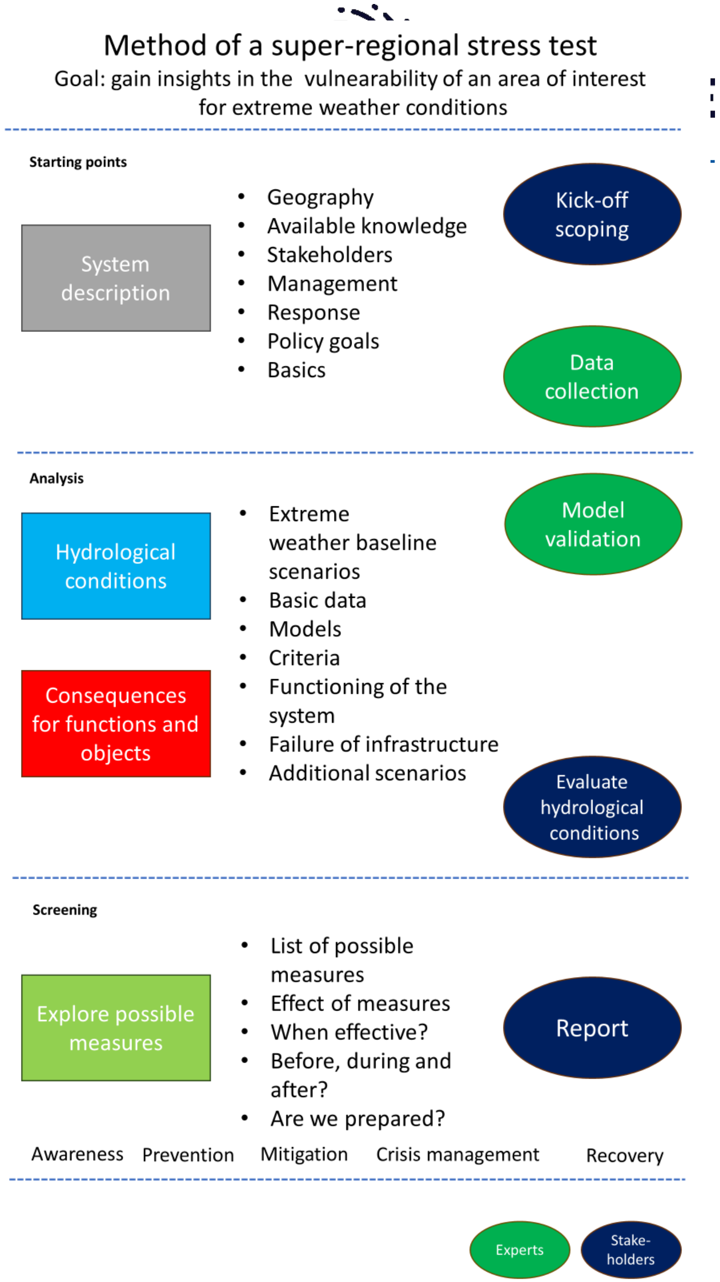
Analysis: work in progress

- Select models
- Design scenarios
- Our approach:
  - Upstream of the reservoirs
    - Generate long time series of weather with a weather generator
    - Feed the weather generator output to the hydrological model
    - Select event that has a return period of around 10 000 years.
    - Compare this to historic event of July flood 2021
  - Downstream of Rurtalsperre Schwammenauel
    - Capacity of the spillway (450 m³/s) bottom outlet capacity (120 m³/s) = 570 m³/s (this is a regular operational scenario)
    - Plus the flood wave from the Inde and Vicht (hydrological modelling or a historic time series from the 2021 flood)
  - Primary subject of the analysis: inundation areas
    - Question: how well can we model inundation with the available models?
    - Selected points of interest, provided by the stakeholders (municipalities)



Picture source: WVER



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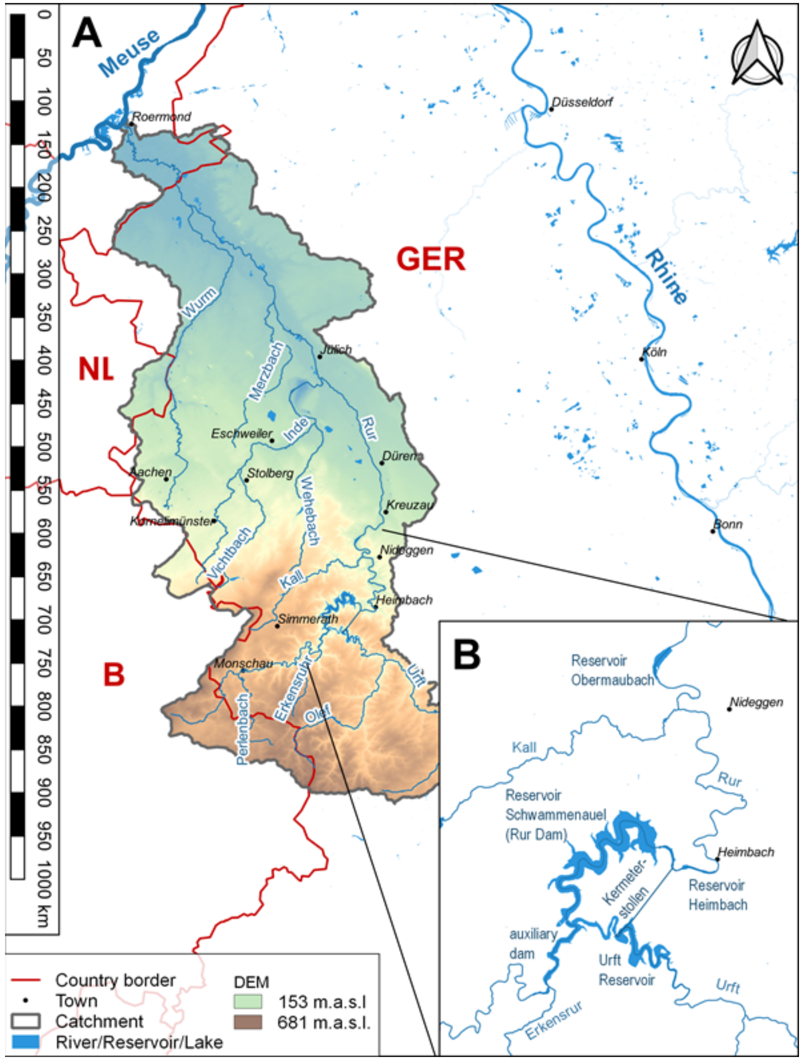
Modelling and analysis

- Which models to use?
  - Upstream of the reservoirs
    - hydrological models in different state of maintenance
    - no hydraulic models
  - Downstream of the reservoirs:
    - Germany: 2D hydraulic models (computationally expensive)
    - The Netherlands: 1D hydraulic model
    - Different hydrological models for different sub-catchments
  - Current idea: HydroAS 2D and mHM models
- How can we estimate inundation areas with the available models in a reasonable amount of time?
  - Inundation areas are the primary parameter of interest for most of the stakeholders
- Reservoir outflow?
  - Peak flow: full capacity of spillway and bottom outlet.
  - Timing and shape of the wave?
  - → reservoir model, or pass inflow



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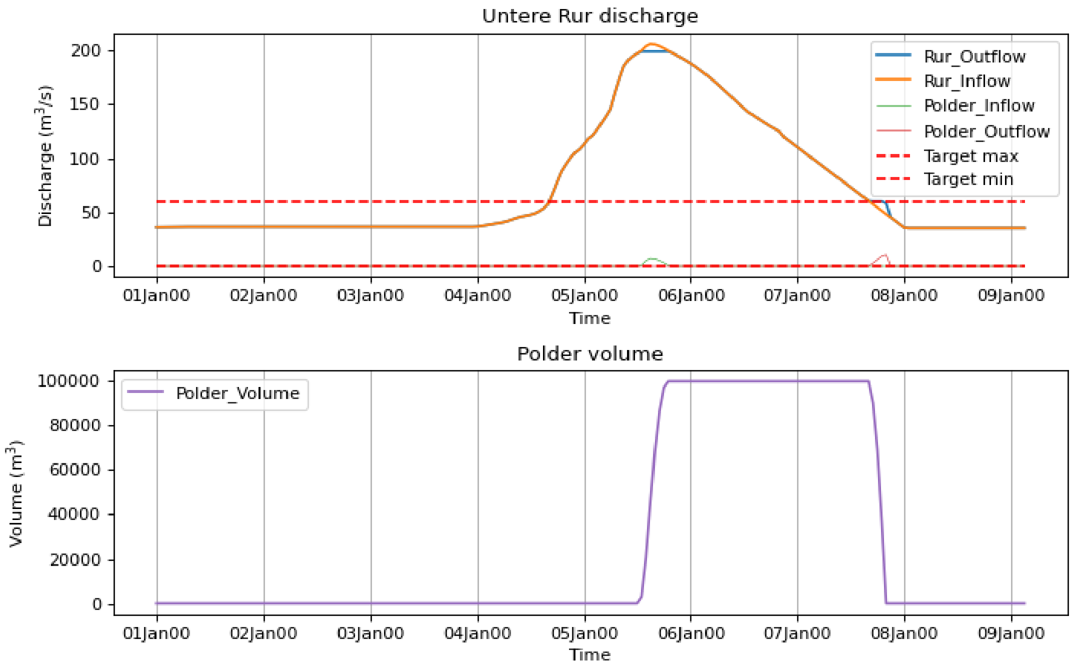
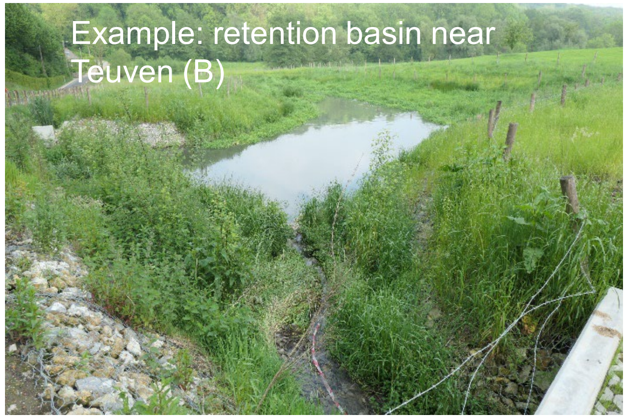
Evaluation of measures

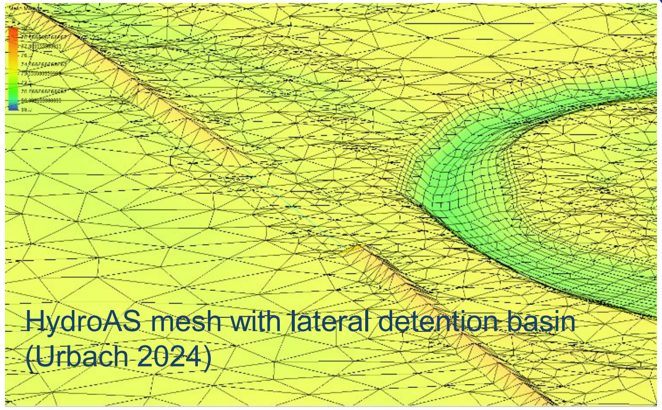
- Lateral detention basins (“Polder”)
  - Limited storage volume
  - Needs just-in-time control, forecast-based
- Retention basins
  - Single-purpose reservoirs
  - Controlled or uncontrolled
- Flood storage zone in the relict lake Inden (when ready)



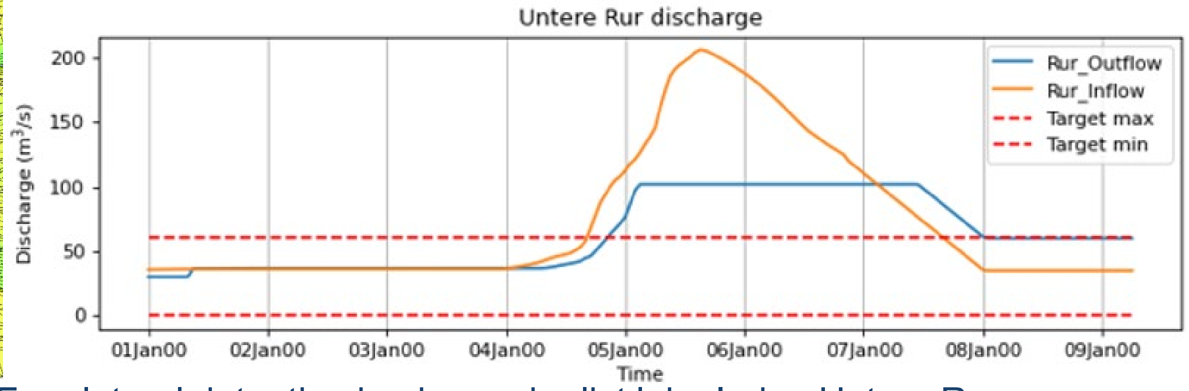
Effect of a lateral detention basin Untere Rur with optimal control (RTC-Tools model, Urbach 2024)



Example: retention basin near Teuven (B)



HydroAS mesh with lateral detention basin (Urbach 2024)



Four lateral detention basins and relict lake Inden Untere Rur (RTC-Tools, Urbach 2024)

Outlook

2024:

- Apply the stress test scenario on hydro models (to be selected)
- Evaluate system behaviour, consequences and measures.

Coming years:

- Dam breach modelling: What happens in case of a failure of Rurtalsperre dam?
- Reservoir management (JCAR-ATRACE PhD project)
  - Dam operations of the future: how best balance flood storage space and water supply requirements
  - The role, potential and limits of forecast and early warning in reservoir operations
- Other measures
  - Upstream retention: technical and natural retention
  - Forecast and early warning
  - Cost sharing between upstream riparian (here the measures take place) and downstream riparian (benefits from the measures).

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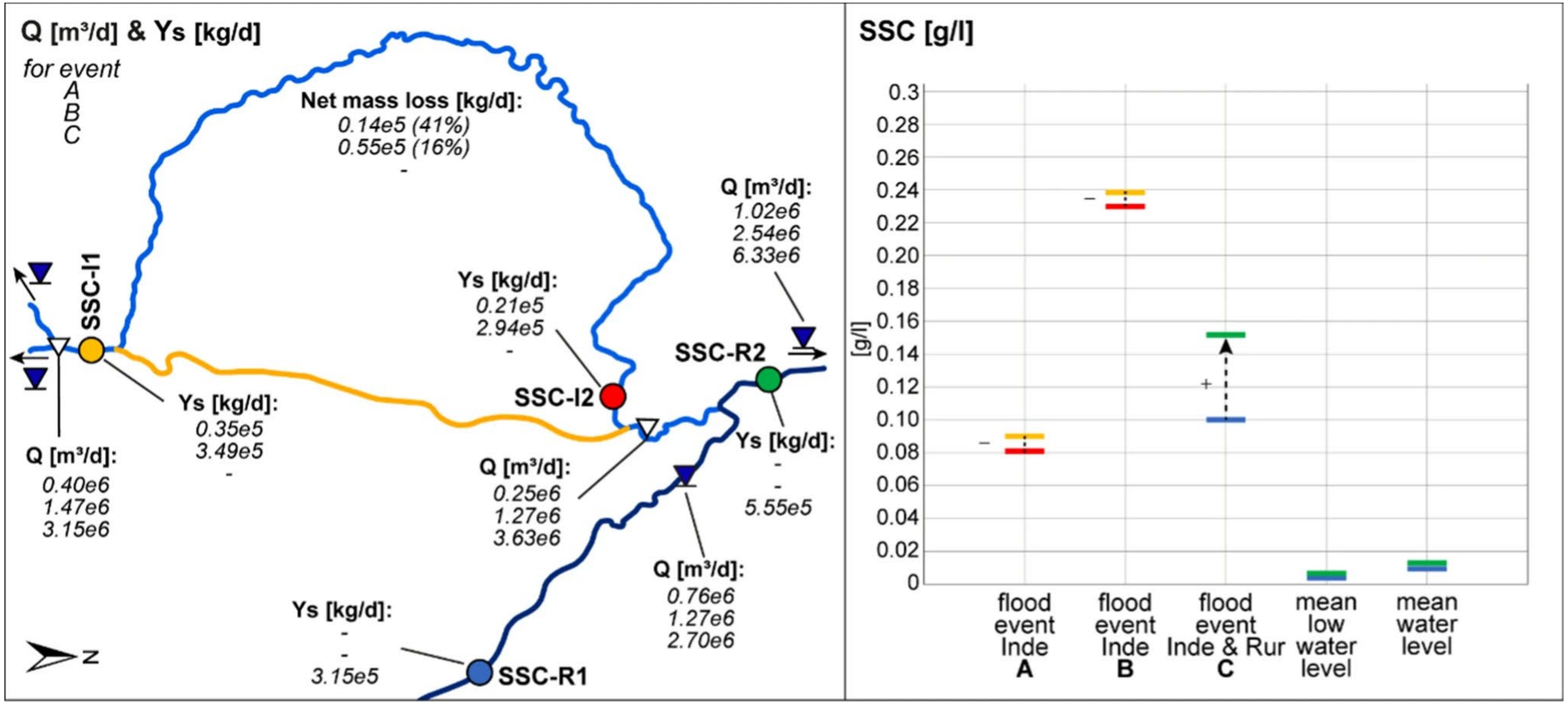
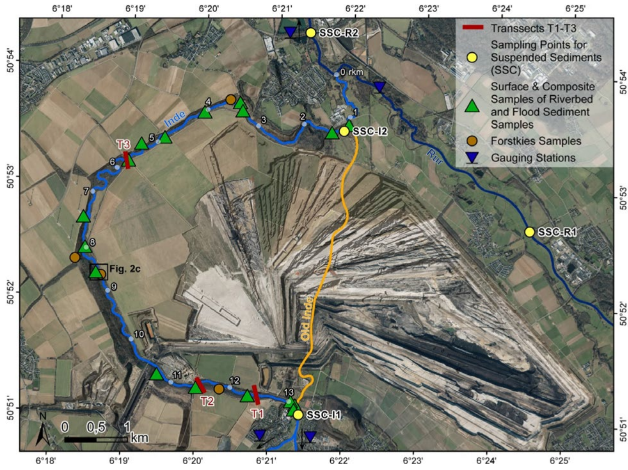
Thank you for your attention!

Open Pit Mine Inden





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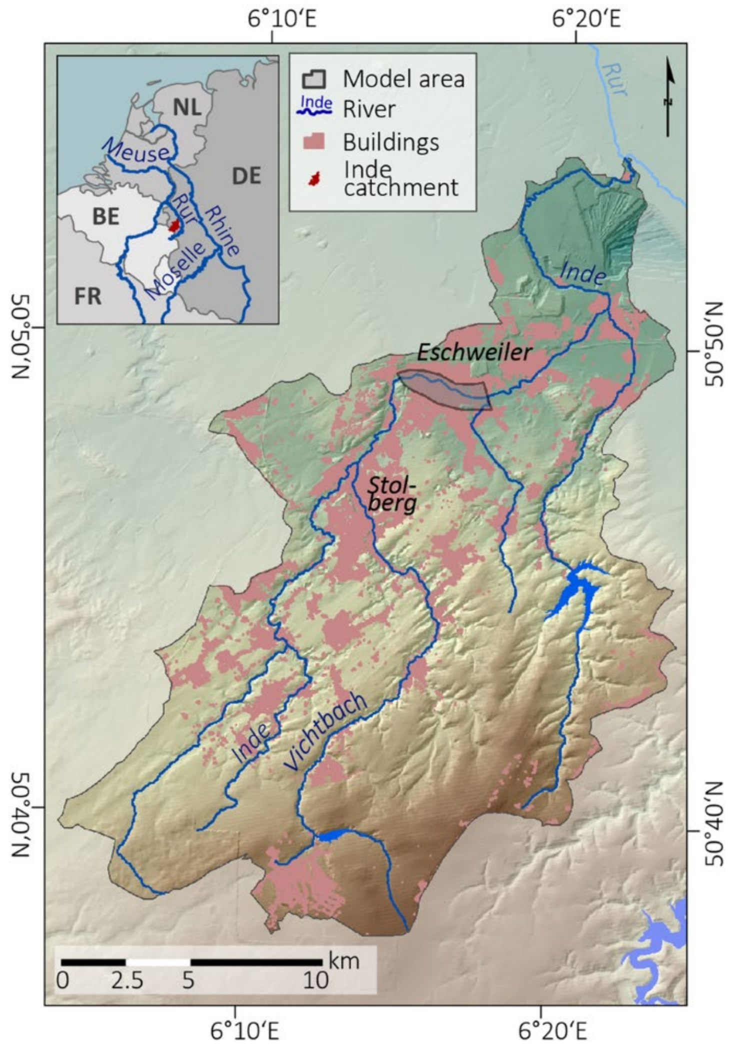
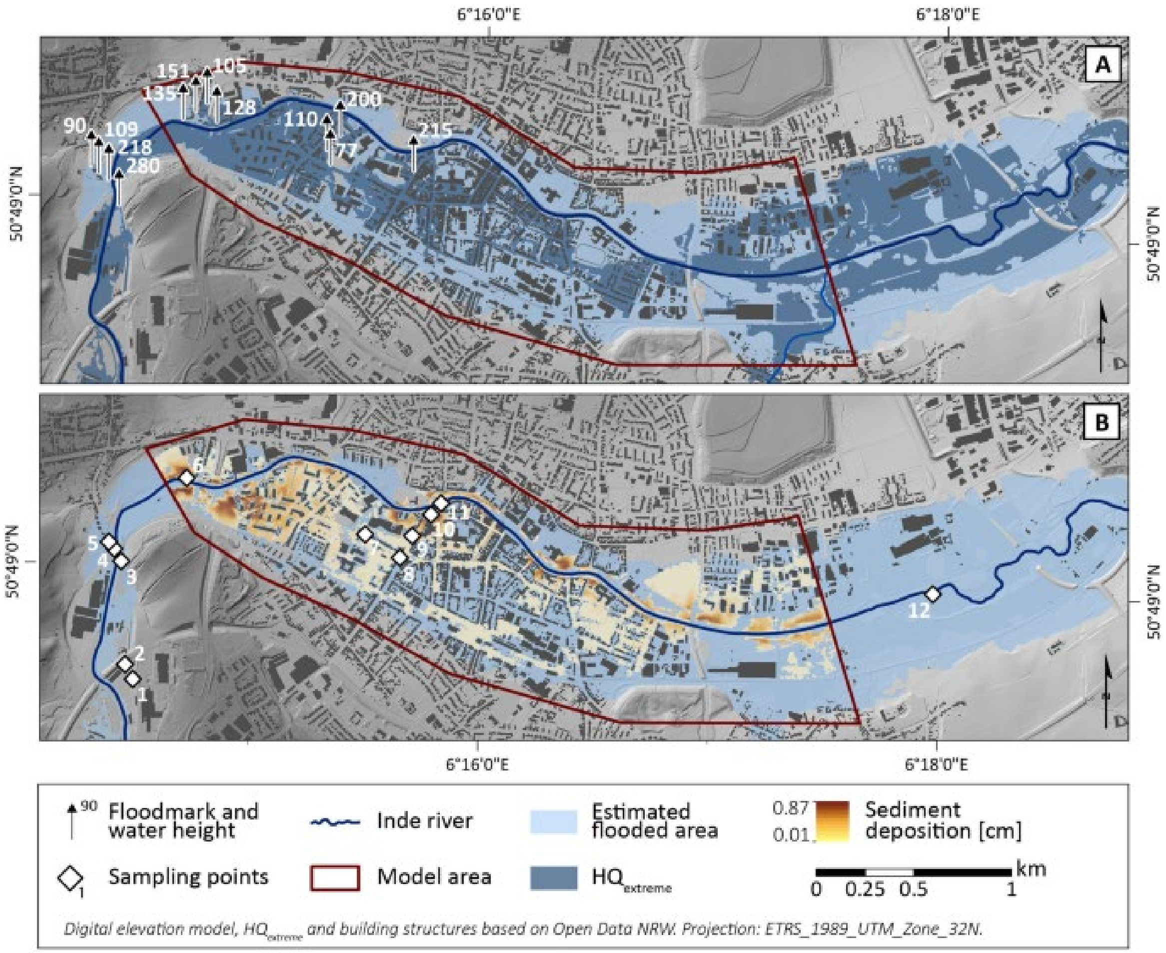
Urban Sediment Deposits





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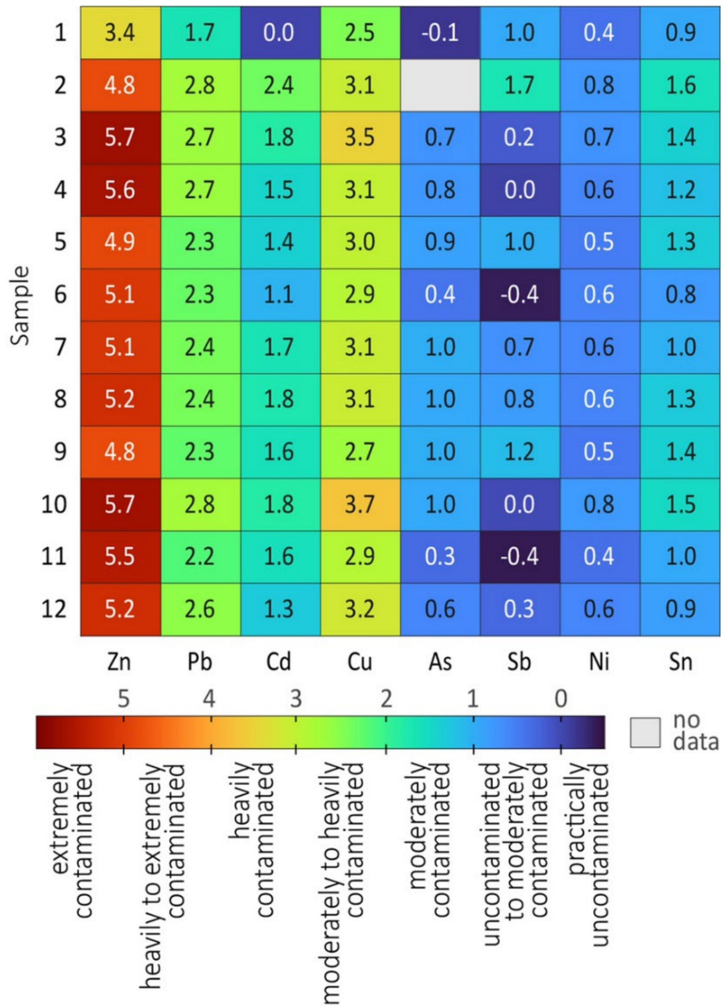


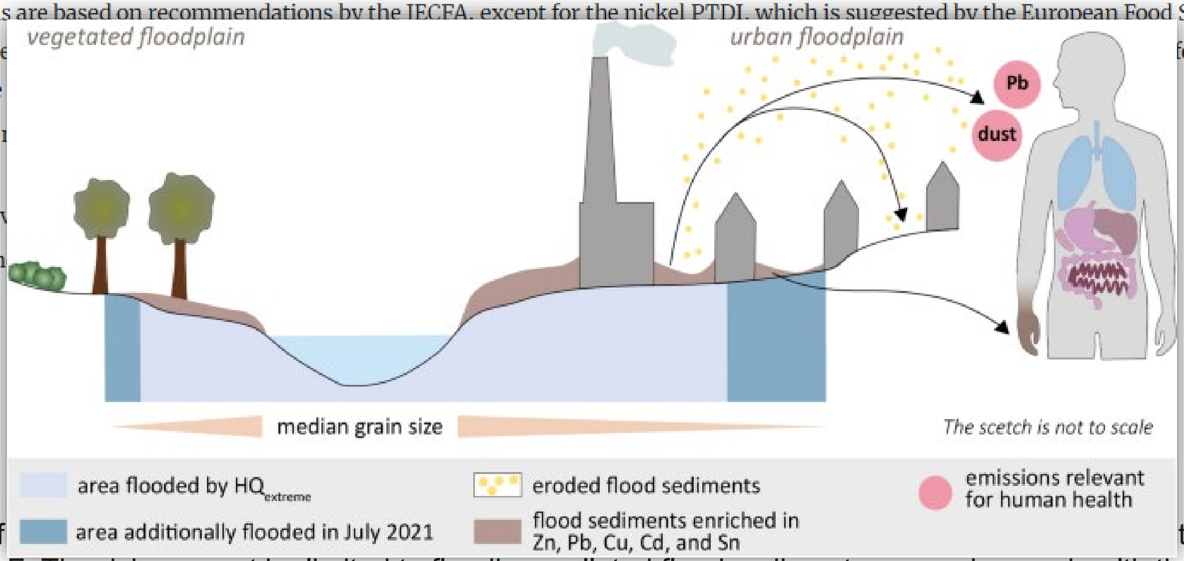
Trace element	Daily dose of ingested trace elements (mg/day)		Probable tolerable daily intake (mg/day)[b]
	Min[a]	Max[a]	
Pb	0.147	0.320	*0.268*[c] [131]
As	0.007	0.016	*0.161*[c] [132]
Cd	0.002	0.008	0.075 [133]
Sb	0.005	0.320	0.450 [134]
Ni	0.010	0.014	0.975 [135]
Zn	0.341	1.664	75 [136]
Cu	0.046	0.108	37.5 [136]
Sn	0.003	0.006	150 [137]

The intake levels are based on recommendations by the JECFA, except for the nickel PTDI, which is suggested by the European Food Safety Authority's Pane … fe level of exposure can be …

[a]Minimum and … respectively

[b]Assuming an av…

[c]Italic writing in…



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