Morphology and eco-morphology in the Meuse River

Hermjan Barneveld
Roy Frings

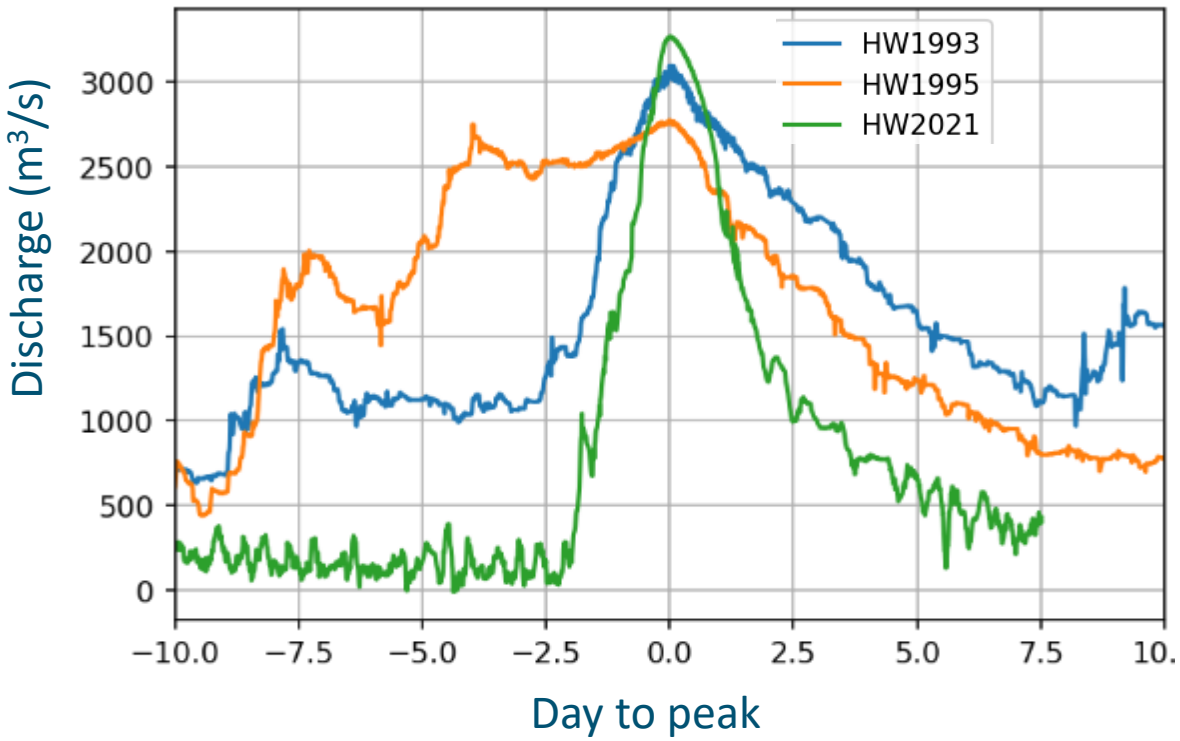
17 October 2022, Liege, 8th International Meuse Symposium

Content

1. Flood event 2021 – Morphological impact
2. Sediment Balance of the Dutch Meuse River
3. International context

Flood July 2021 – Flood Wave

- Peak equal to previous large floods (T≈120 yr)
- Very short duration
- Downstream less extreme in peak discharge and water level (1:15 and less)



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Flood July 2021 – Flood Wave

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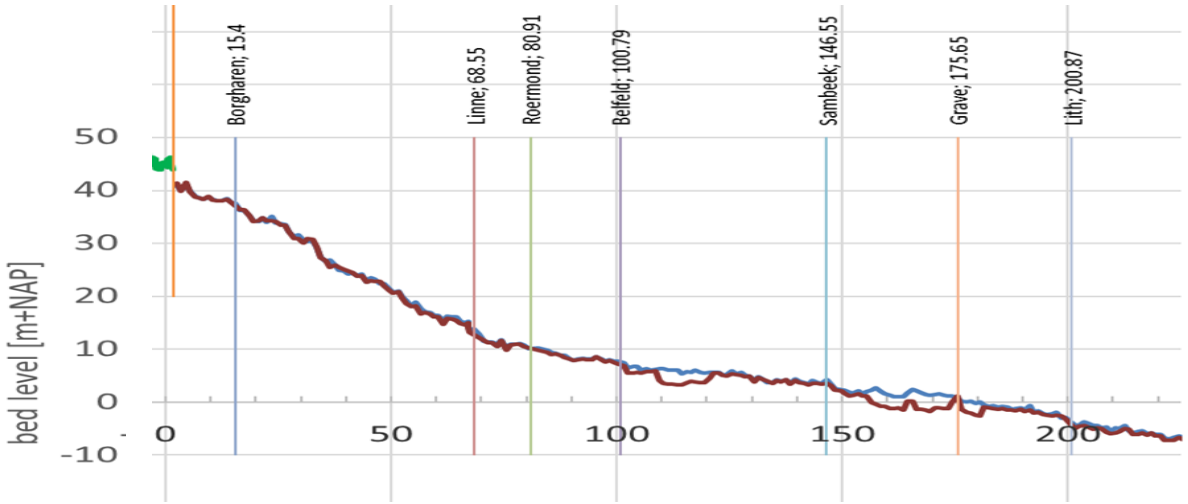
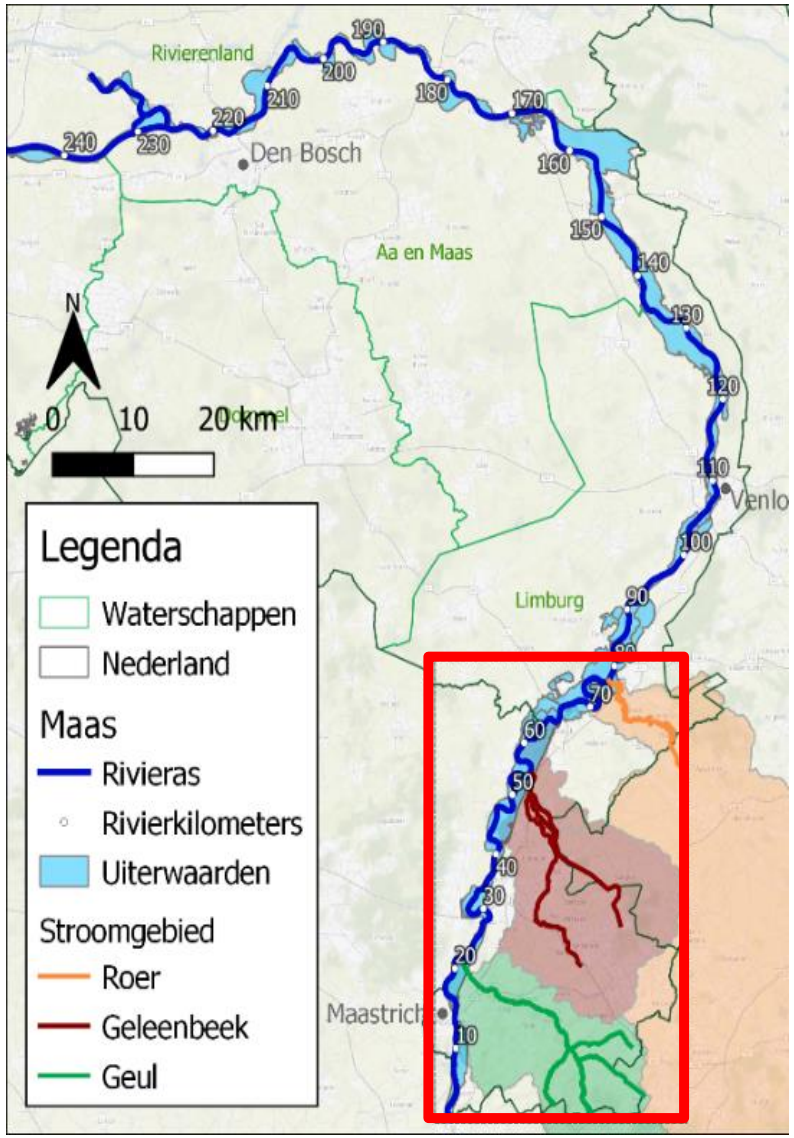
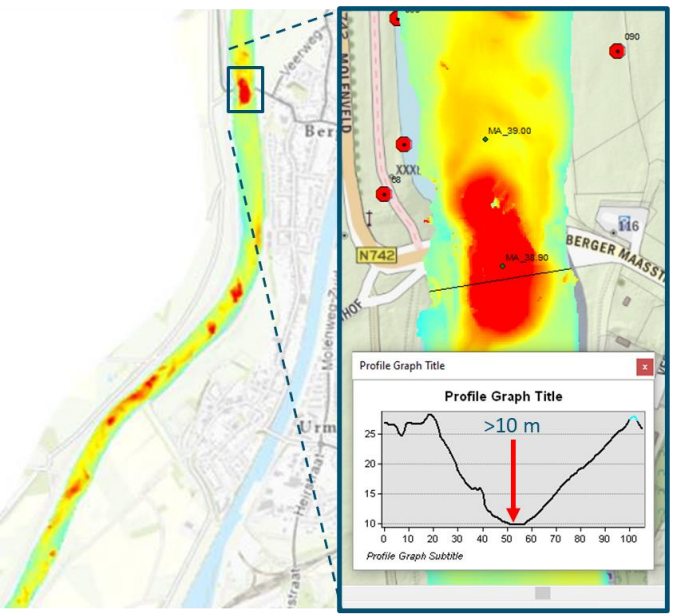


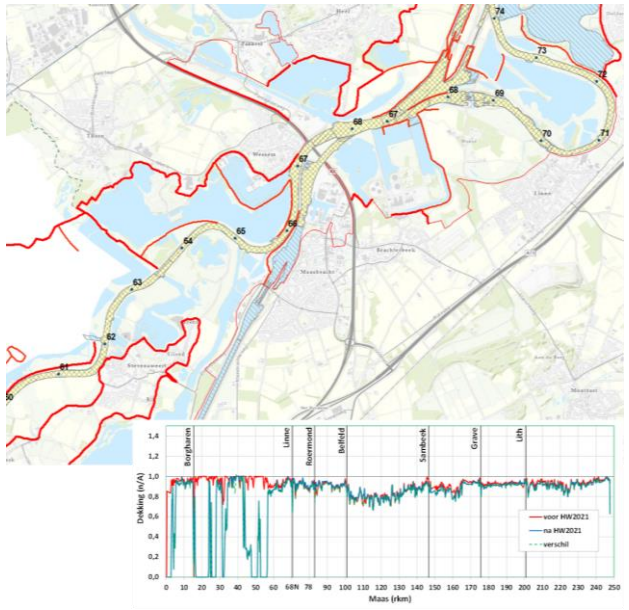


Flood July 2021 – Morphology



Scour holes Common Meuse

Wageningen University & Research (WUR)



General erosion/deposition main riverbed

RiQuest

Bank erosion

HKV

Floodplain deposition

HKV, WUR, VU

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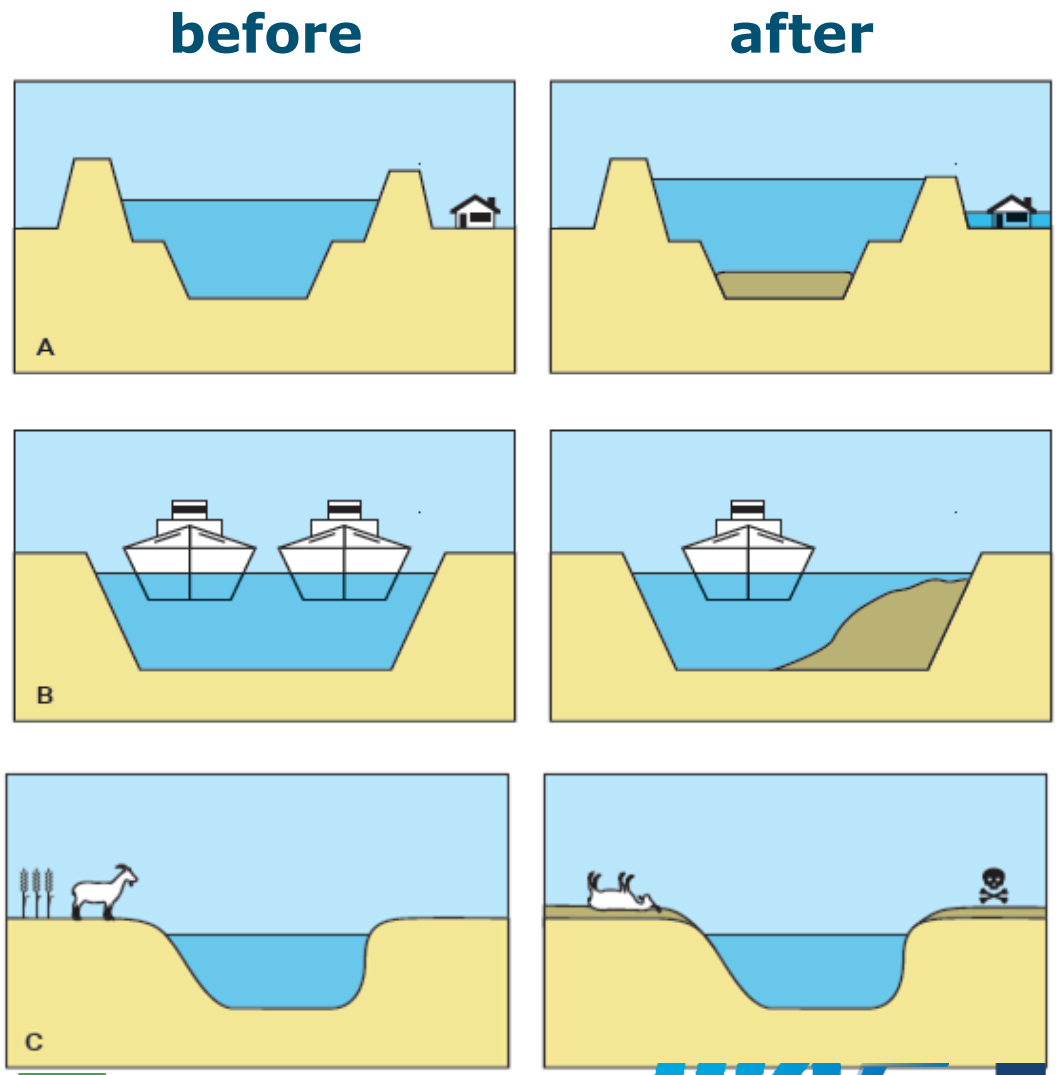
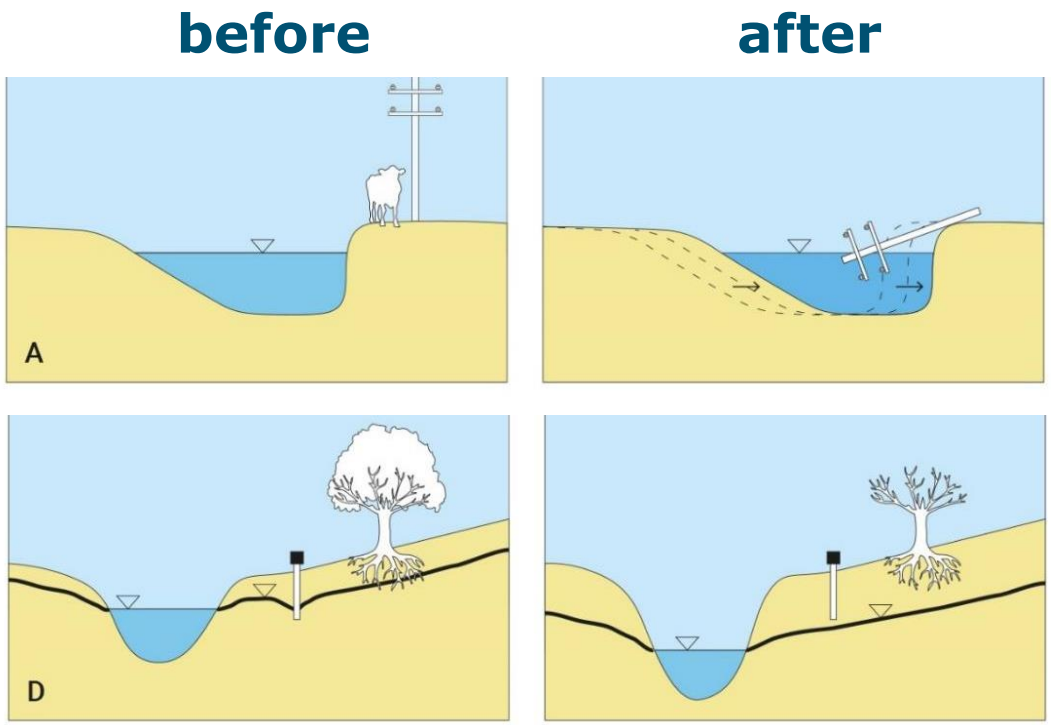
Morphology – why relevant?





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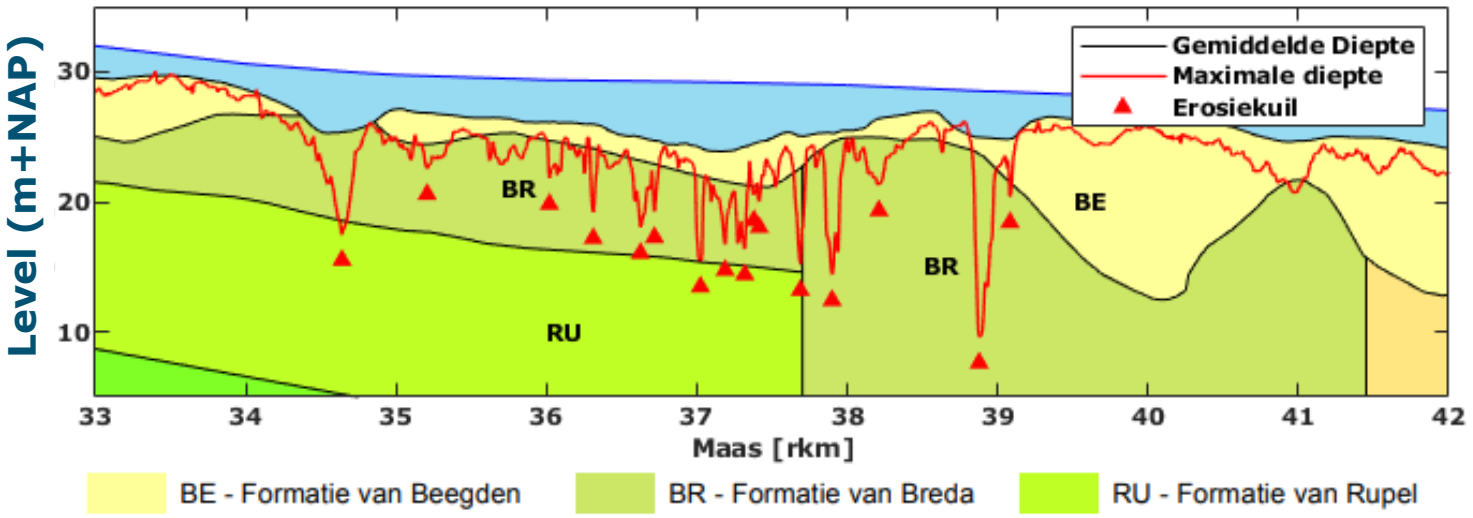
Flood July 2021 – Scour holes Common Meuse



Gravel & coarse sand

Fine sand

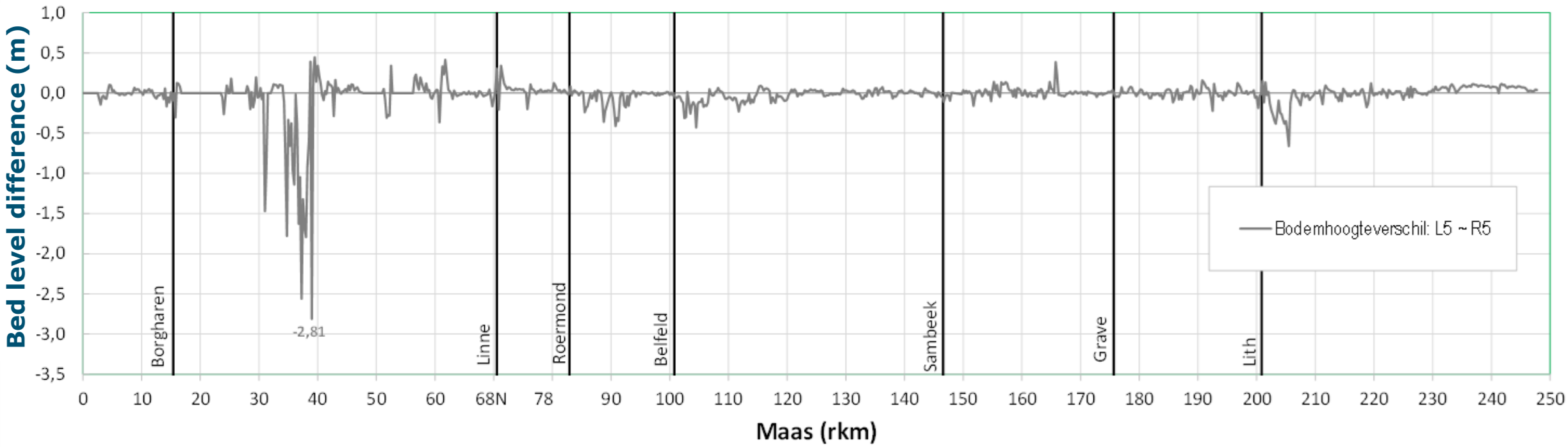
Silty clay

- High and increased flow velocities
- General ongoing bed erosion
- Geology
- Bend flow
- Riverbed dunes

Adjusted to Meijer D.G., J. Lambeek en J.D. van der Werff ten Bosch (2011): Inventarisatie en interpretatie ondergrondgegevens Maas (Inventory and interpretation subsurface data Meuse River).

Thanks to Wageningen University & Research: Joris Beemster, Bart Vermeulen, Ton Hoitink, Ferry van Tilburg

Flood July 2021 – General erosion/deposition main riverbed



Thanks to RiQuest: Douwe Meijer

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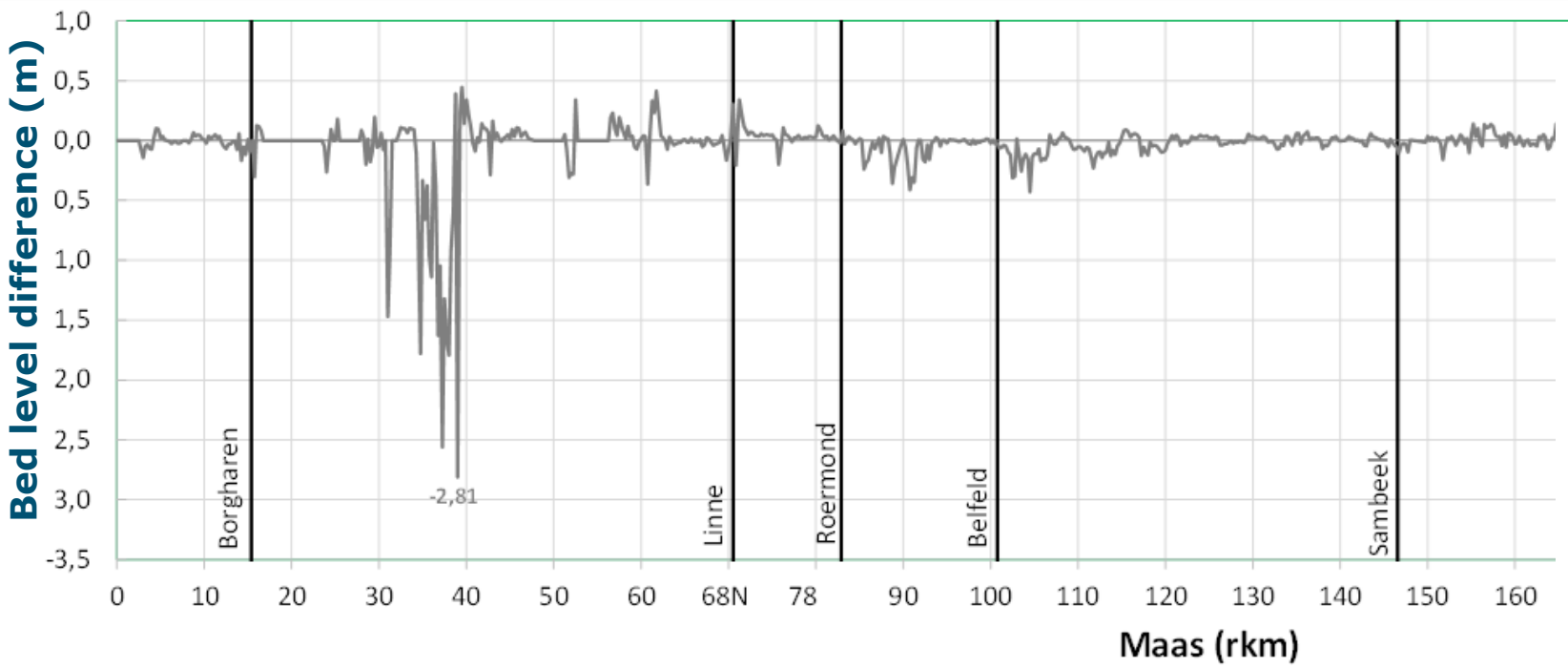
Flood July 2021 – General erosion/deposition main riverbed



- Flood impact often in line with long-term trends
- Erosion in bottlenecks
- Aggradation in widened sections
- 500.000-600.000 m^3 erosion in total Meuse, 80% Common Meuse
- Riverbed not completely covered by multibeam soundings

Thanks to RiQuest: Douwe Meijer

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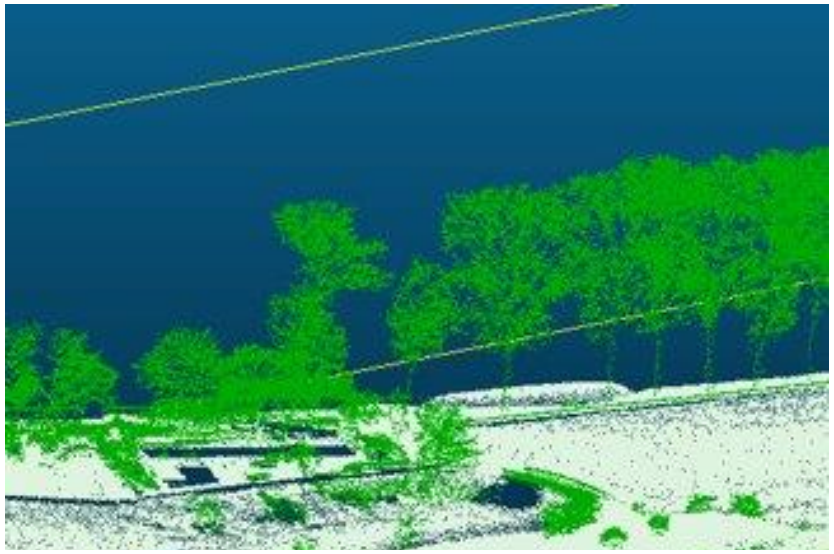
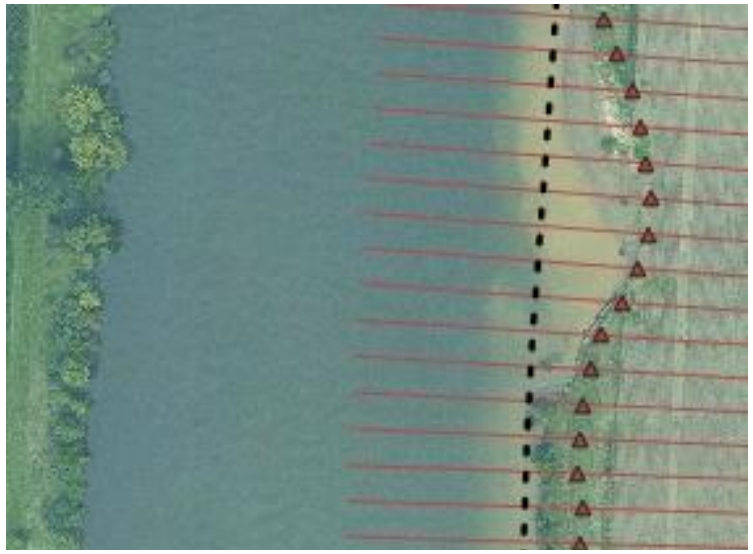
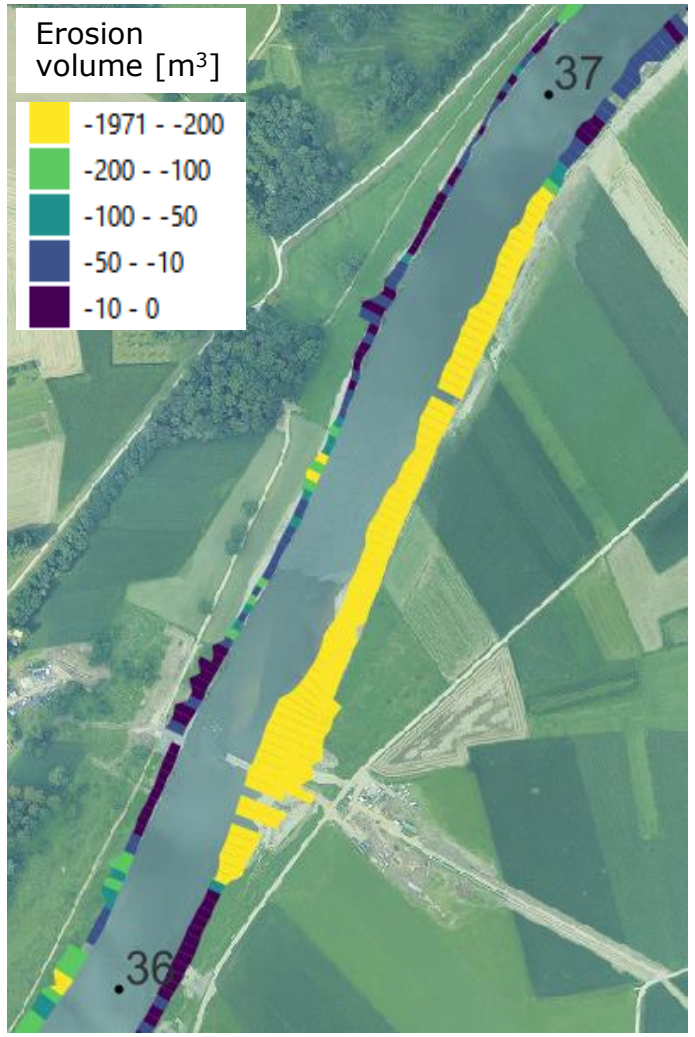
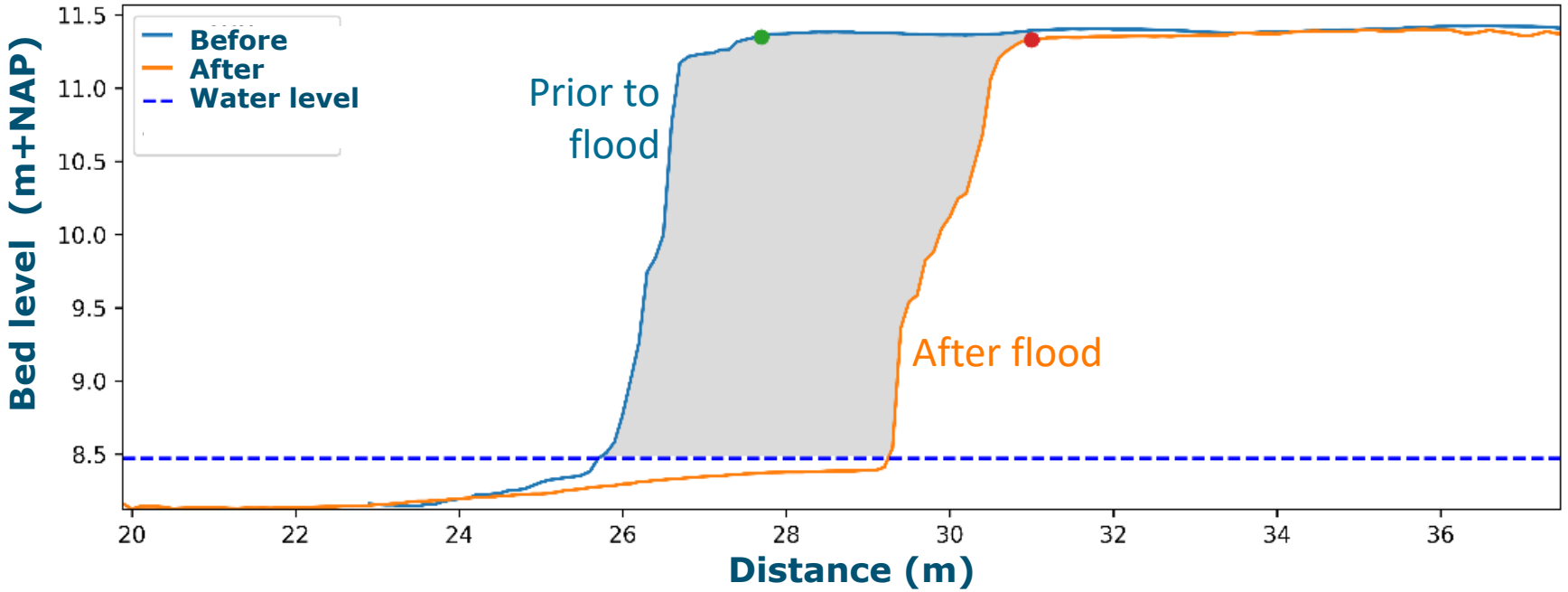
Flood July 2021 – Bank erosion



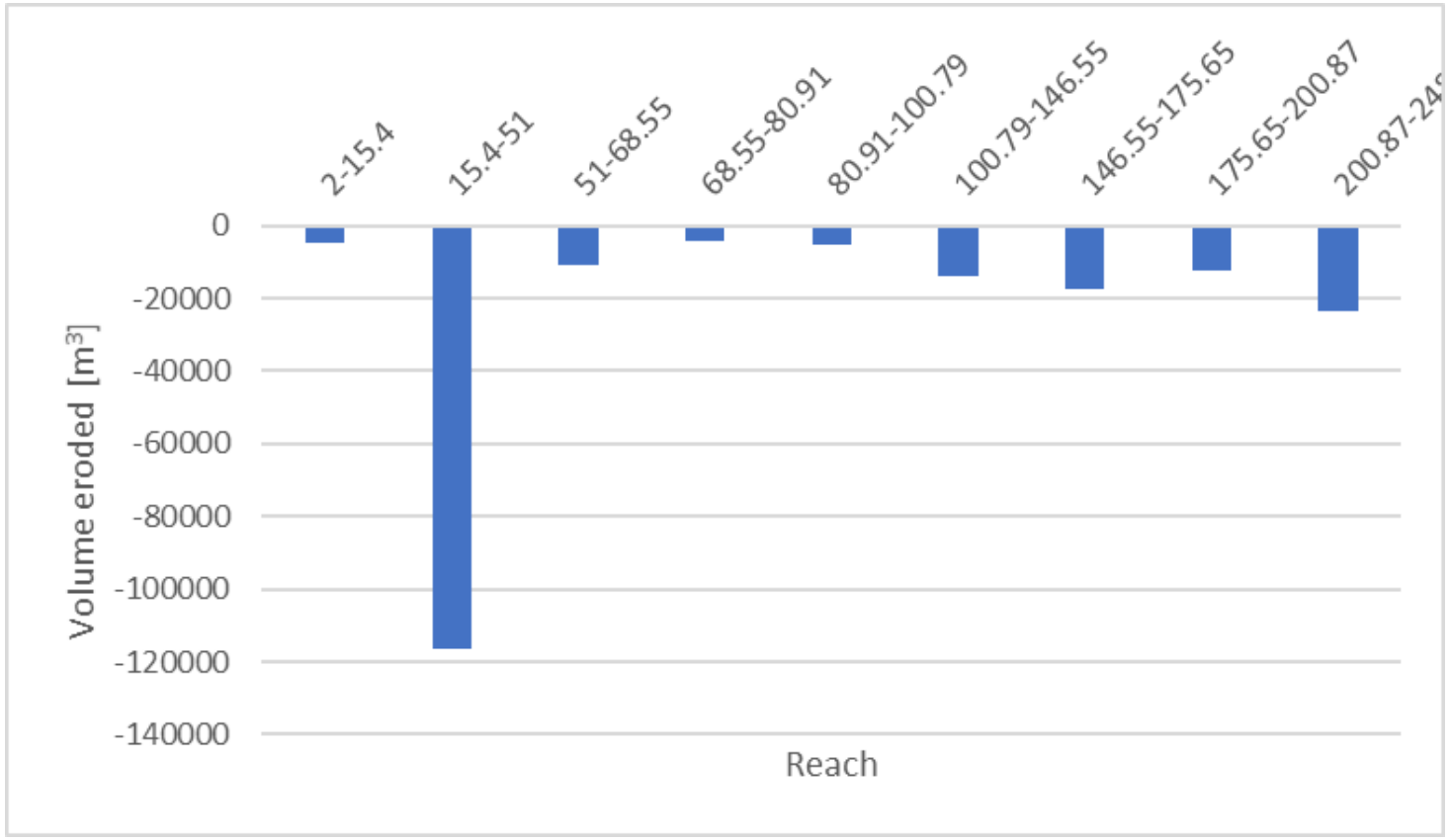


Thanks to HKV: Pepijn van Denderen, Kris van den Berg





Flood July 2021 – Bank erosion



- Impact of
  - Flow velocities
  - Scour holes
  - Bank height
- 208,000 m^3 ± 24%
- Composition unknow: percentage sand/gravel?
- Common Meuse ~60%
- Classification LiDAR (vegetation, bed, water) is challenge

Thanks to HKV: Pepijn van Denderen, Kris van den Berg

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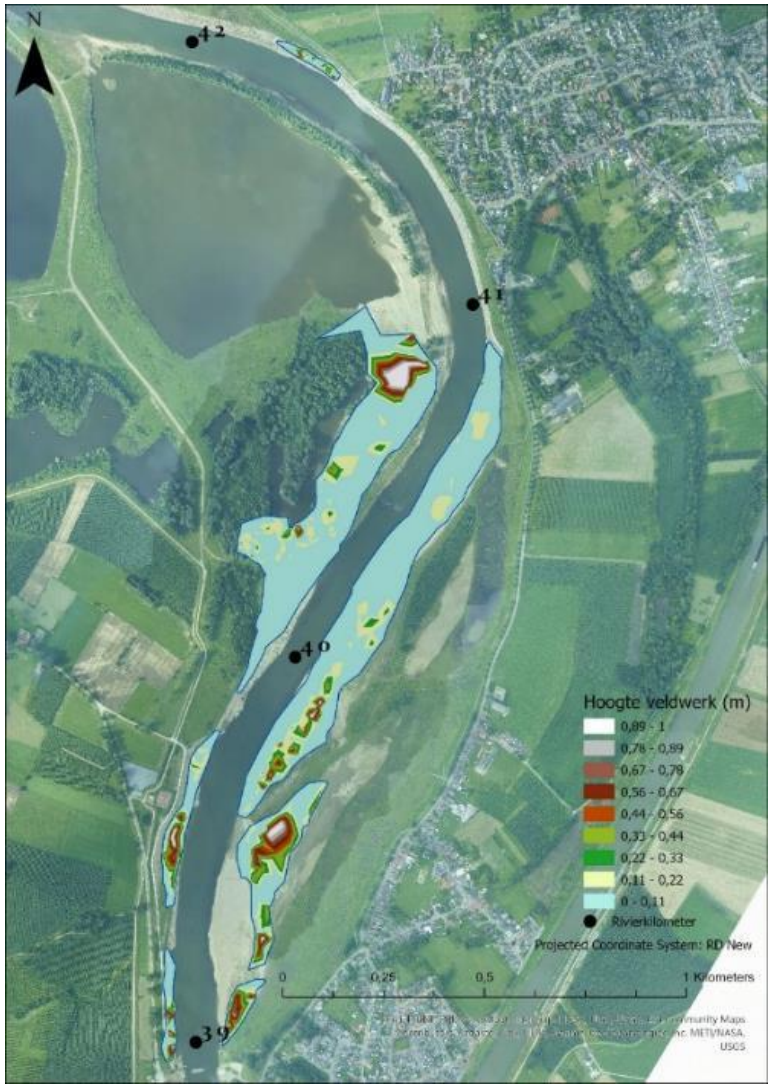
Flood July 2021 – Floodplain deposition

Fieldwork

- 89 floodplains
- 250 km river
- ~3000 thickness measurements sand
- 201 soil samples

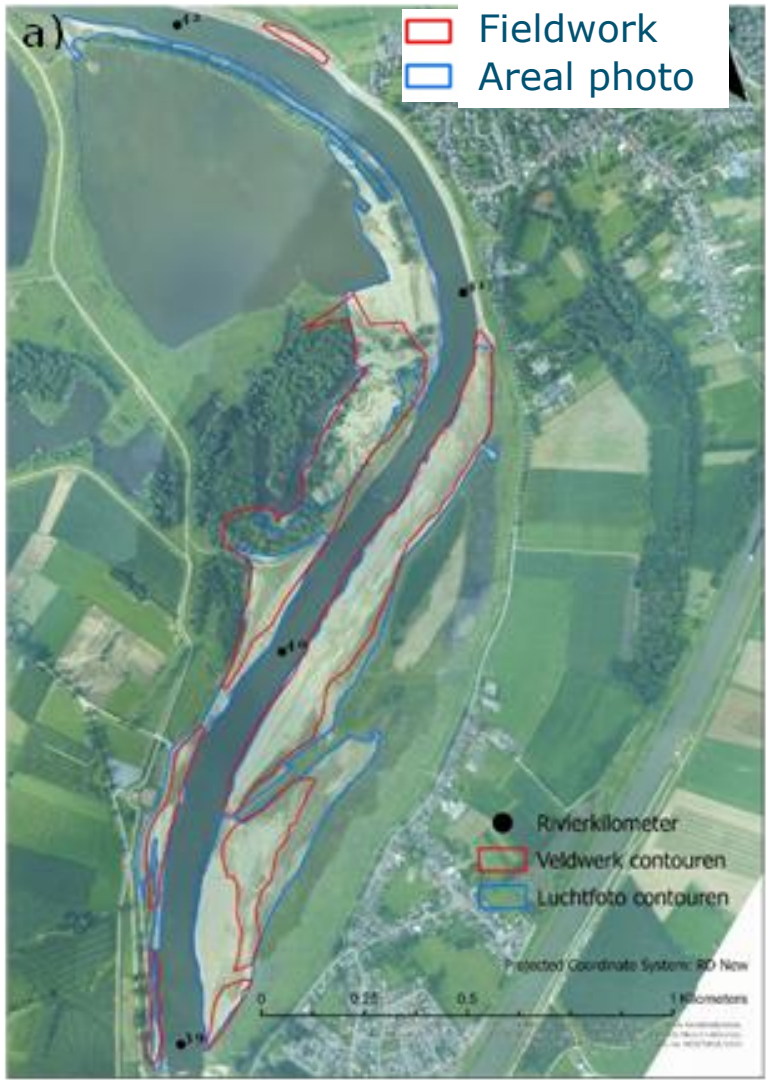


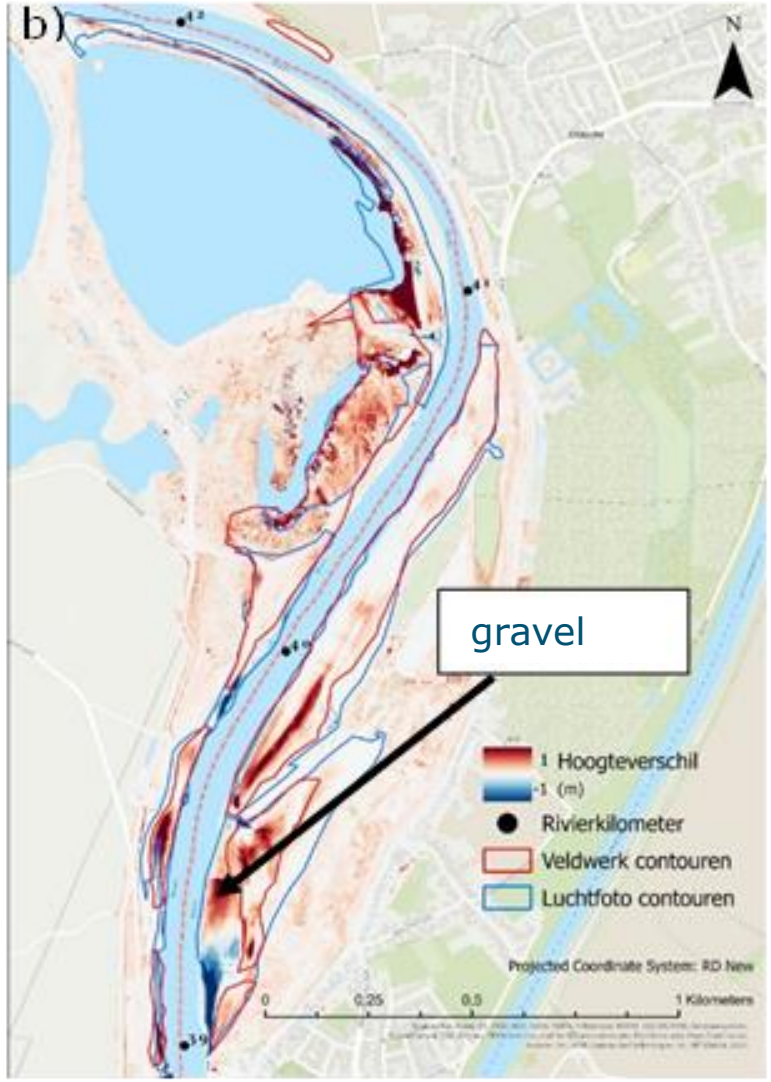
Flood July 2021 – Floodplain deposition

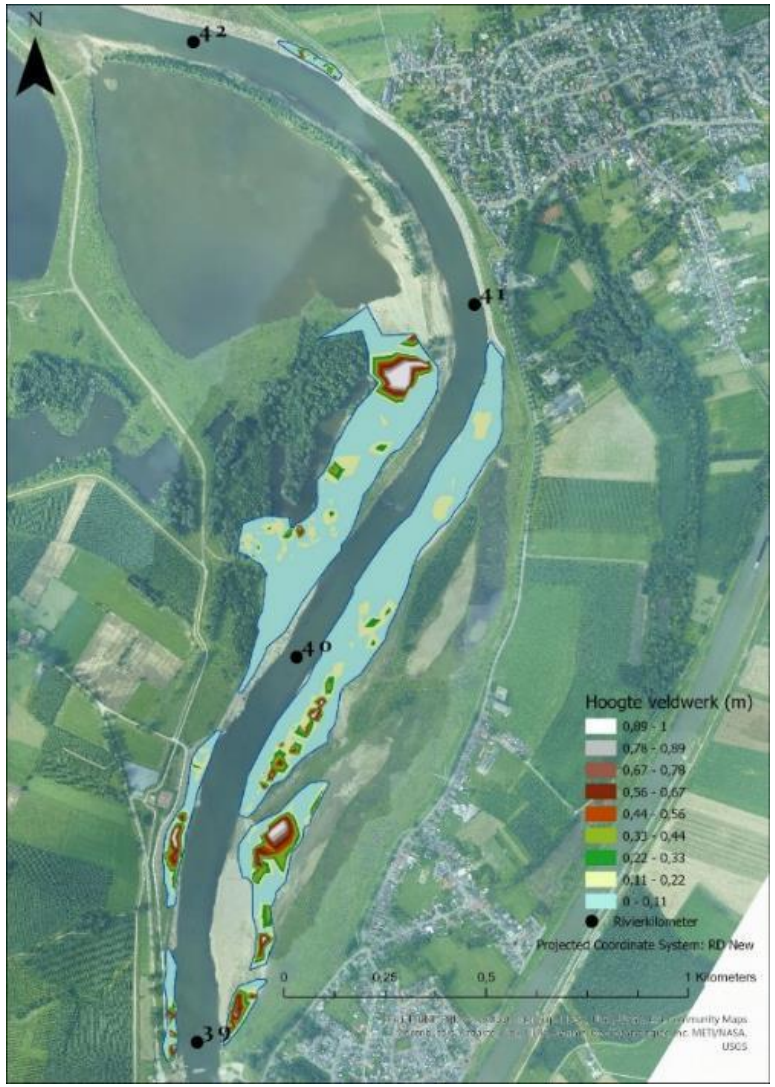
Areal photographs: deposition area from fieldwork (red) and areal photos (blue)

LiDAR

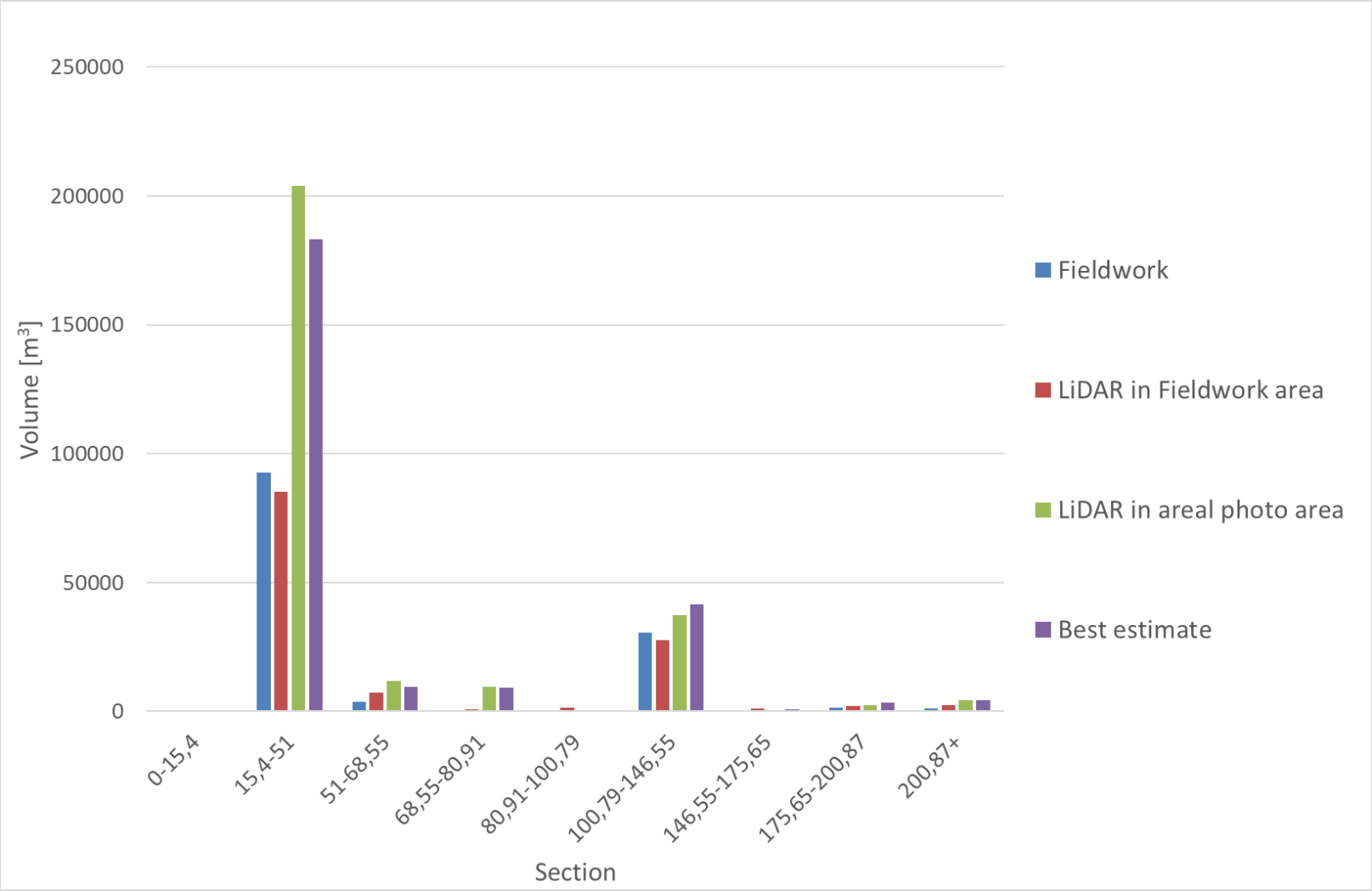
Fieldwork







Flood July 2021 – Floodplain deposition



- Impact of
  - Availability sediment
  - Alignment
    Inner bends: 67&
    Straight: 25%
    Outer bends 8%
- Best estimate 250,000 m^3 ± 15%
- Background deposition ~90,000 m^3 (rough estimate)
- Common Meuse ~75%

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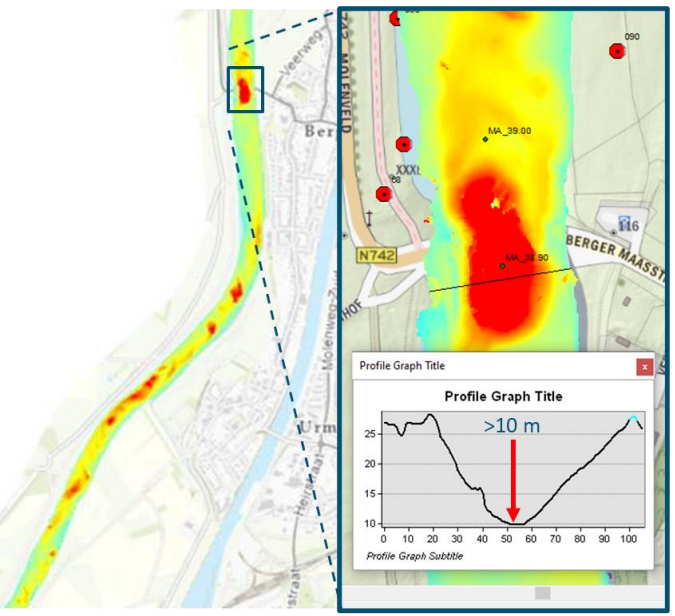
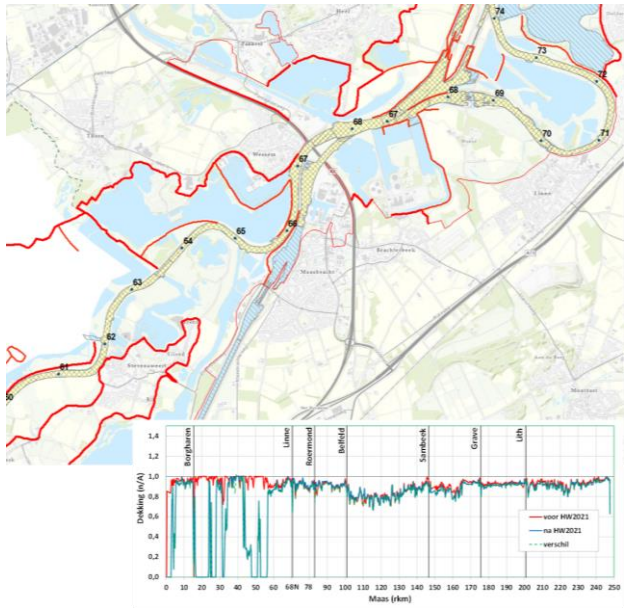
Flood July 2021 – Morphology, balance



400,000-500,000 m³



570.000 m³
unmeasured sections?

210,000 m³
Percentage alluvial?

340,000 m³
Volume gravel? Reliability background deposition?

- In?
  - At border → small?
  - Tributaries → small?
- Out?
  - Dredging: 86.000 m³ Amer
  - Aggradation lakes and harbours → ?

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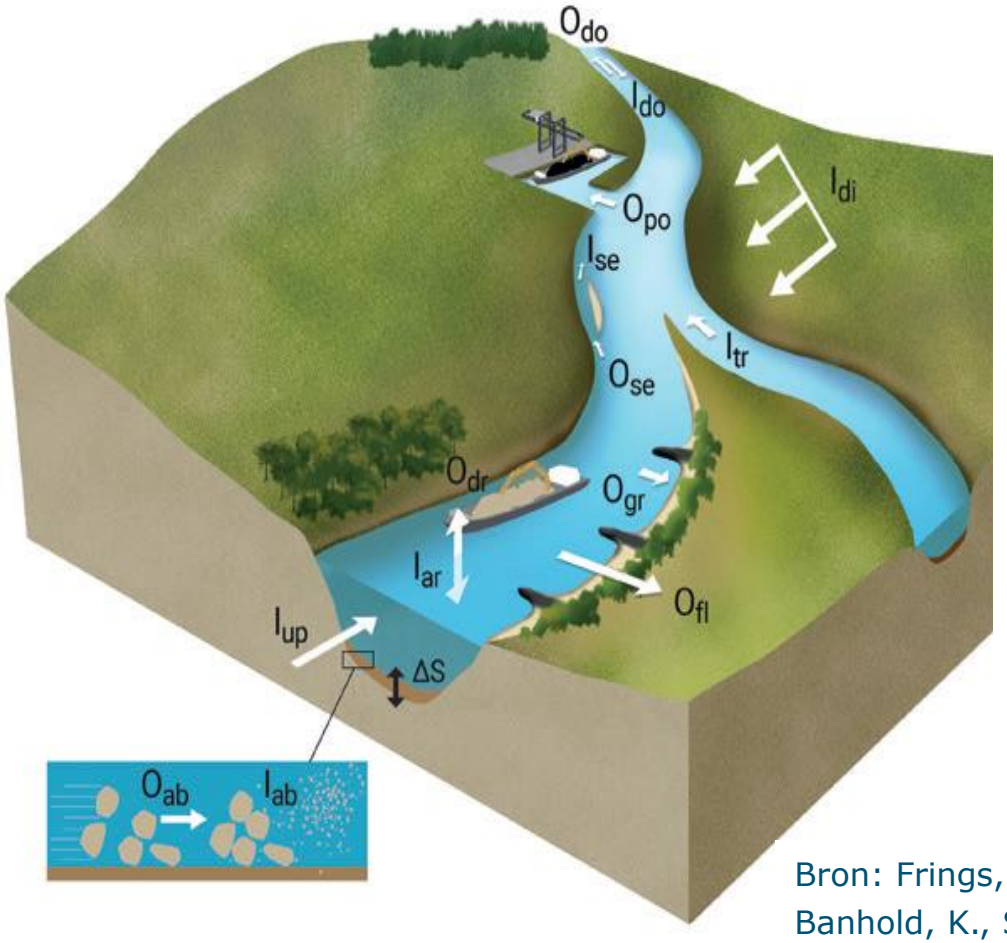
The Sediment Balance of the Dutch Meuse since 1995



I_{up} input from upstream
I_{tr} input from tributaries
I_{se} input from secondary channels
I_{di} input from diffuse sediment sources
I_{ar} artificial sediment input (nourishment)
I_{ab} input through abrasion of coarser grain size fractions
I_{do} input from the downstream area (in estuarine environments)
O_{do} output to the downstream area
O_{se} output towards secondary channels
O_{dr} output due to dredging
O_{gr} net output to groyne fields
O_{fl} output due to floodplain sedimentation
O_{po} net deposition in ports
O_{ab} output to finer sediment fractions through abrasion
ΔS change in sediment storage (~bed level change).

$\Sigma I_i - \Sigma O_i = \Delta S$

Bron: Frings, R.M., Hillebrand, G., Gehres, N., Banhold, K., Schriever, S., & Hoffmann, T. (2019). From source to mouth: Basin-scale morphodynamics of the Rhine River. Earth-science reviews, 196, 102830.

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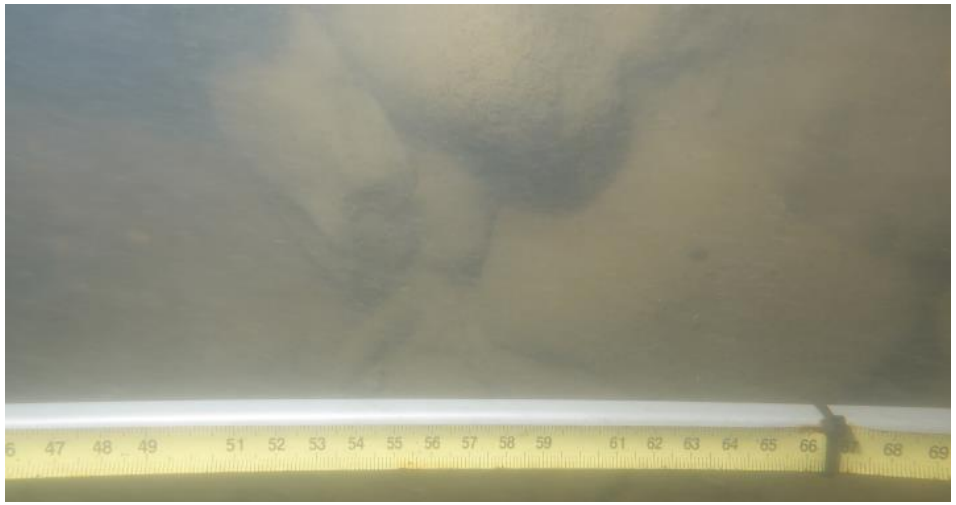
Sediment balance components so far

Input

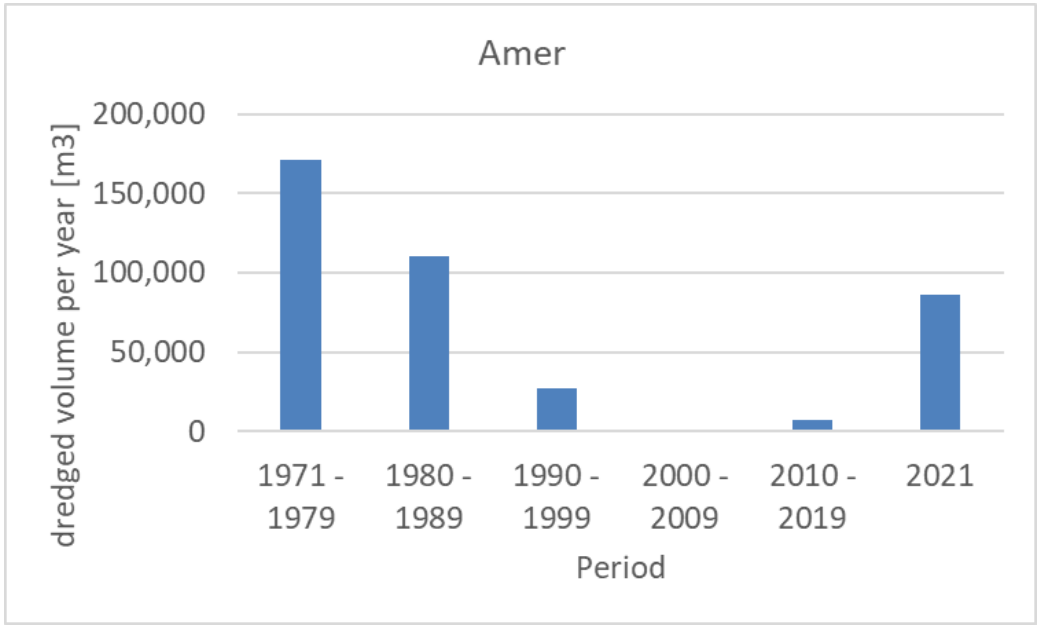
1. Nil from upstream?
    - Seldom opened
    - Low shear stresses
    - Coarse bed?
2. Tributaries: no data on sand/gravel (yet)
3. Natural banks (analysis on LiDAR)



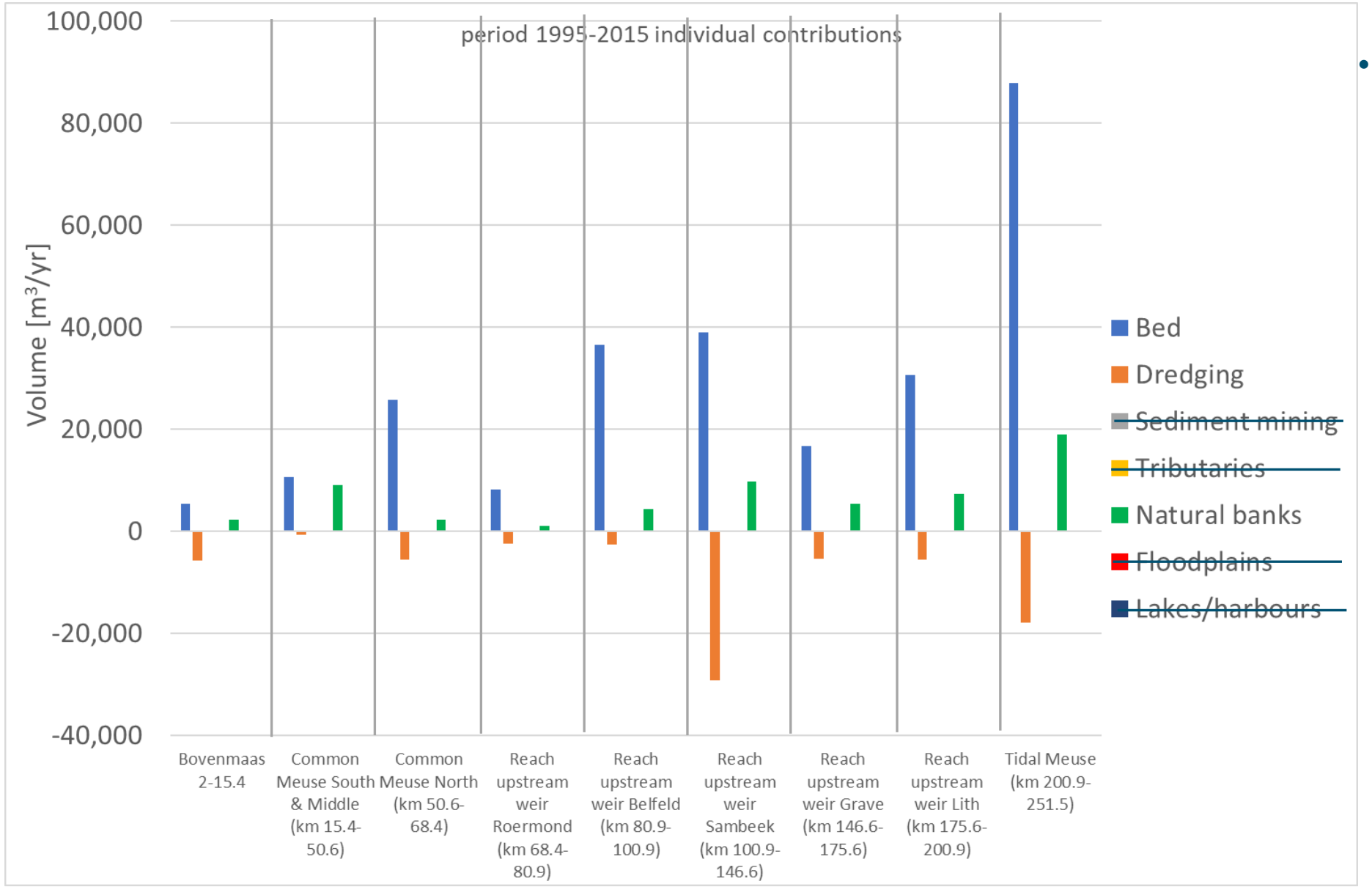
Sediment balance components so far

Output

1. Dredged volumes Meuse for maintenace and project implementation
2. Dredged material in downstream reaches

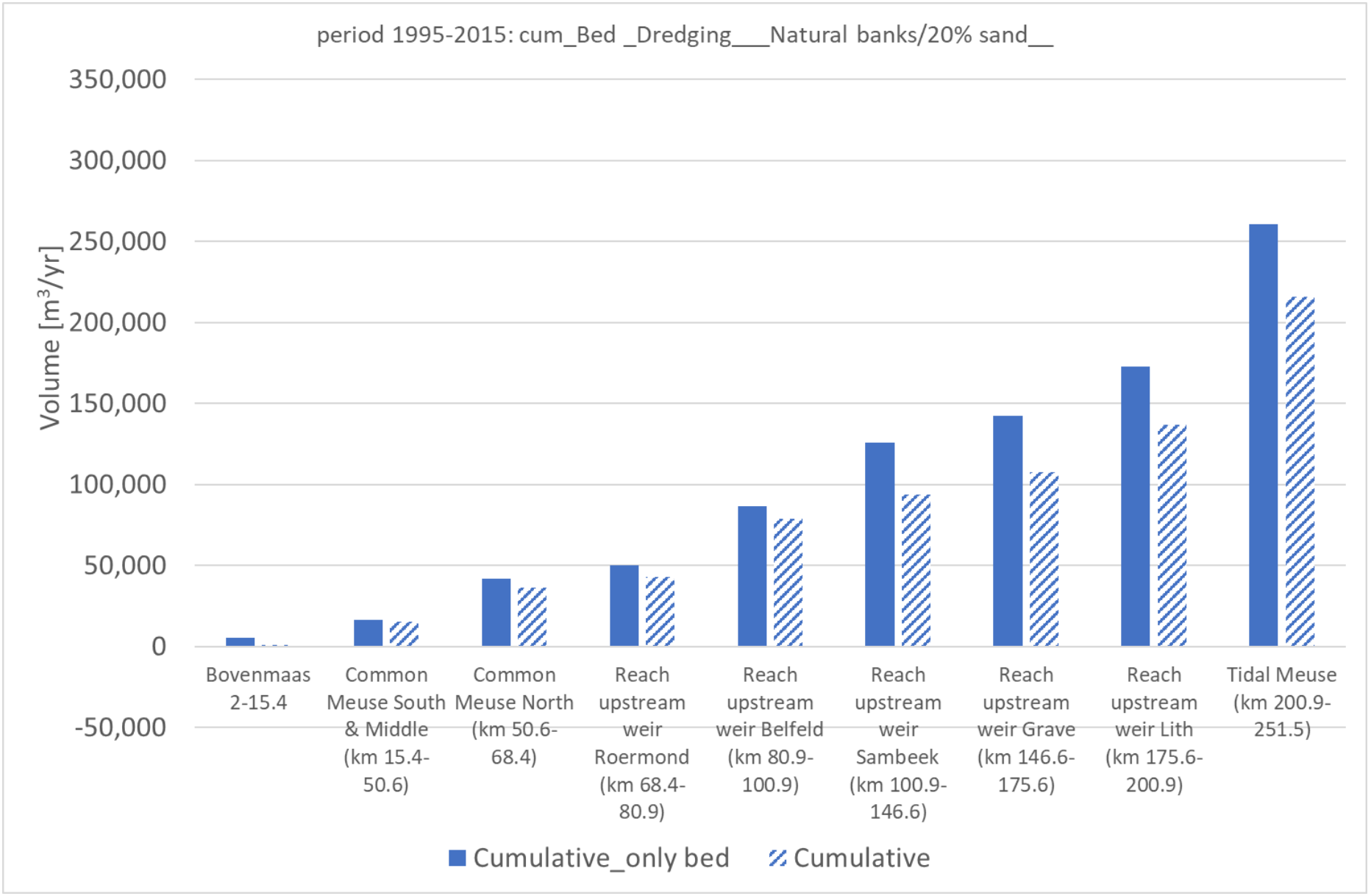


Components in volumes



- 1995-2015

Conversion to loads (1995-2015)

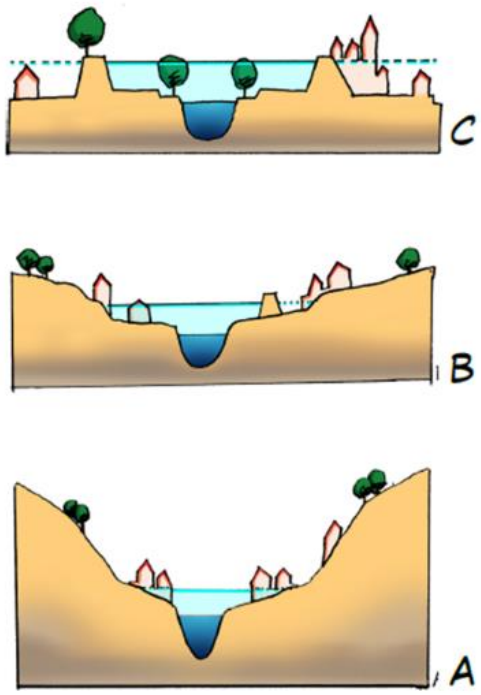


- 20% natural banks sand

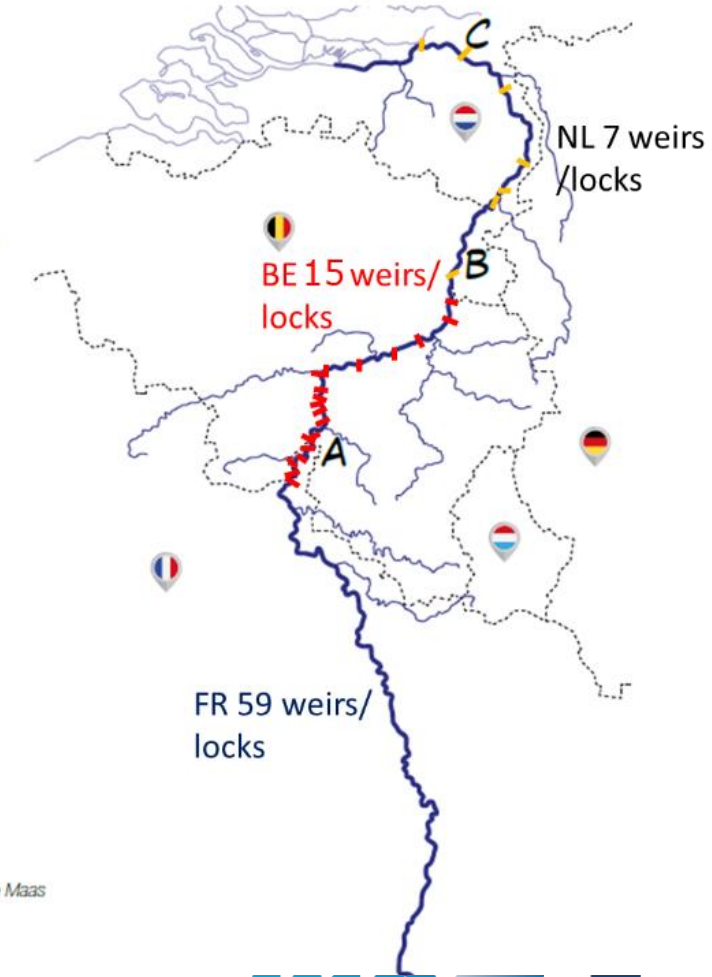
Open questions

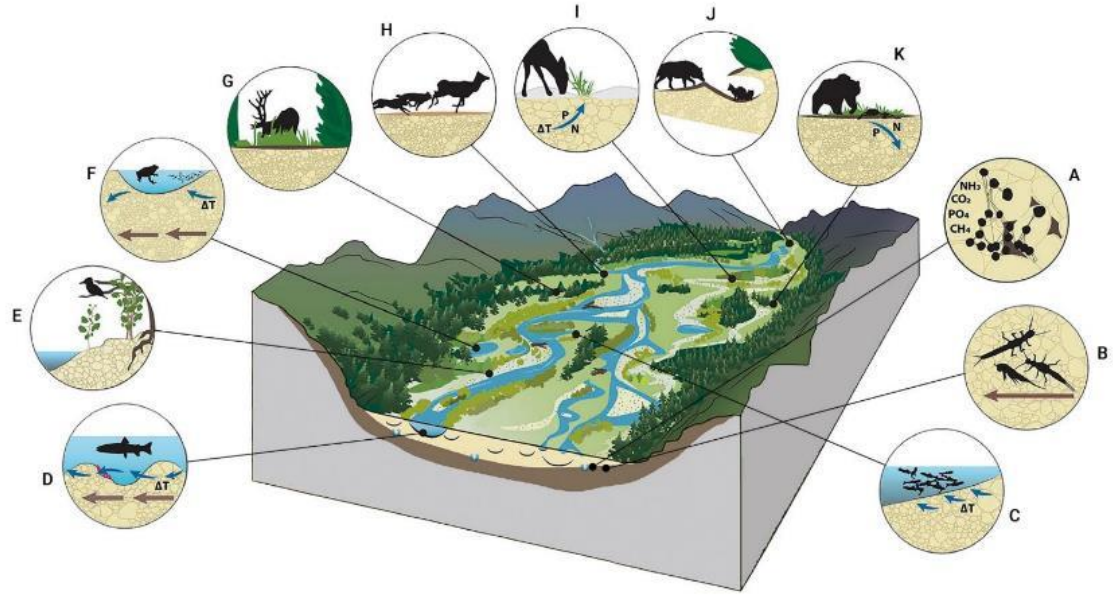
1. Load from tributaries
2. Deposition in lakes and harbours
3. Sediment transport from upstream → validation needed
4. Sediment composition upstream Lixhe

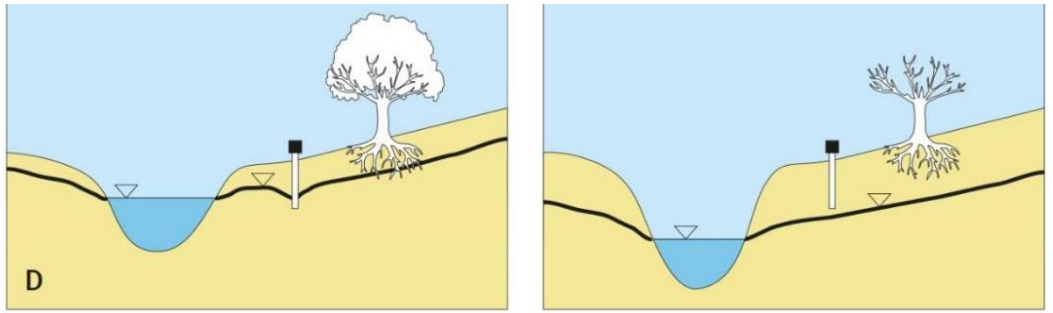
International context



Karakteristieken van hoogwater in de verschillende delen van de Maas







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International perspective

If we wish to continue utilising the riches offered by the river, to fight the threats of the river effectively and to halt the regression in biodiversity:

We must cooperate… and

River management must be (1) integrated, (2) sustainable and (3) river basin-wide

Thoughts by:

Grégory Stephan (EPAMA, FR)
Benjamin Dewals (Univ. de Liege, BE)
Roy Frings (Rijkswaterstaat, NL)
Hermjan Barneveld (Wageningen University & Research, NL)

→ **For water *and* sediment**

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International perspective - objective

To get insight in the sediment dynamics of the Meuse on the basin scale

and to understand the influence of humans and climate thereon

→ by bringing together existing knowledge, extend it in a homogenous way and develop an integrated vision

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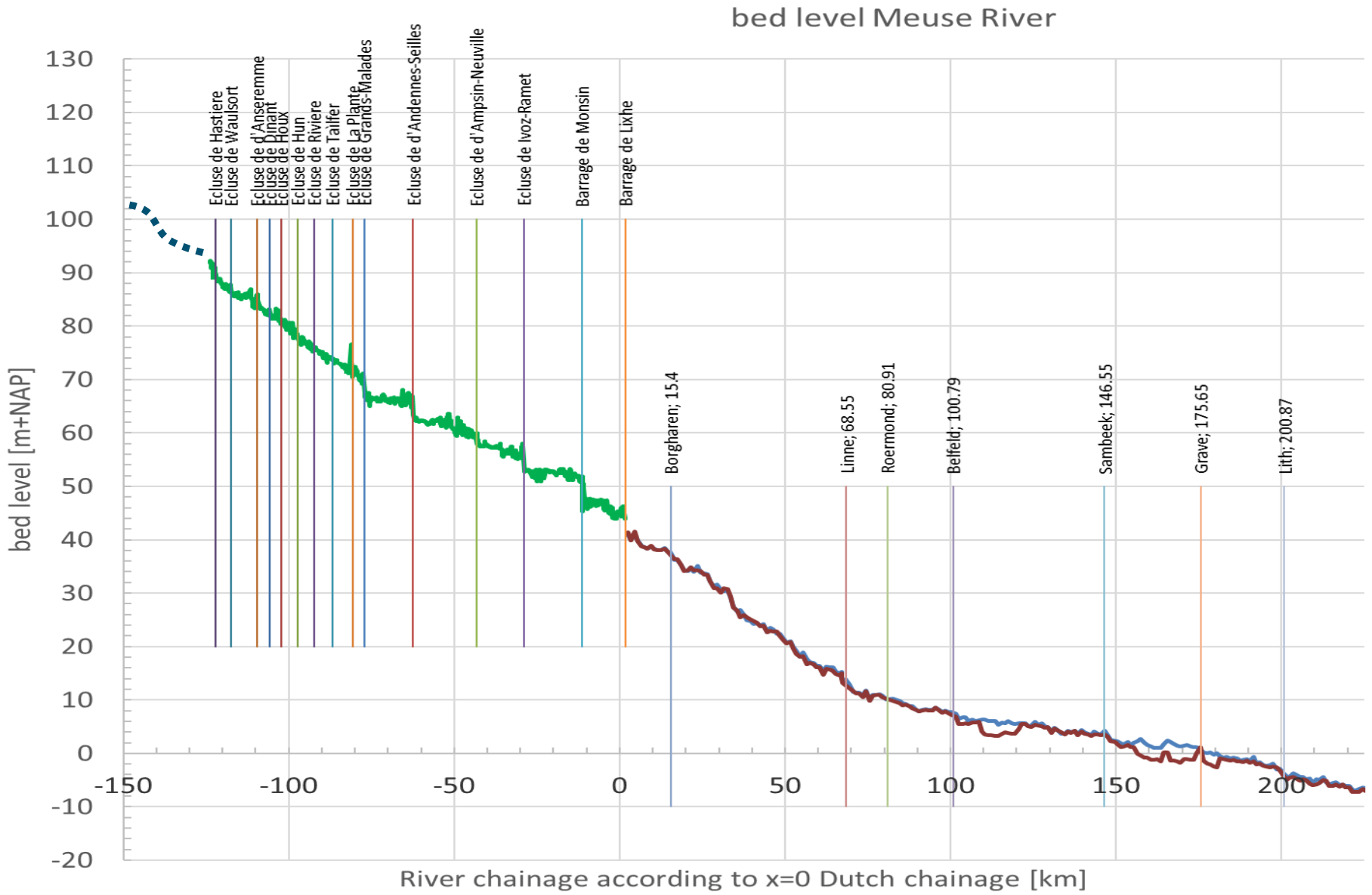
International perspective – a start



1. Average bed level
2. Different years
3. Location of dams/weirs/ structures
4. Location tributaries

International perspective - continued

Feel free to join us and think with us on:

1. Content / work packages
2. Partners
3. Programmes
4. Financing
5. ……

Thanks and Questions?

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