ETH zürich

Suspended load modelling in revitalization projects

Case study on the Alpine Rhine River

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VAW
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie

Project team

- Work:

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- Lead:

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- Advisors:

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- Project commissioned by:

  IRR – International company for the regulation of the Alpine Rhine

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Mittelgerinnewuhr 80.2 – 82.4 L, 24.06.2016

Foto Nr.: 5574

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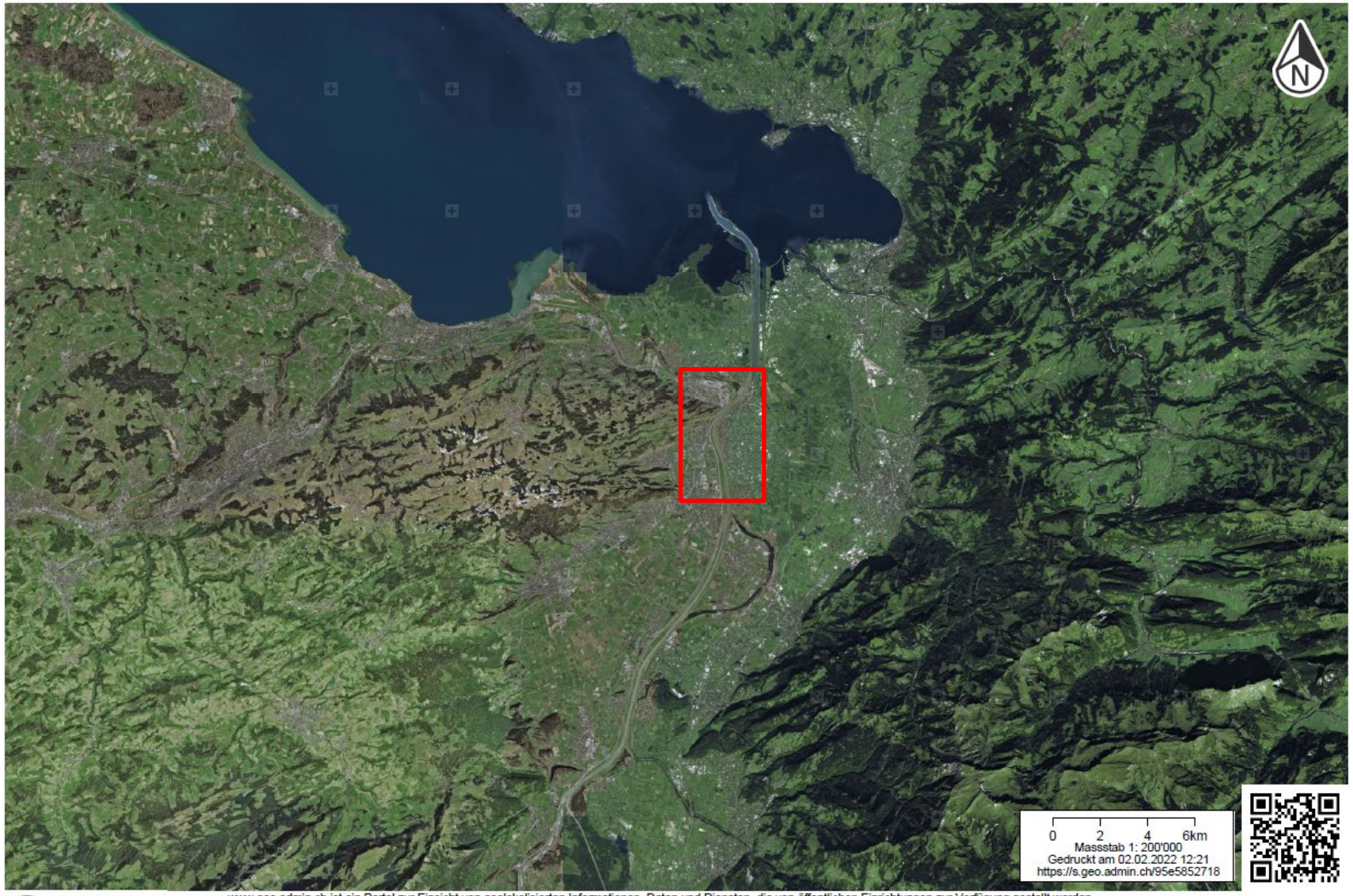
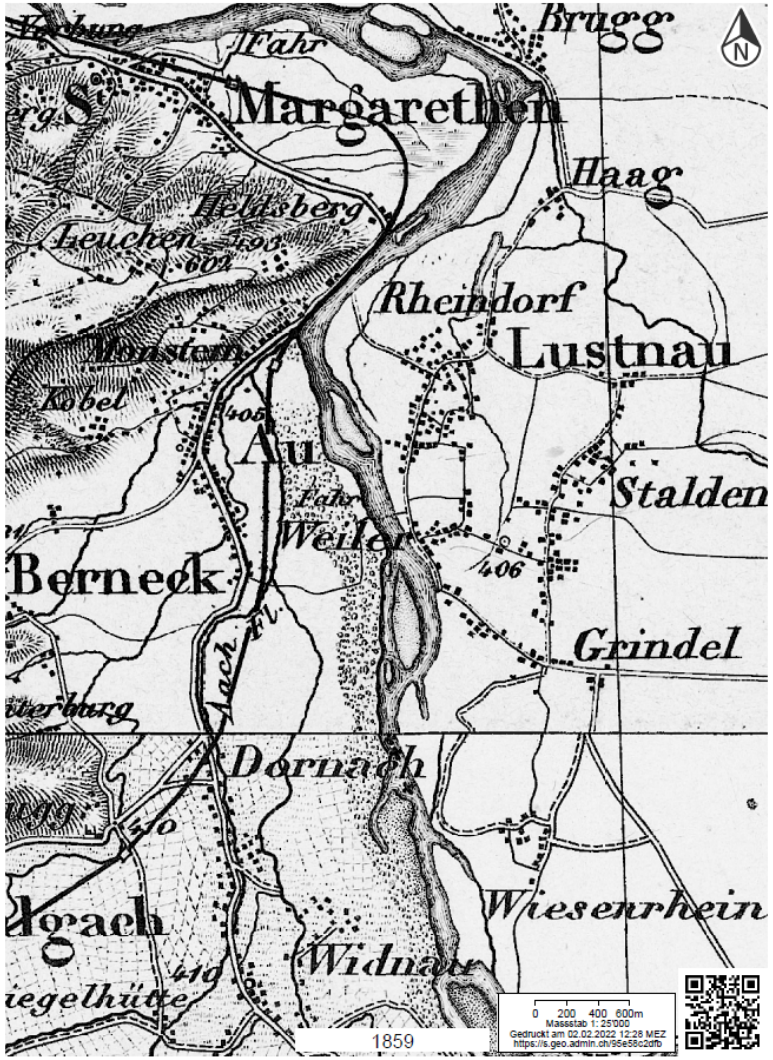
Overview

- Alpine Rhine
- HQ100
  2’600 m^3/s
- Total annual sediment load
  ca. $2.5x10^6$ m^3/a



Overview

around 1860

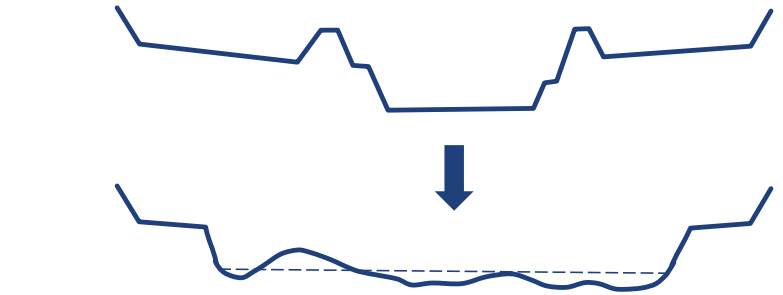


today

Objectives

Planned restoration measures

- Widening of regulated channel
- Lowering of flood plain
- -> less flood plain area, more frequent flooding

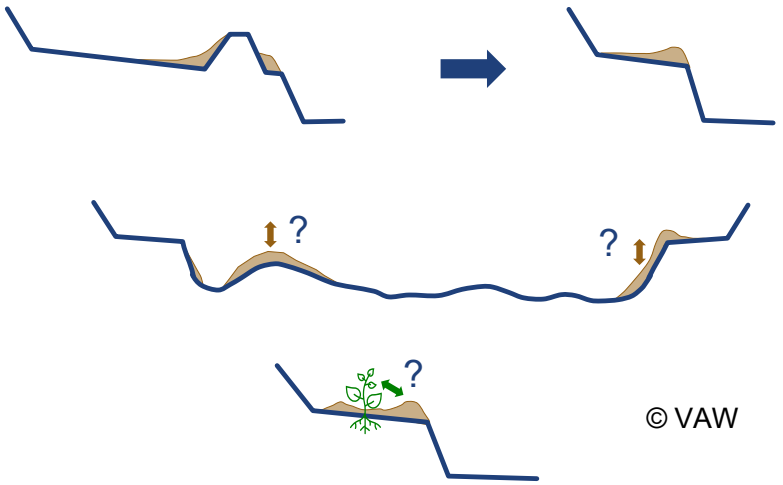


Main questions

? Deposition of fine sediments on flood plains

? Impact on channel conveyance

? Effect of vegetation



Software & Models

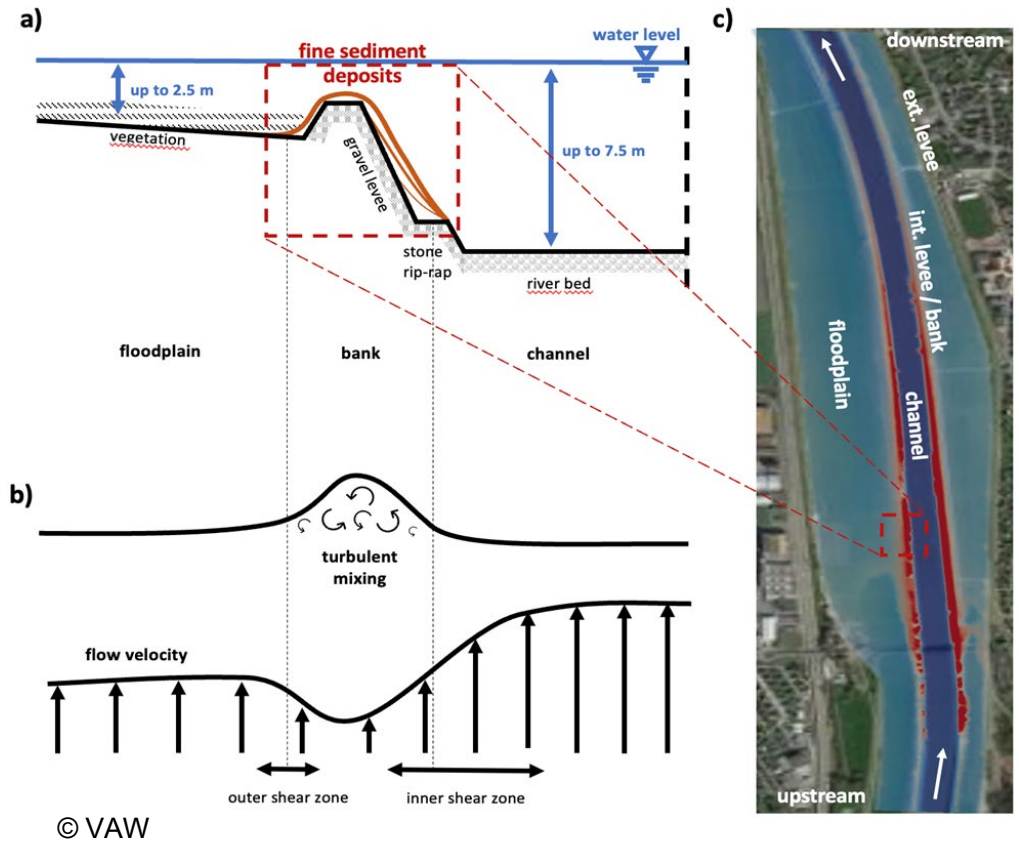
- Software:

  BASEMENT v3.1.x (development version)

- Models:
  - *k*-ε turbulence model:
    - transversal momentum exchange
    - turbulent diffusion (local dispersion) for advection-diffusion equation
  - Shear stress splitting: bed shear stress ↔ flow resistance
    - local erosion and deposition
    - effect of vegetation
  - Suspended sediment- and bed load transport model:
    - susp. sed. load: van Rjin (erosion), Xu (deposition)
    - bed load: Wong & Parker
    - fixed bathymetry from laboratory experiments
    - uniform sediment
  - BASEveg: conceptual (flow resistance), not dynamic

Processes

distinct shear zones (current situation)



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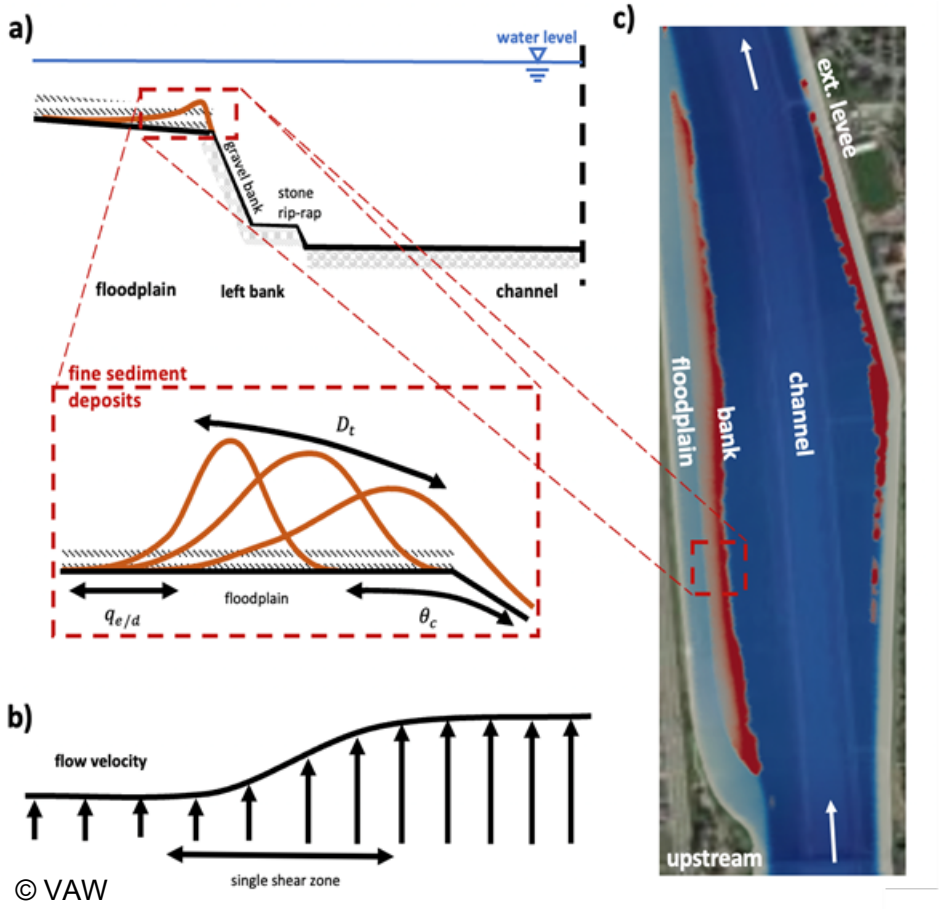
relevant parameters (project situation)



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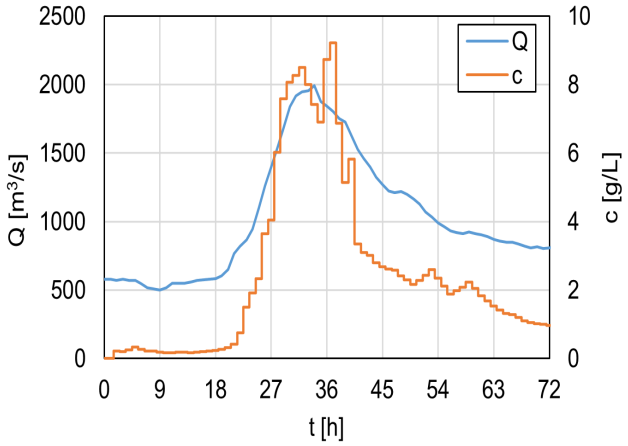
Setup

- mesh and roughness

	Bestand	Projektzustand
Abschnitt	km 78.0 - 86.4	km 79.6 - 86.4
Anzahl Elemente	775’000	445’000
Anzahl Knoten	390’000	225’000

- upstream boundary, 2016 flood

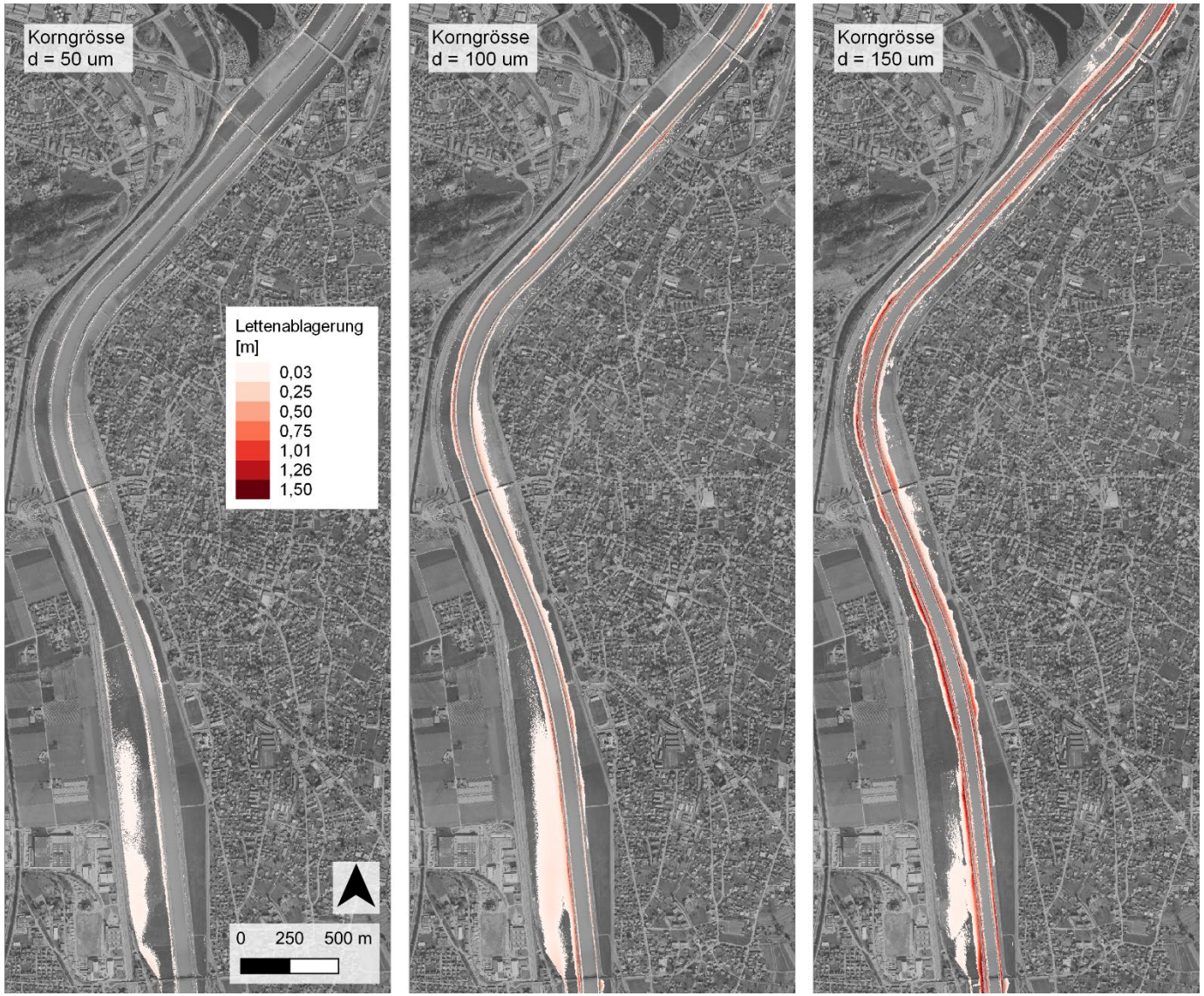


	Bestand		Projektzustand	
	A_{max} [m^2]	k_s [m]	A_{max} [m^2]	k_s [m]
Gerinnesohle	10	0.1	10	0.1
Gerinneböschung Fuss	1	1.0	-	-
Vorgrund	1	0.6	-	-
Gerinneböschung	1	0.6	2	0.6
Vorland	10	0.1	10	0.1
Dammböschung	2	0.36	5	0.36
Bewuchs «wenig»	-	0.1	-	0.1
Bewuchs «mittel»	-	0.25	-	0.25
Bewuchs «viel»	-	1	-	1

Results

Calibration / validation
/ model sensitivity

- based on current situation
- 2016 flood
- qualitative assessment (pictures, experts)
- sensitivity of different parameters (grain size, angle of repose, local dispersion)
- relevant: different grain size

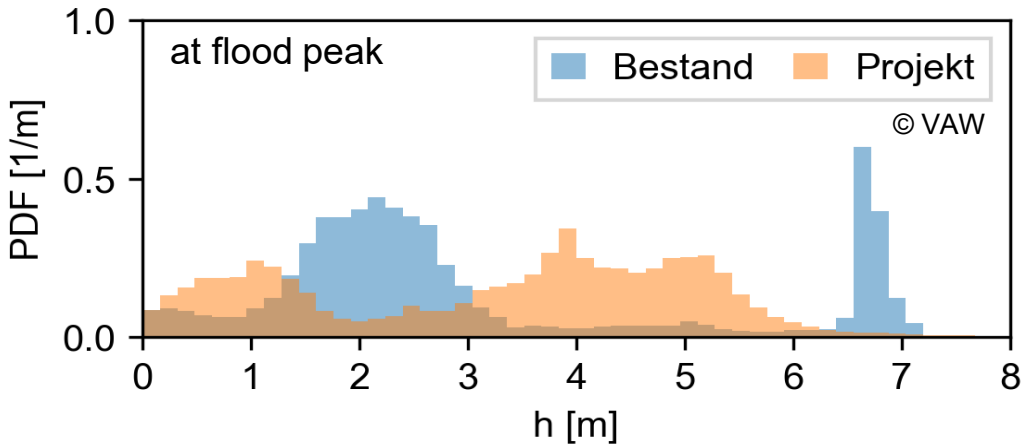


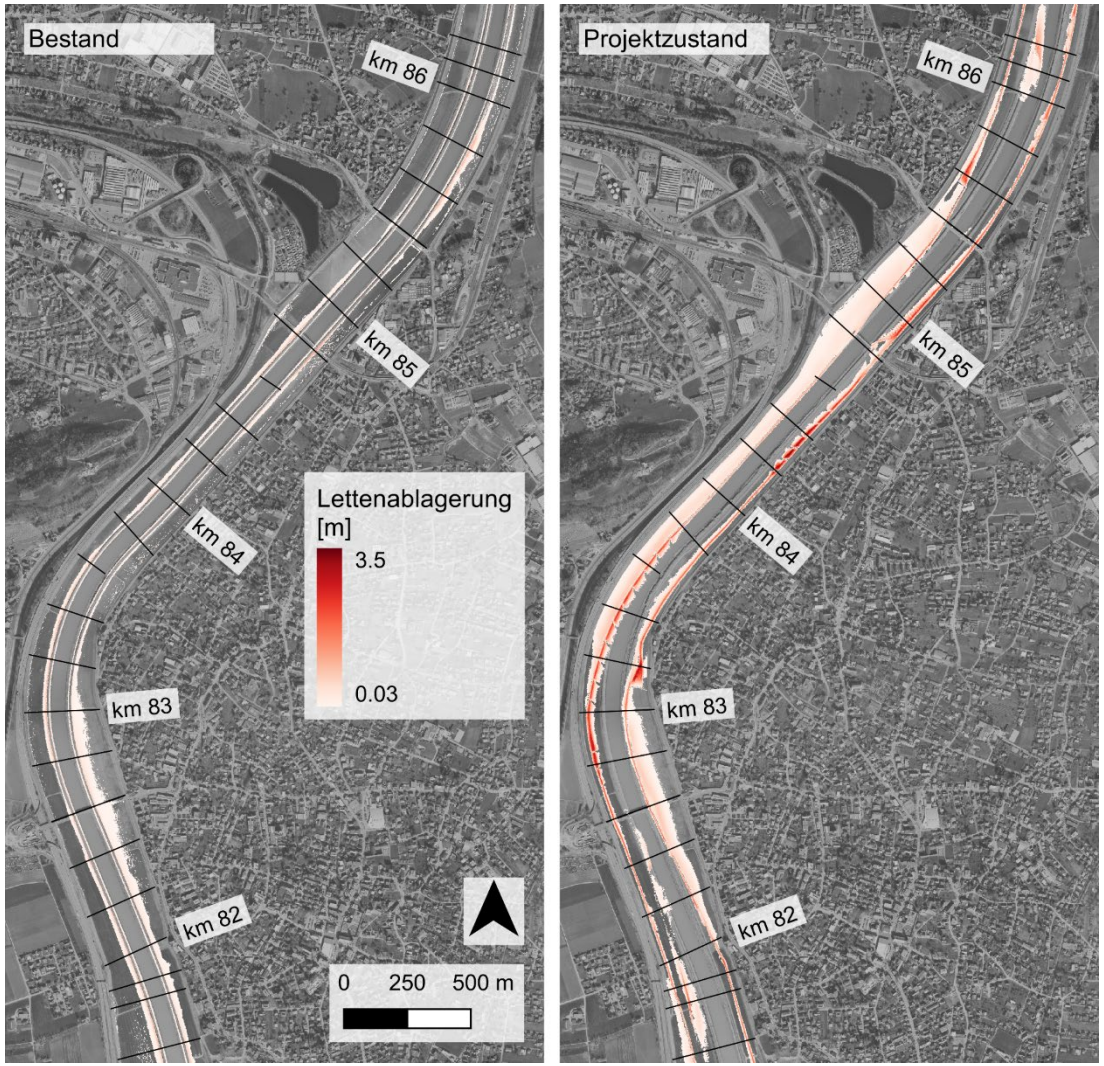
Results

Sedimentation (project)

- 2016 flood
- d = 100 µm
- distinct increase of sediment deposition

- flood plain: 0.05 – 0.8 m
- groyne fields: up to 3 m
- gravel bars: 0.2 – 2 m





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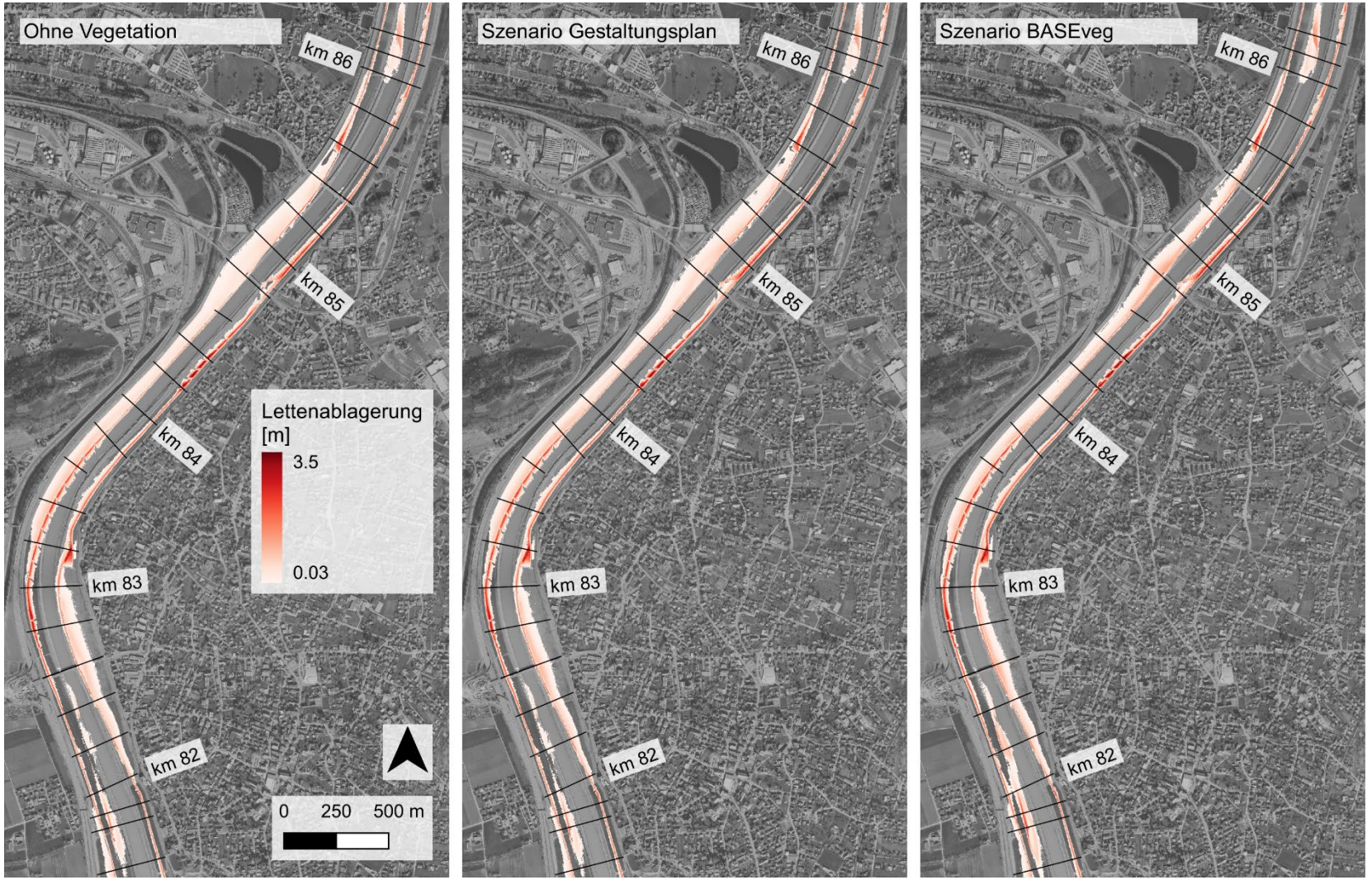
Results

Effect of vegetation (project)

- 2016 flood
- little effect on deposition
- flood plains: more pronounced dep. smaller area
- gravel bars: +0.2 bis 0.5 m



Conclusions

- distinct increase of sediment deposition
- no clear remobilization during successive floods (HQ_2 to ~HQ_{20})
- vegetation mainly affects distribution of sediments
  but only slightly affects total volume
- quantitative assessment is mainly limited by data for model calibration
- turbulence model allows for realistic simulation of shear zones
- the more complex the model,
  - the more detailed the required data basis
  - the more computationally expensive the simulation

Outlook

- peer reviewed journal papers
  - turbulence model
  - suspended sediment transport model
- reports / engineering journal contribution
  - BAFU Umwelt Wissen (report in English, German, French, Italian)
  - WEL (Swiss journal)
- tutorials (expected)
  - turbulence modelling
  - suspended sediment transport
  - vegetation