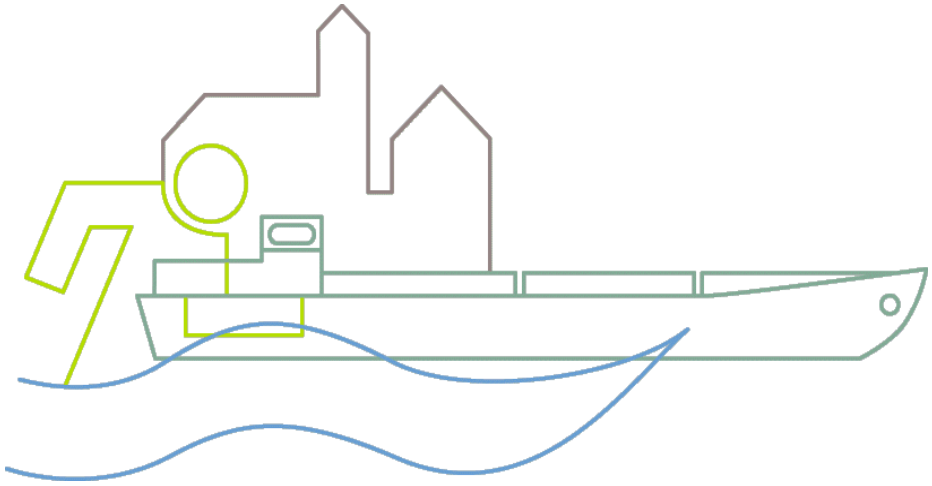


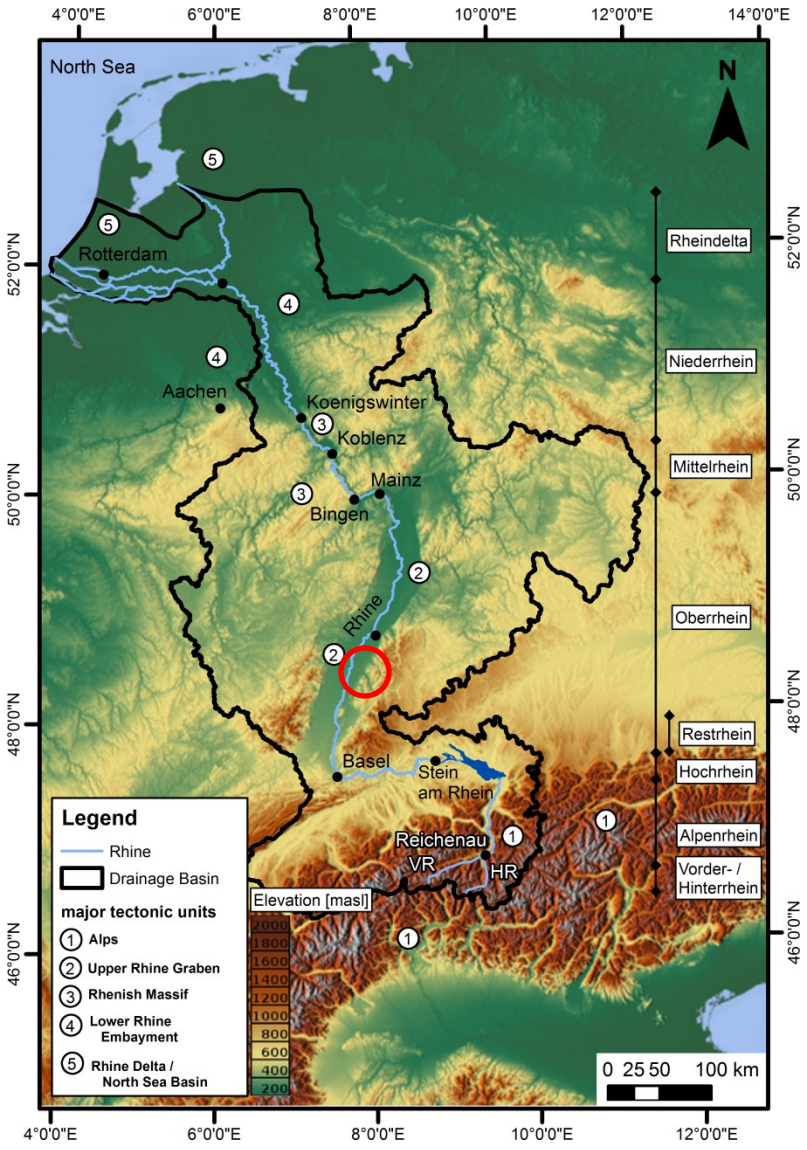
Implications of spatial distribution of suspended sediment concentrations on reservoir management, case study Iffezheim

G. Hillebrand[1], I. Klassen[2] & N.R.B. Olsen[3]

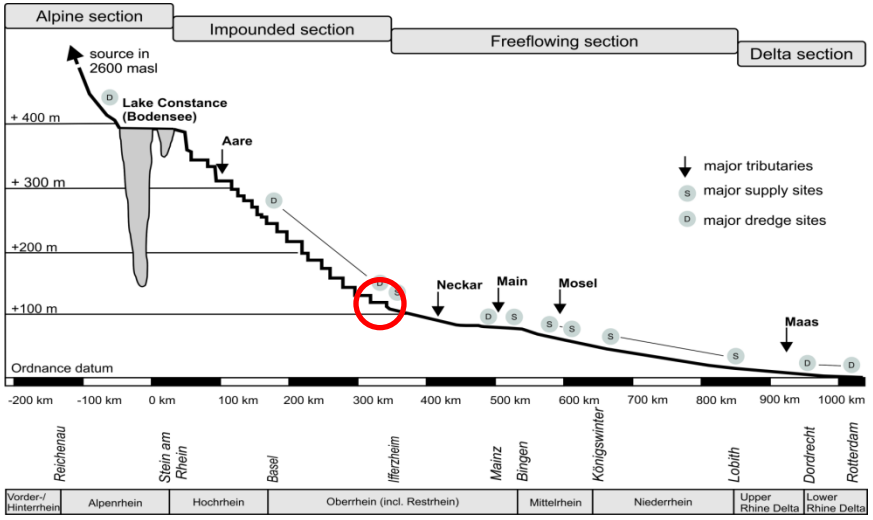
[1] Federal Institute of Hydrology, Koblenz, Germany
[2] Karlsruhe Institute of Technology, Karlsruhe, Germany
[3] The Norwegian University of Science and Technology, Trondheim, Norway

SedNet, Genoa
June 14th – 17th 2017

Iffezheim reservoir, Upper Rhine



- Last of 10 reservoir of the Upper Rhine
- completed in 1977
- used for hydropower, navigation and flood protection
- German Waterways and Shipping Administration responsible for sediment management



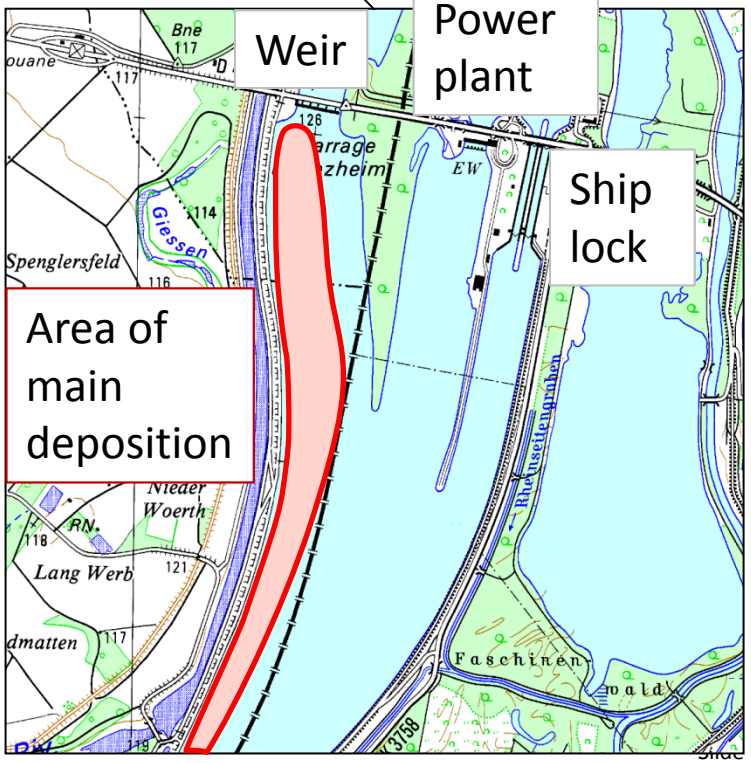
Figures: Frings, R.M., Hoffmann, T., Hillebrand, G., Gehres, N., Banhold, K., Schriever, S. (in revision): FROM SOURCE TO MOUTH: BASIN-SCALE MORPHODYNAMICS OF THE RHINE RIVER. Earth Science Reviews.

Iffezheim reservoir, Upper Rhine

© WSA Freiburg

Iffezheim barrage

Gambsheim barrage



Research questions

- Net deposition rate as function of discharge:
  - sediment supply from upstream
  - deposition rate of sediments
  - erosion of deposited sediments during floods
- Influence of changes in reservoir operation (e.g. additional turbines)

Iffezheim

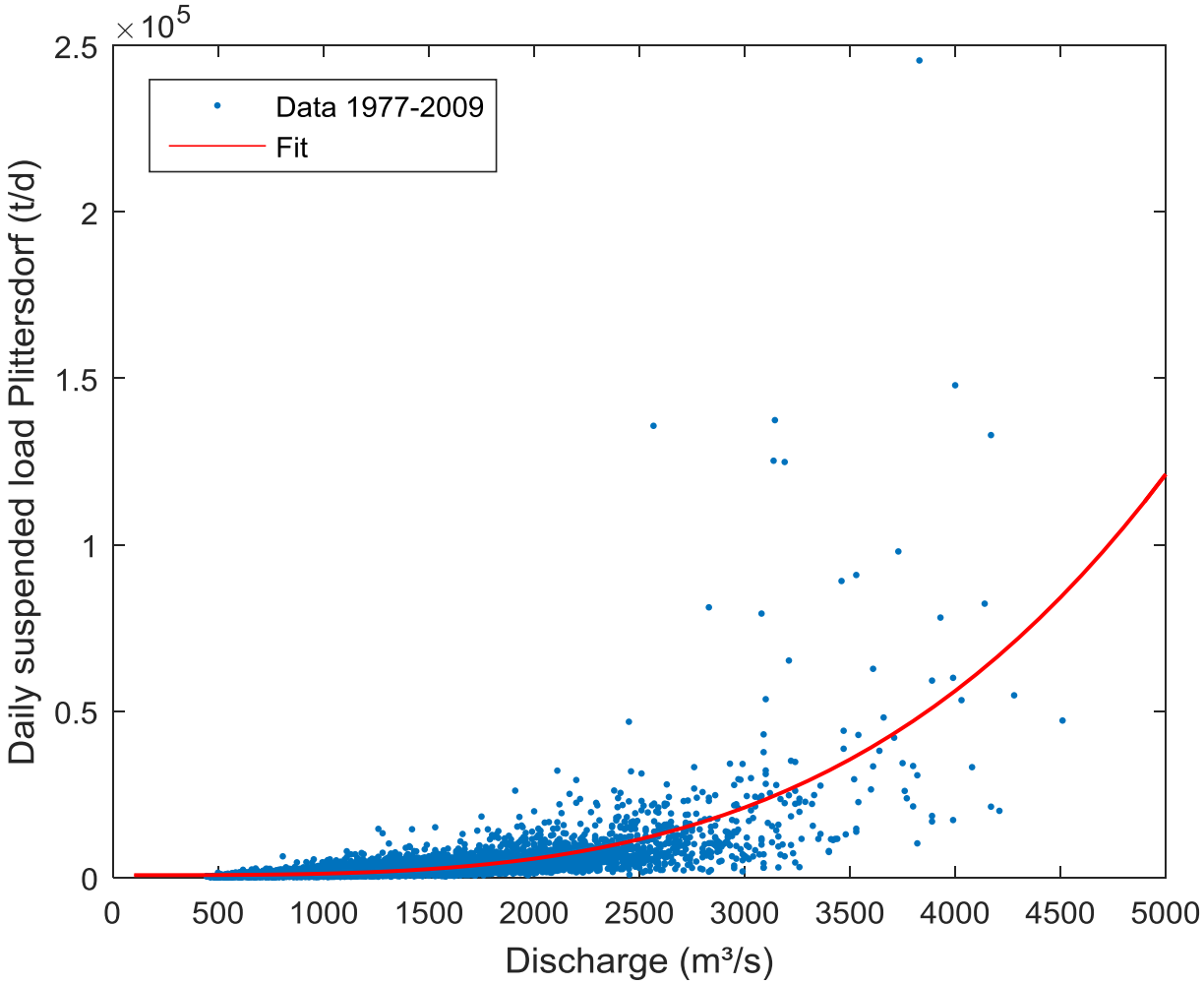
Gambsheim

© Google Earth

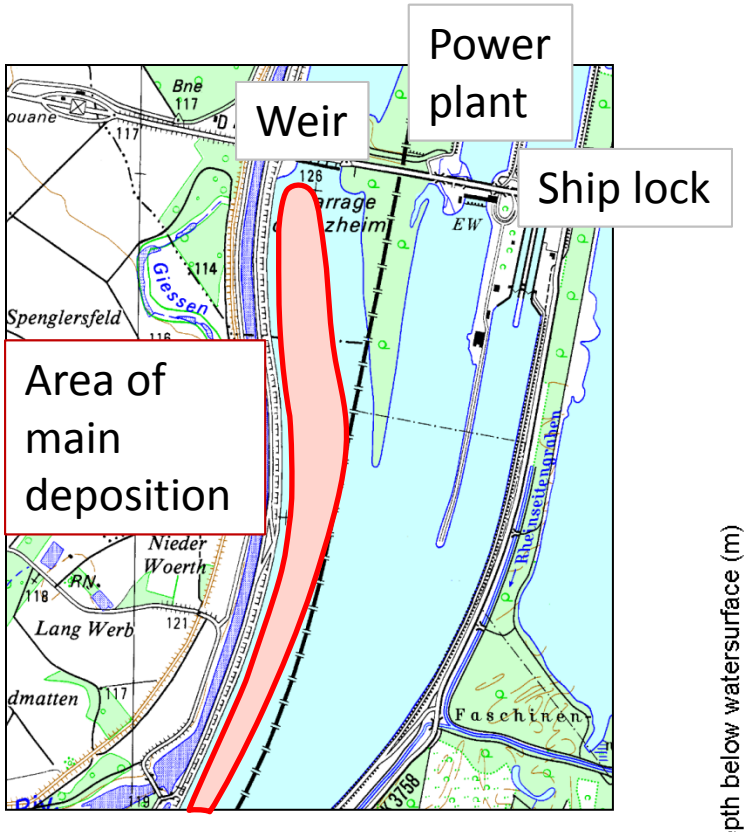
	Average dredged volume (1995 – 2005)
Iffezheim	ca. 210.000 m³
Gambsheim	ca. 60.000 m³

Sediment supply

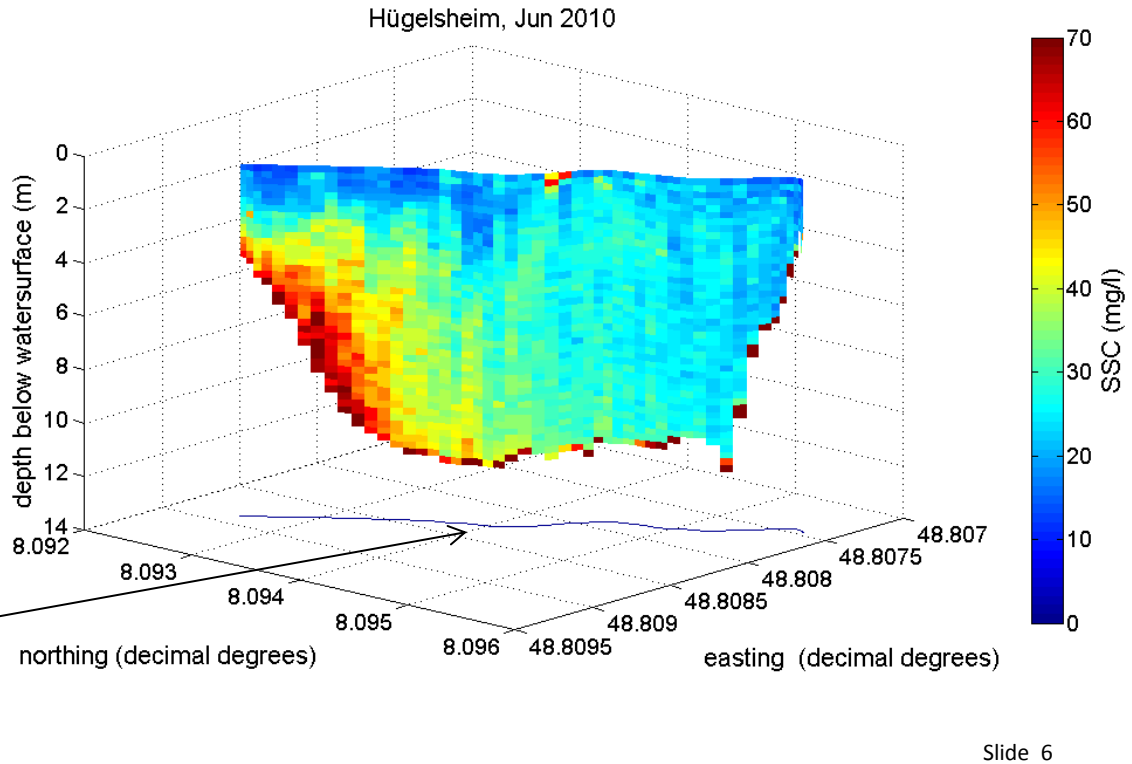
- Measurement station Plittersdorf (downstream of the Iffezheim reservoir)



Spatial distribution of SSC

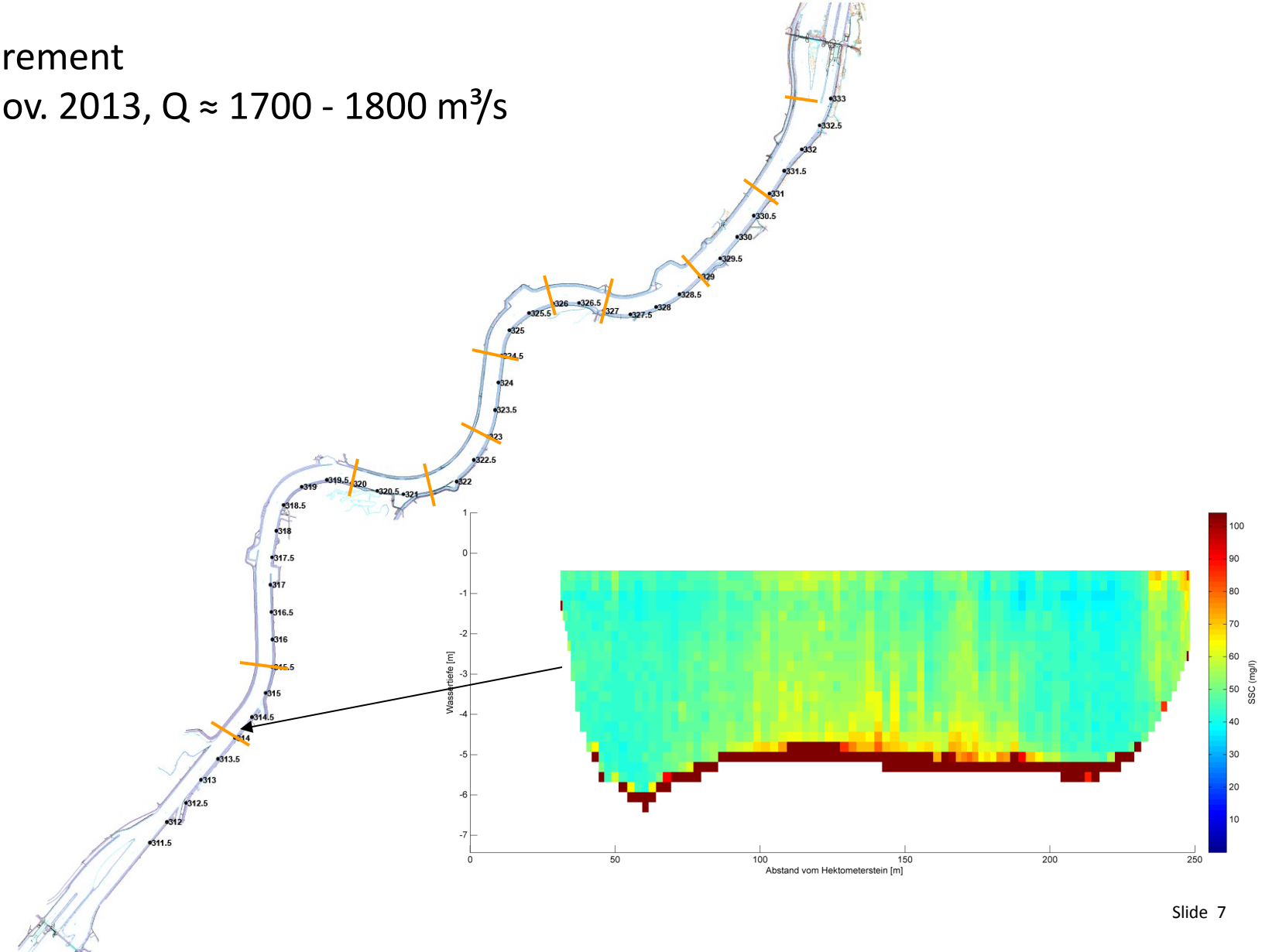


ADCP measurement



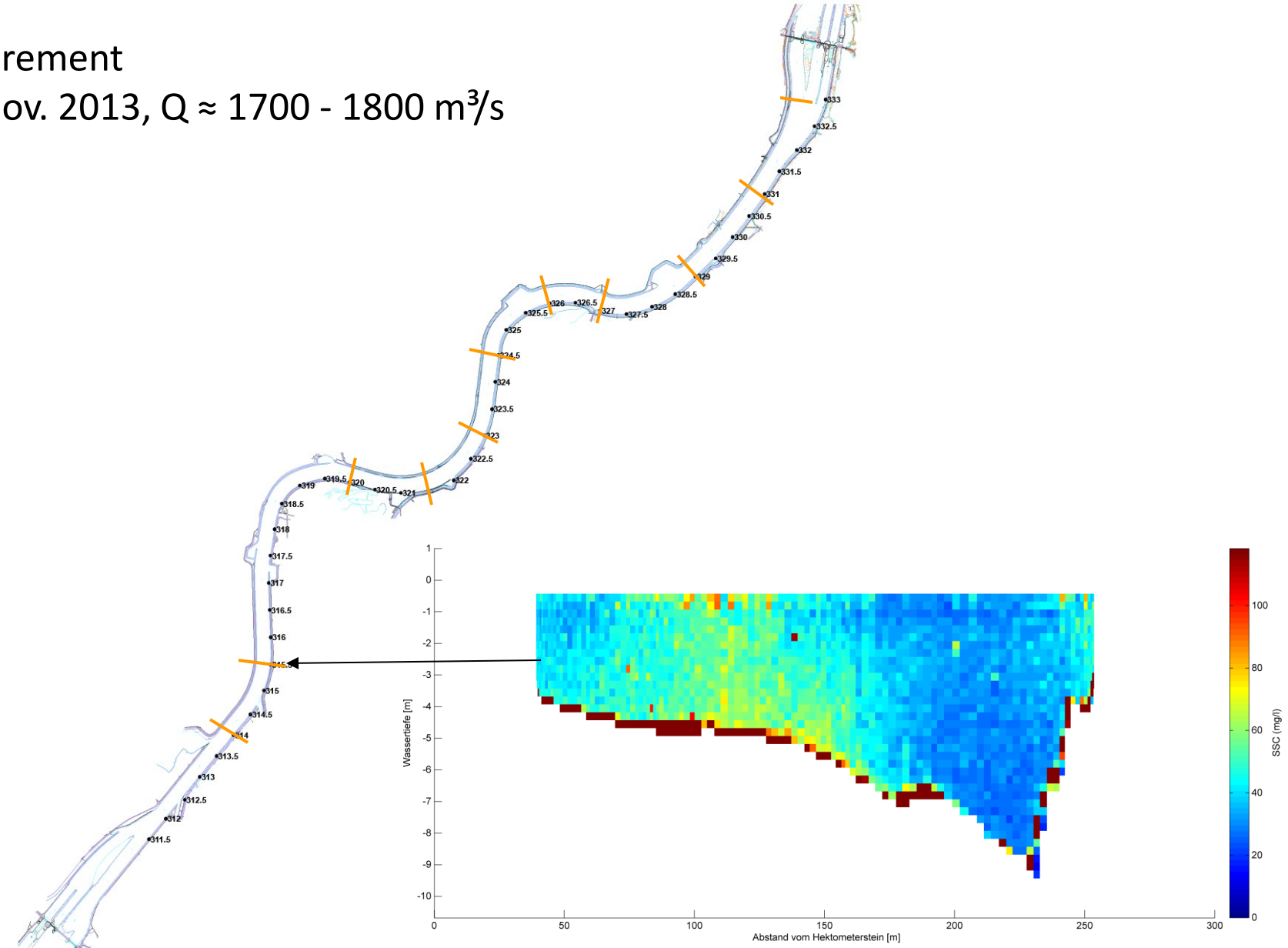
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



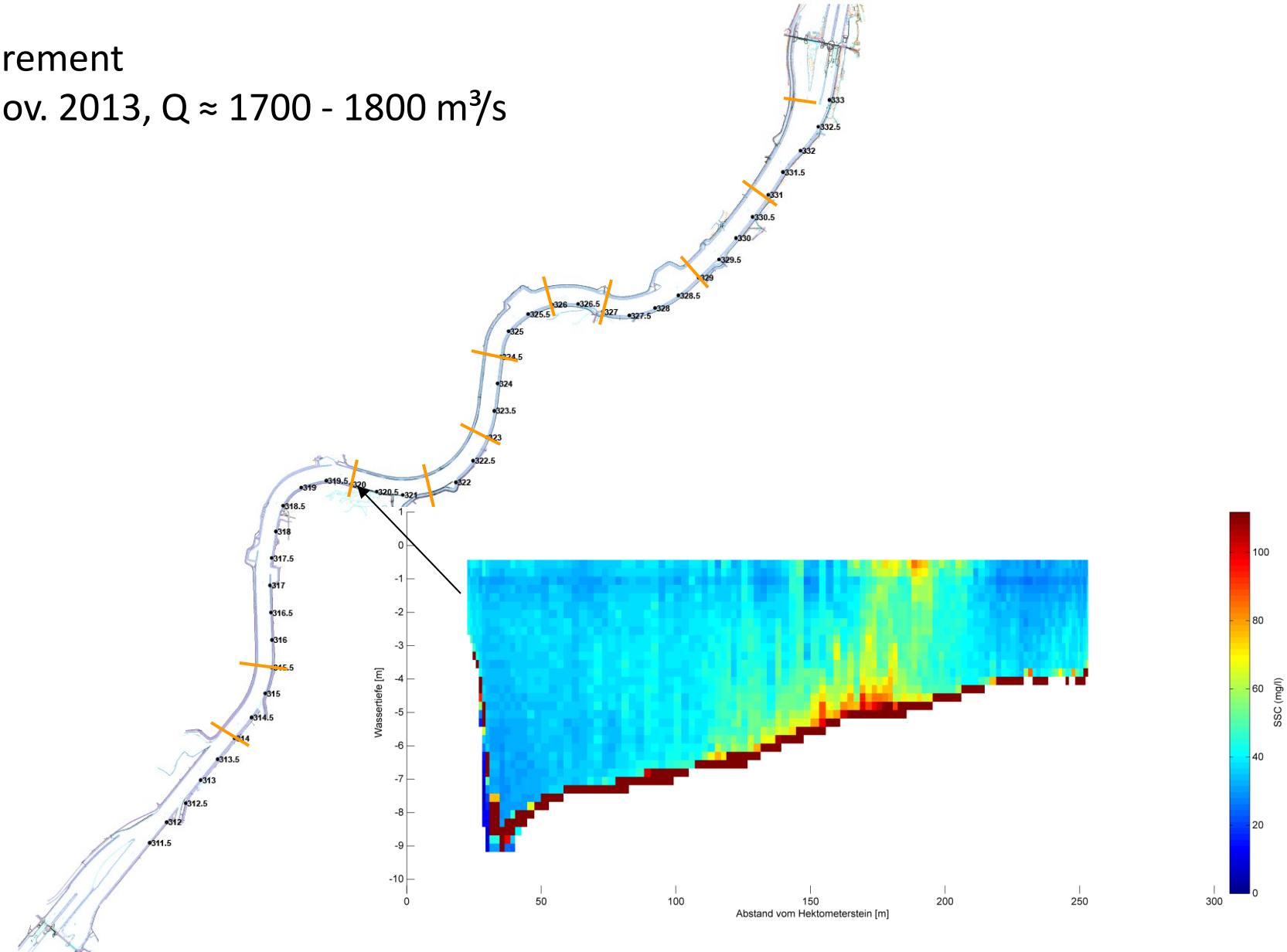
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



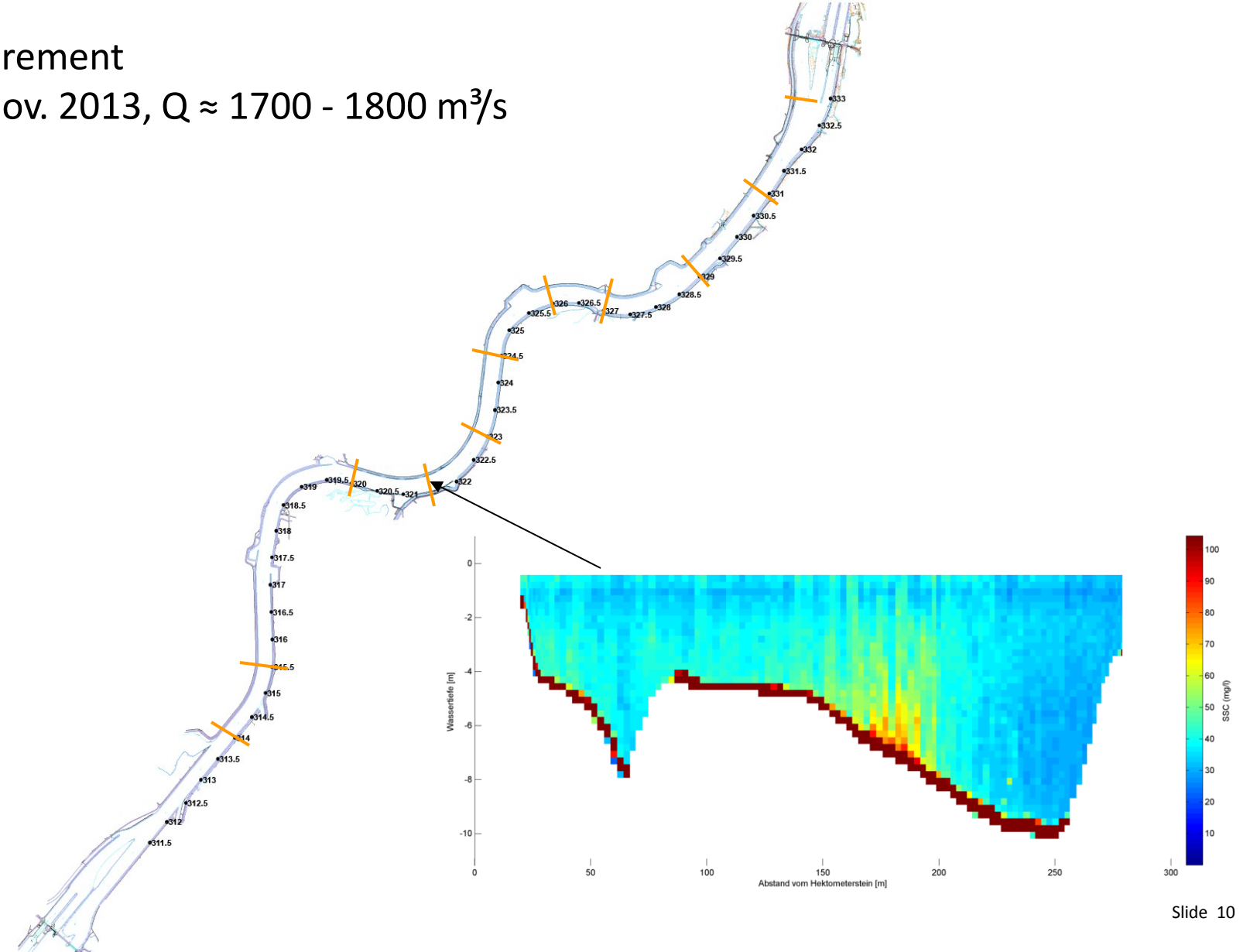
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



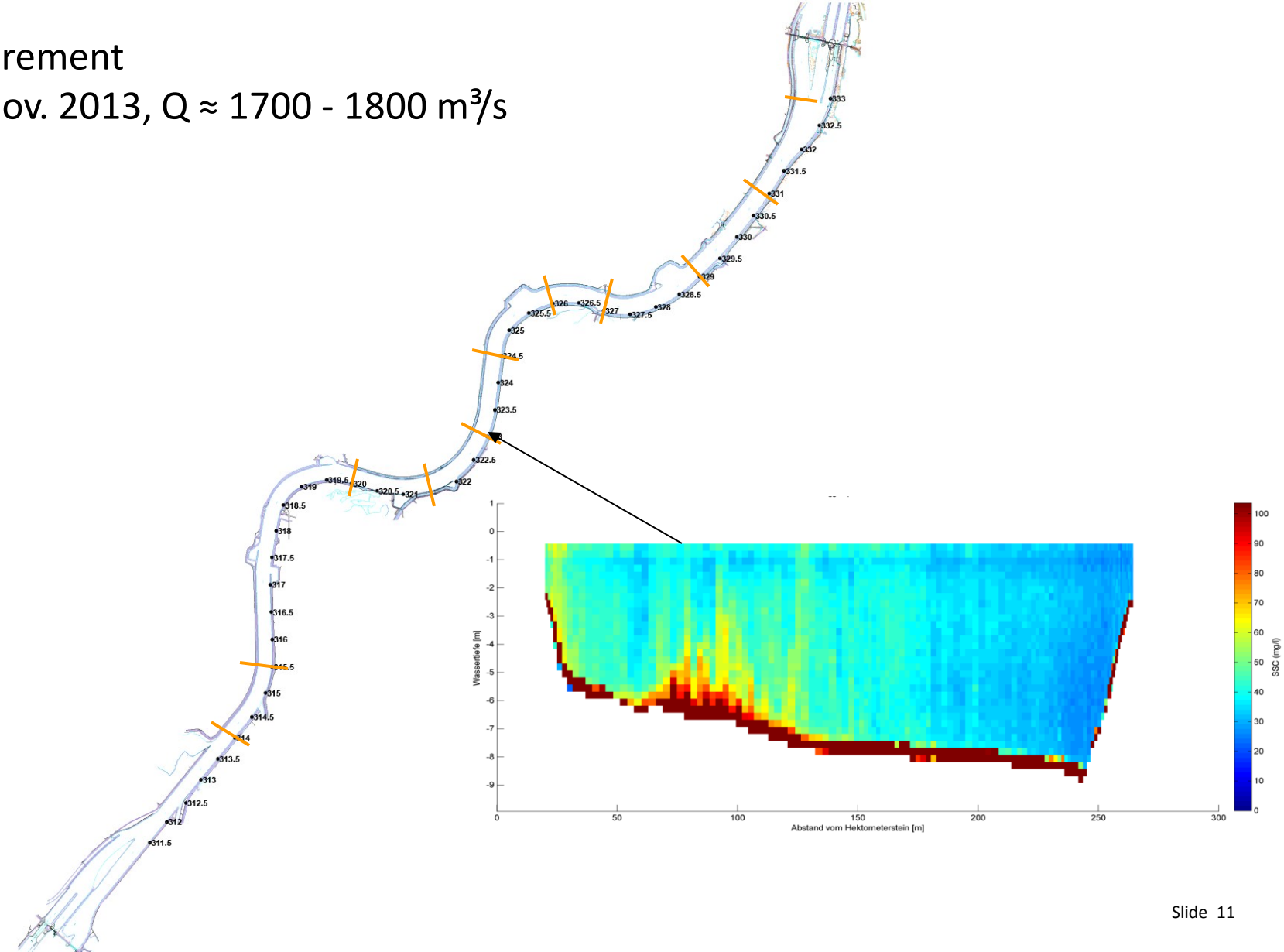
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



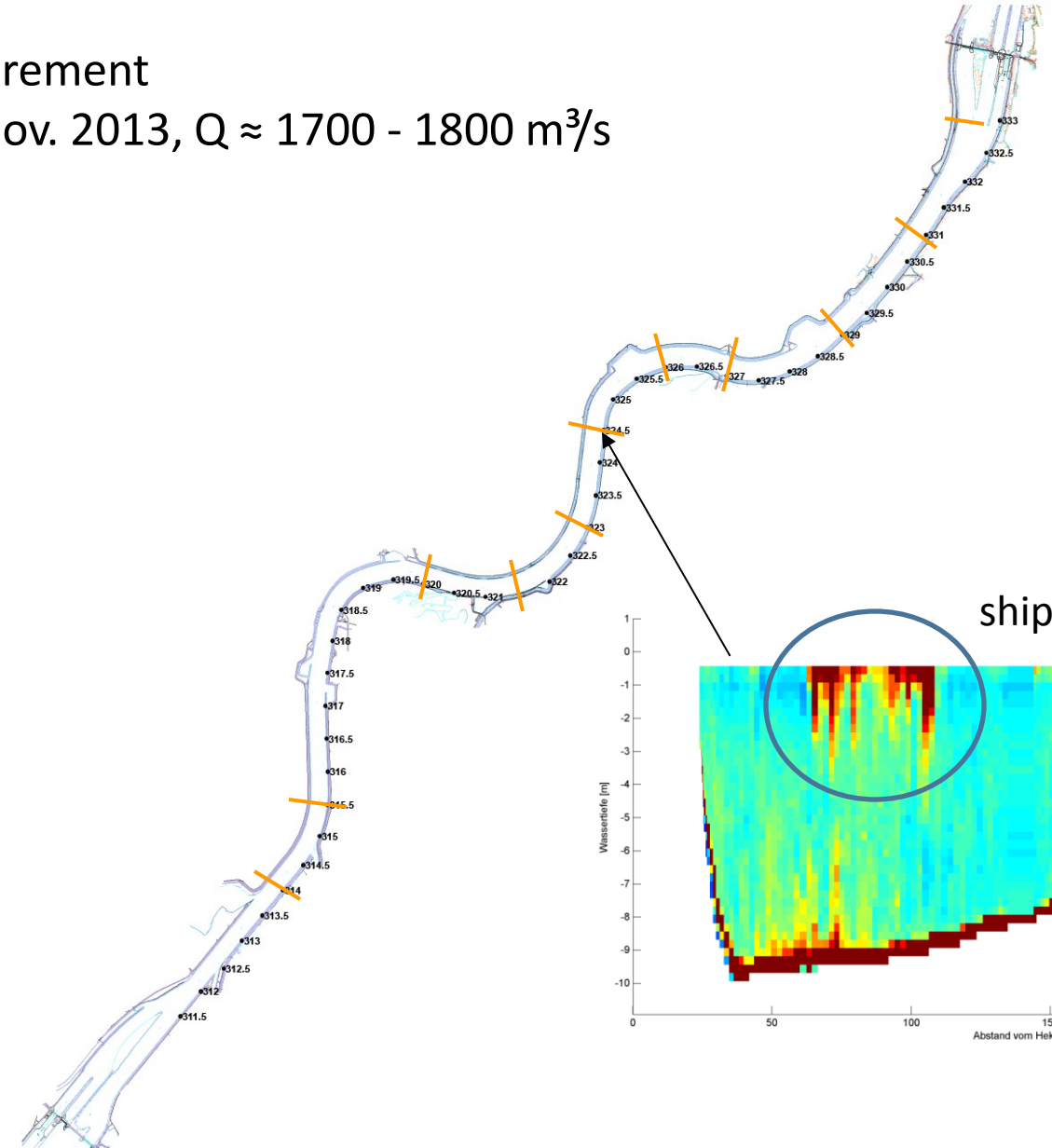
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s

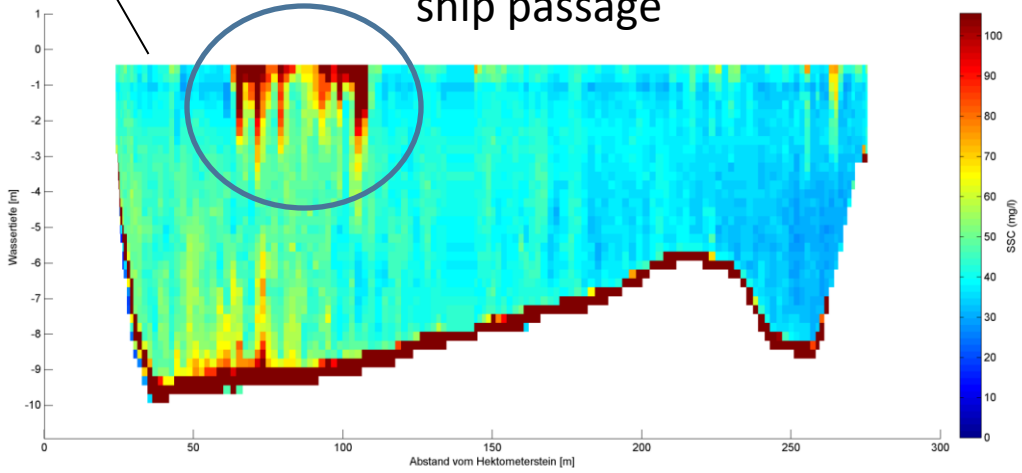


Spatial distribution of SSC within the reservoir

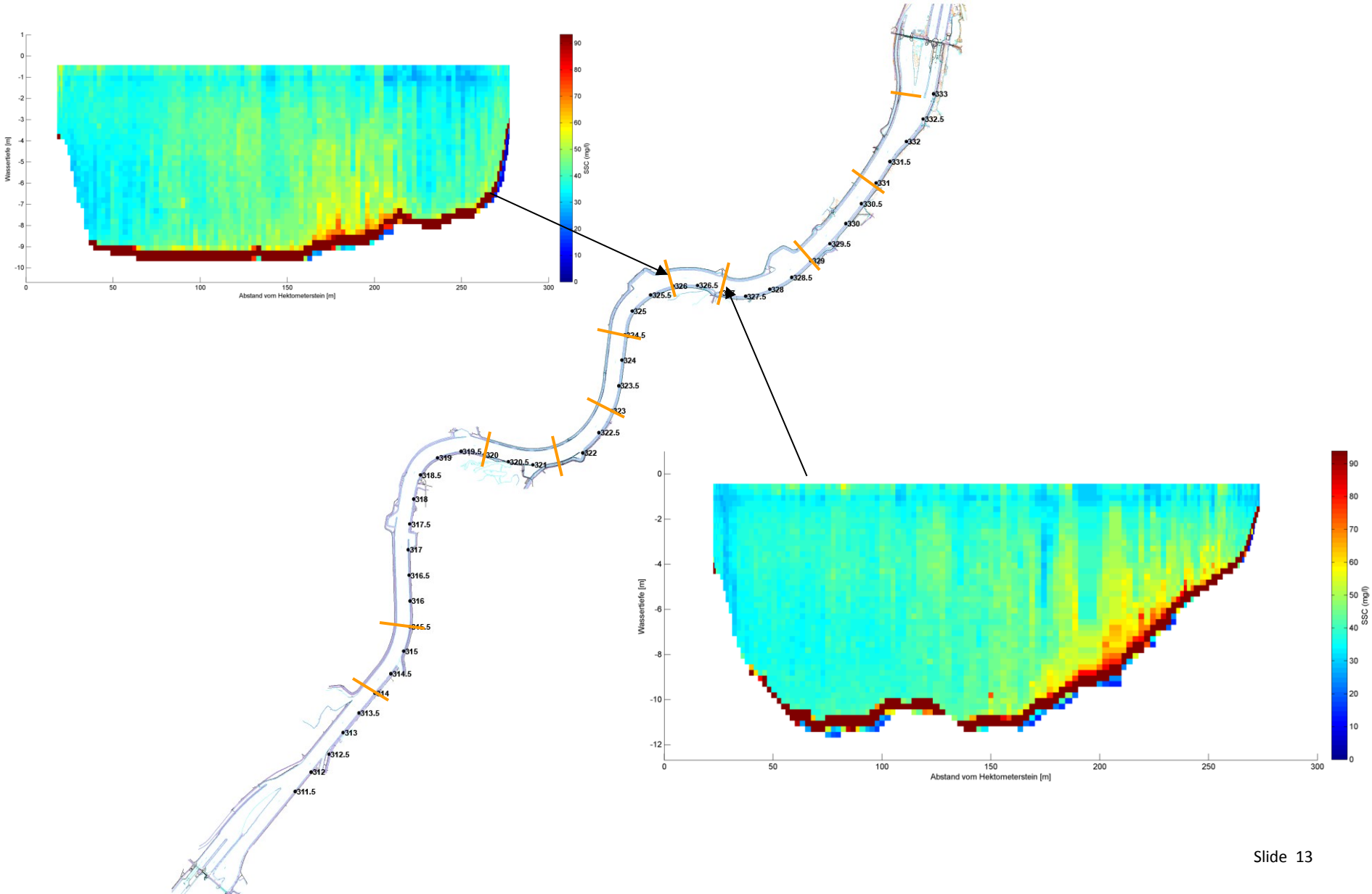
Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



ship passage

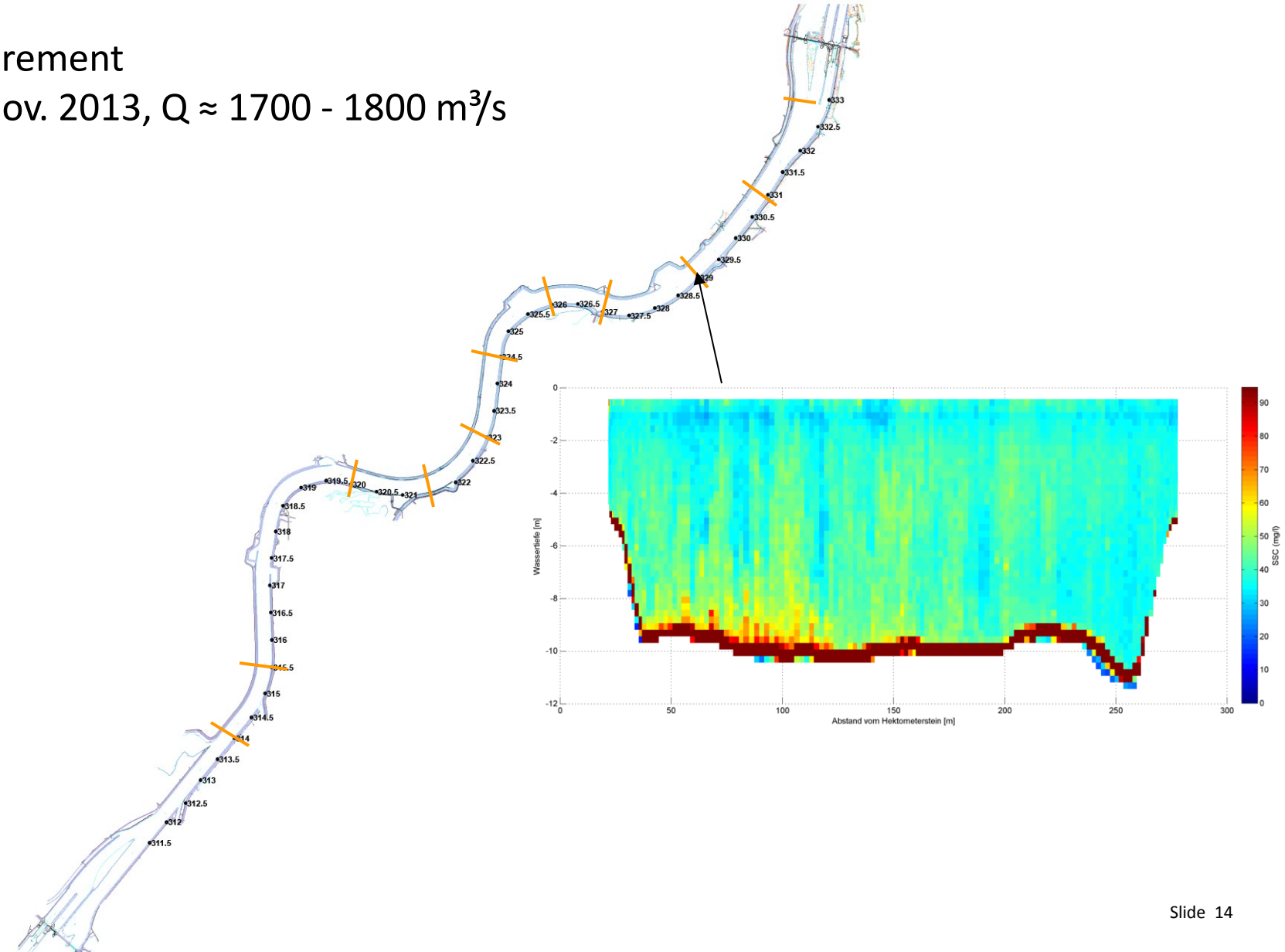


Spatial distribution of SSC within the reservoir



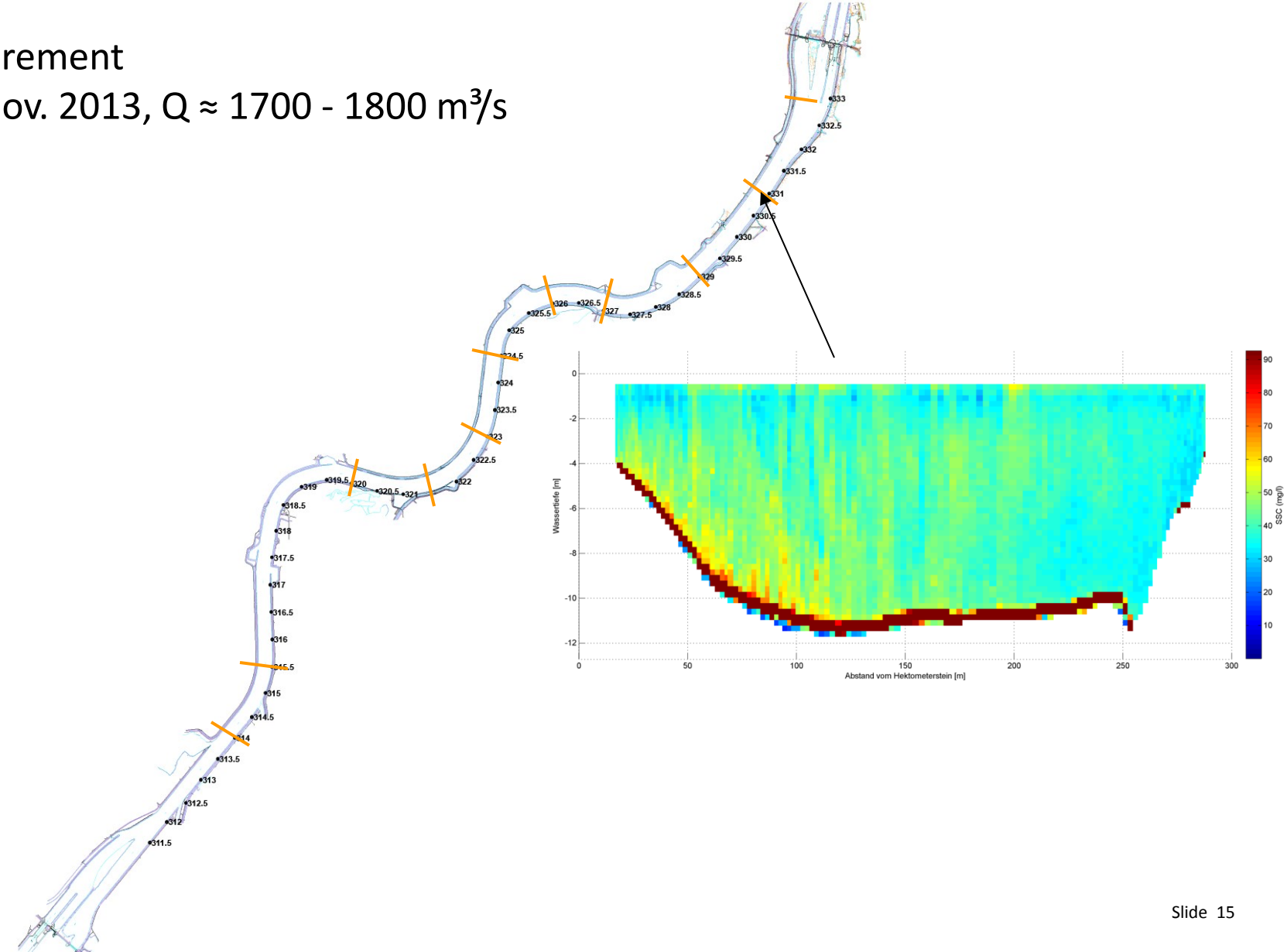
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



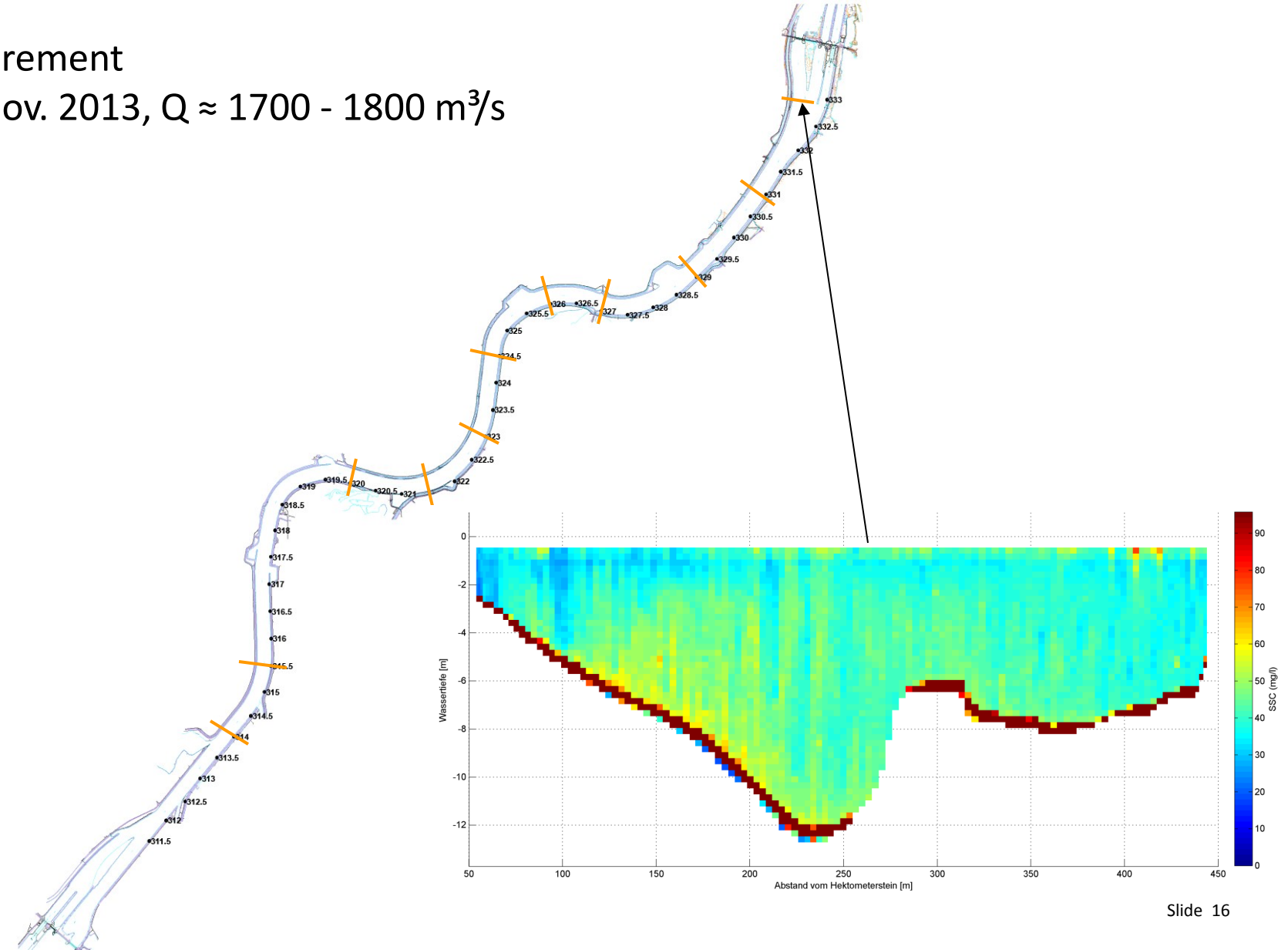
Spatial distribution of SSC within the reservoir

Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



Spatial distribution of SSC within the reservoir

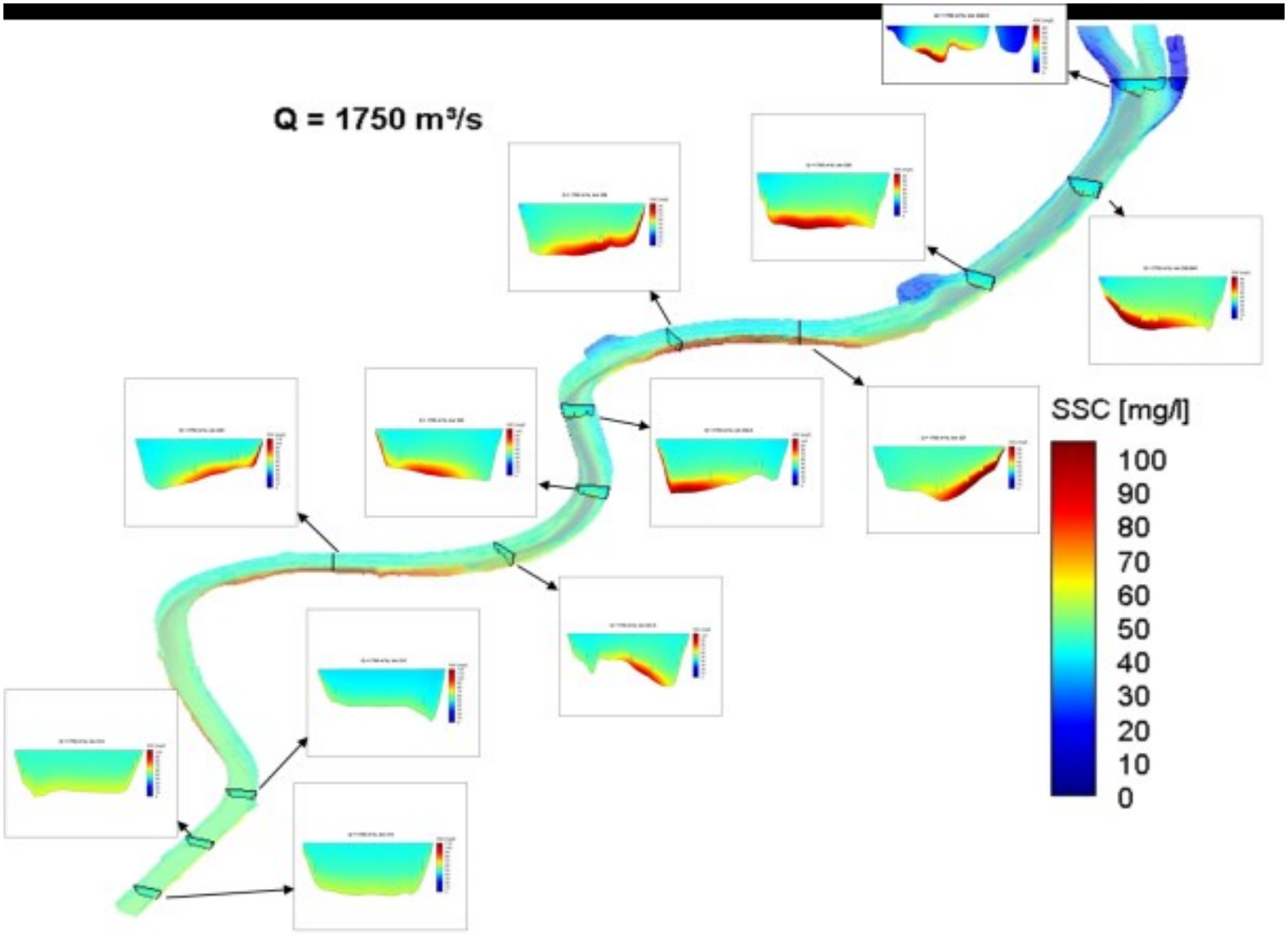
Measurement
5./6. Nov. 2013, Q ≈ 1700 - 1800 m³/s



3D-model of suspended sediment transport

SSIIM

Total number of cells: 612.543



Results I

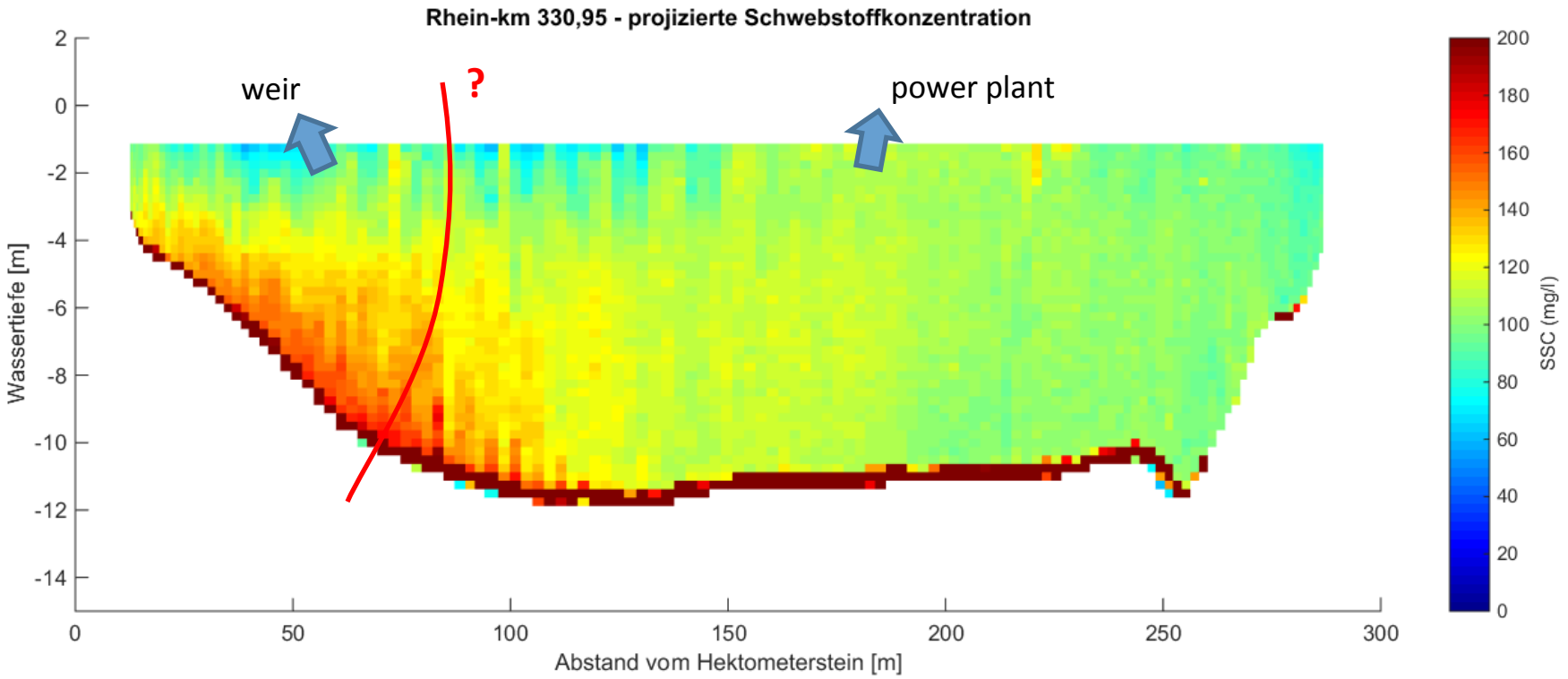
- Net deposition rate as function of discharge:
  - sediment supply from upstream
  - deposition rate of sediments
  - e… ite… …ods

highest sediment yield during floods

Input to weir channel disproportionately high due to lateral gradients

- Influence of changes in reservoir operation (e.g. additional turbines)

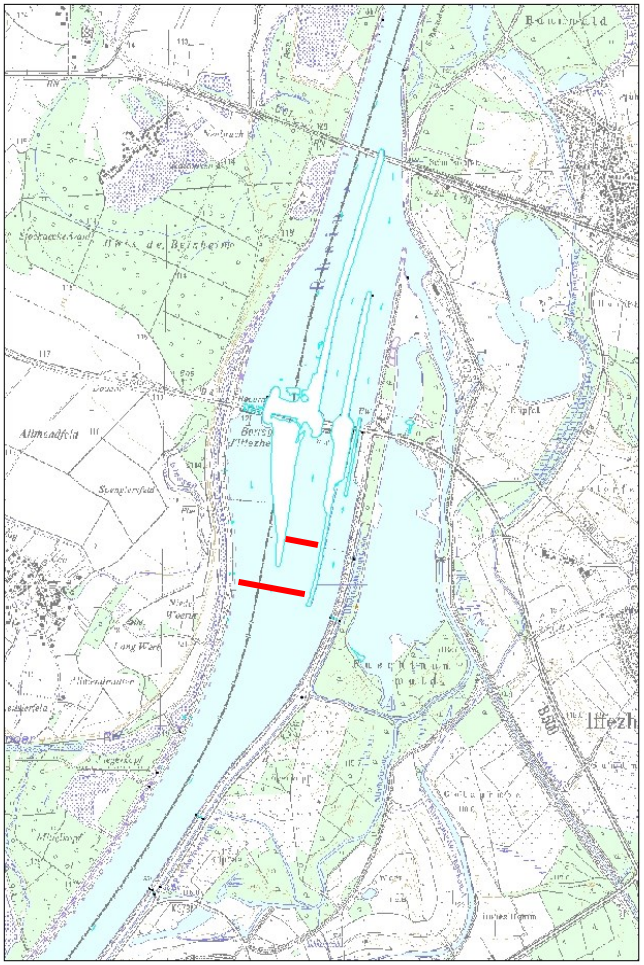
Suspended load entering weir channel



Portion of susp. load entering weir channel – a function of discharge?

Measurements

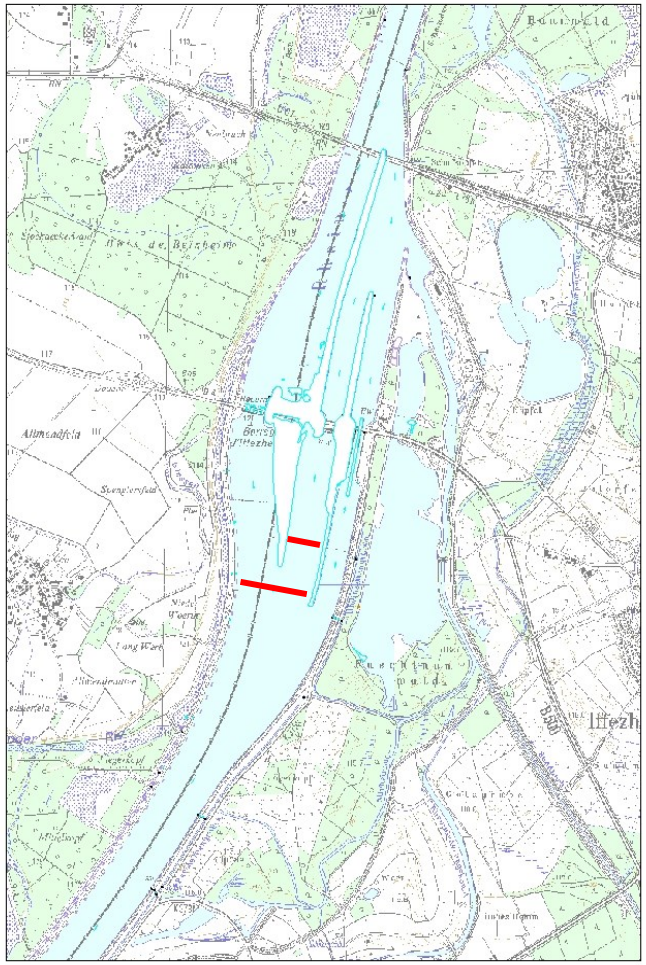
- 11 ADCP measurement campaigns

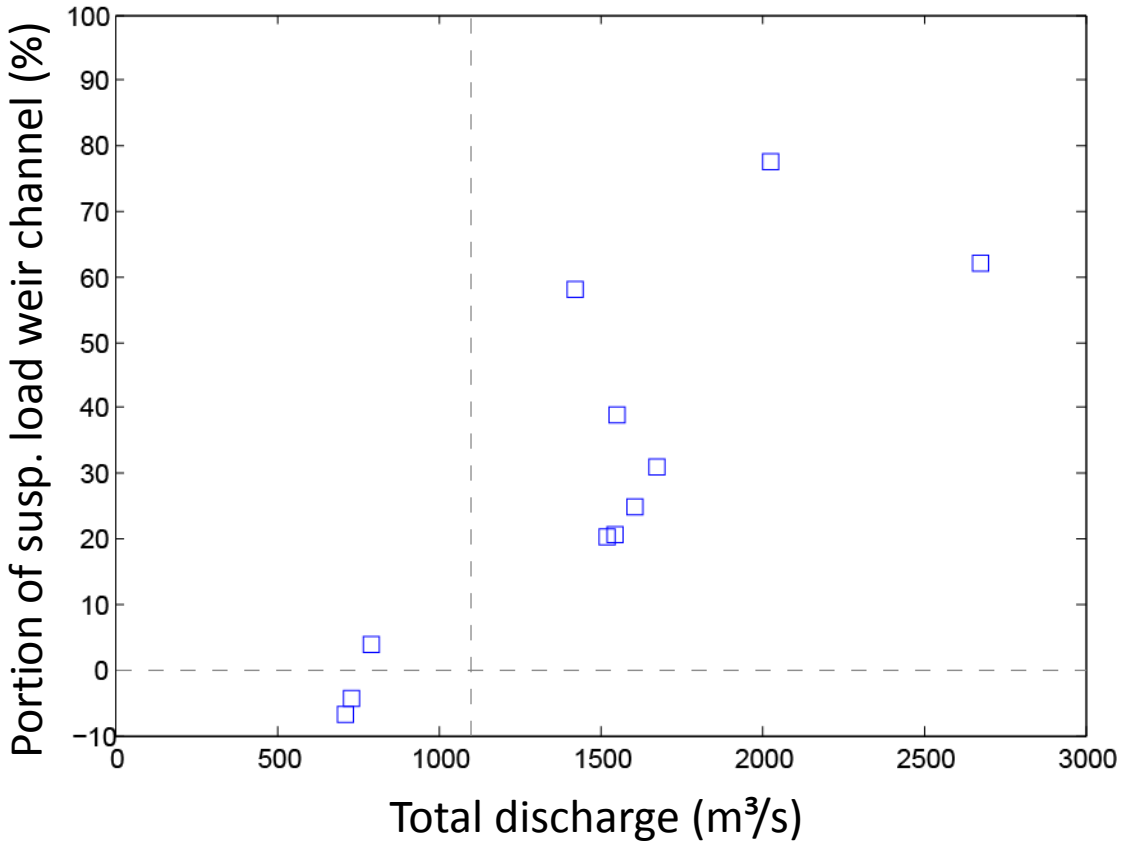


Date	Discharge (m^3/s) (km 332.9)	Portion weir channel
10.06.2010	1555	38,8 %
31.01.2011	*791*	*3,9 %*
07.02.2011	*710*	*- 6,9 %*
08.02.2011	*730*	*- 4,5 %*
25.01.2012	1673	31,1 %
26.01.2012	1519	20,2 %
14.05.2012	1609	24,9 %
15.05.2012	1545	20,5 %
16.05.2012	1422	58,1 %
12.06.2012	2025	77,6 %
13.06.2012	2679	62,1 %

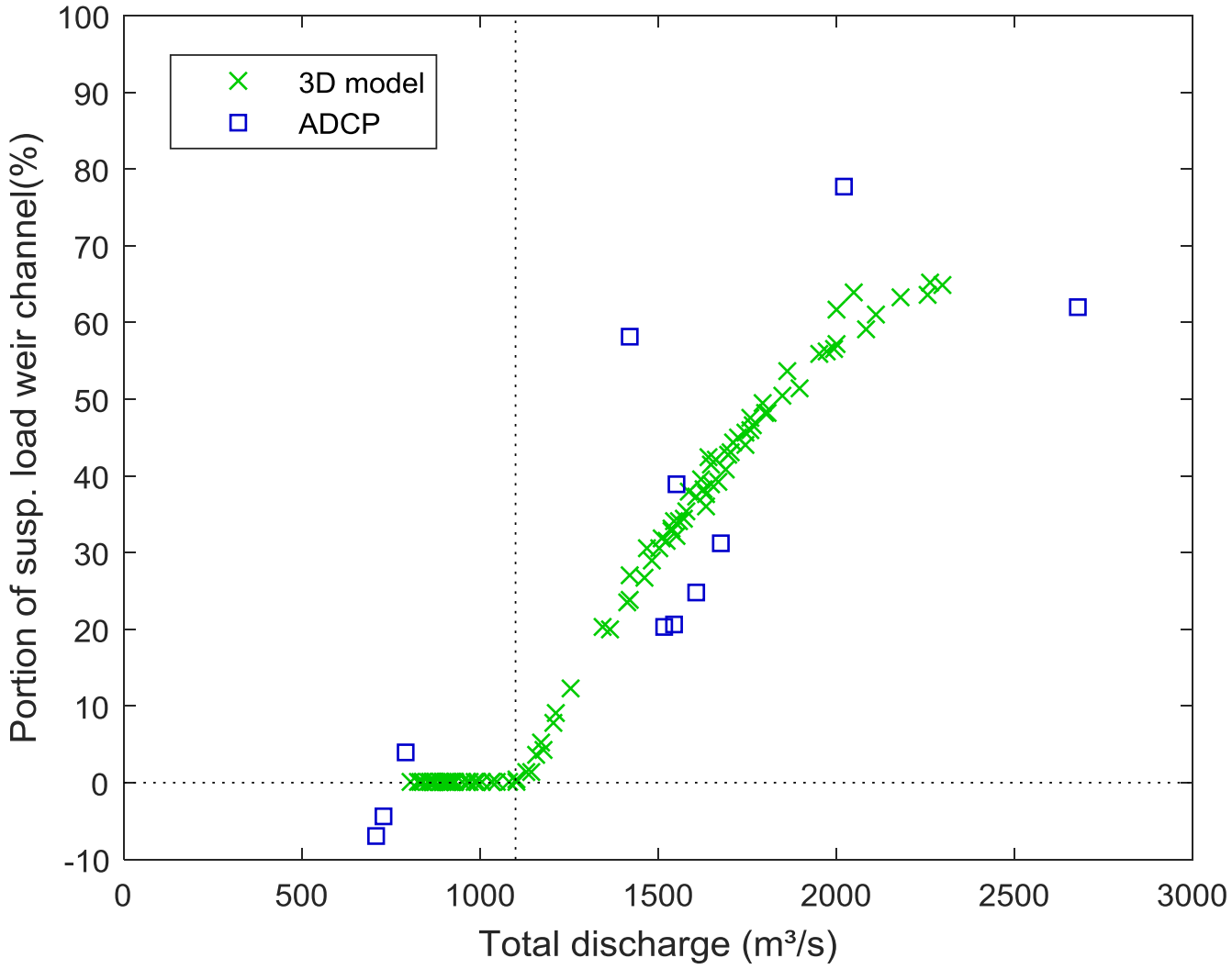
Measurements

- 11 ADCP measurement campaigns

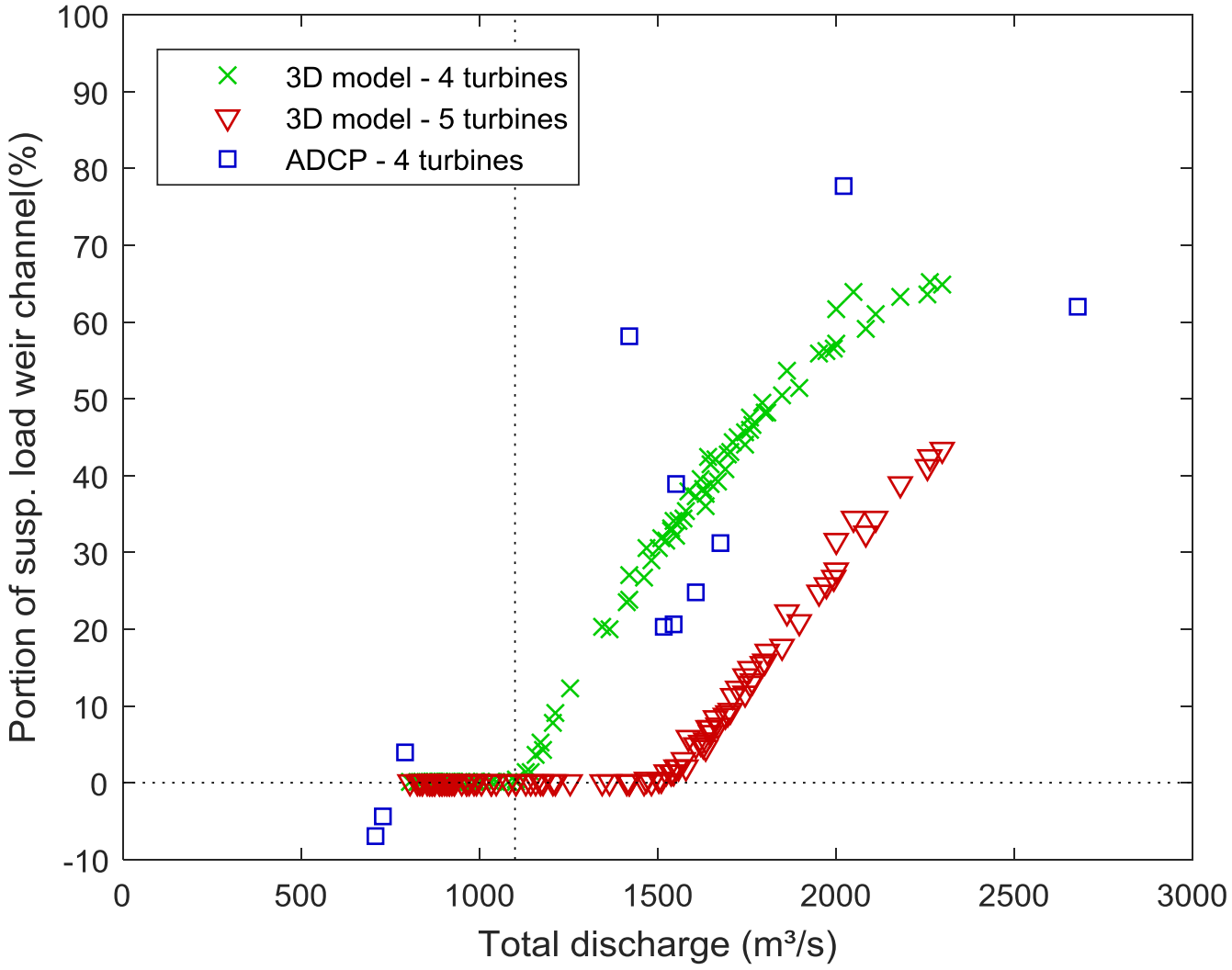




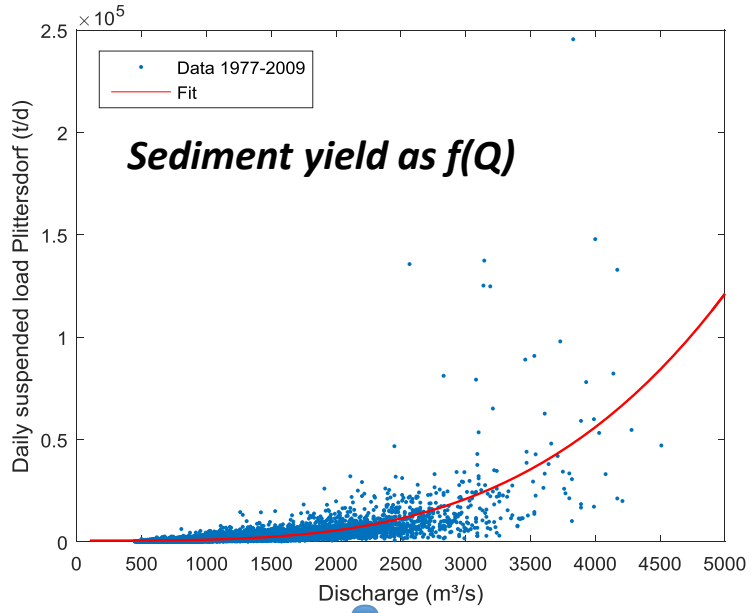
Comparison with results of 3D-model



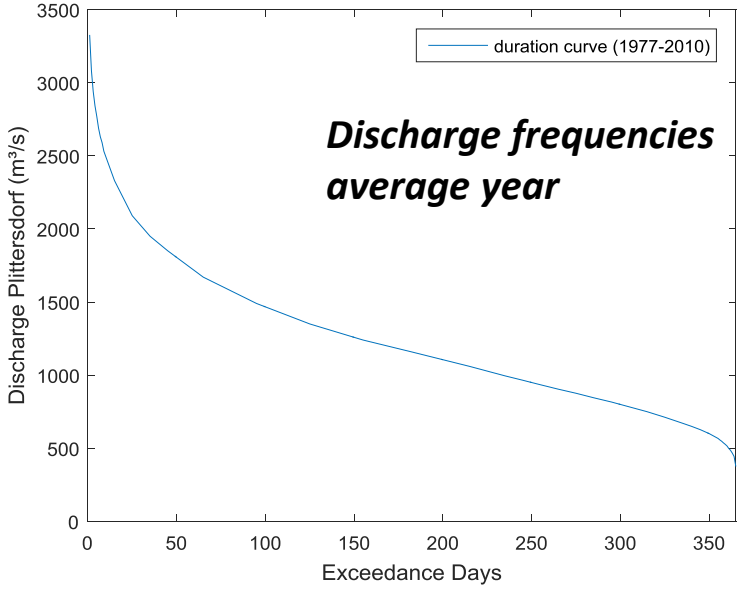
Effect of 5th turbine



Division of suspended loads on average (4T)



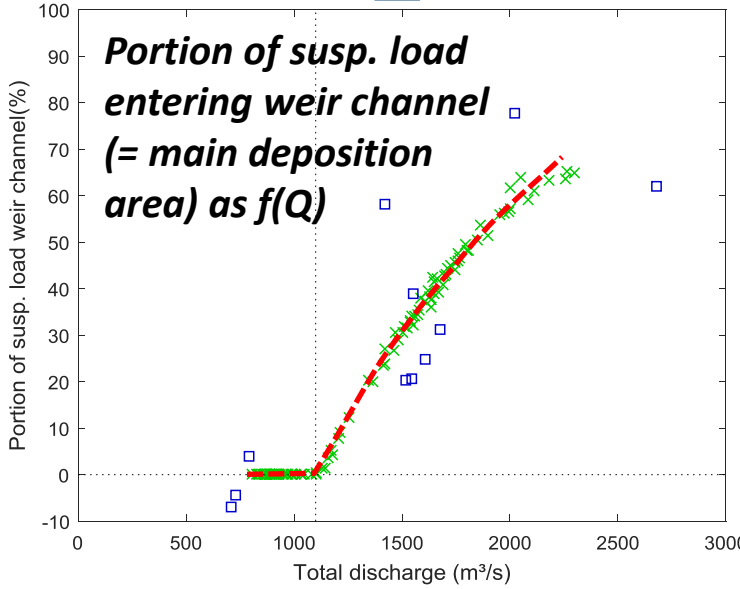
&



&

Portion of susp. load weir channel
on average:
ca. 40 – 45 %
(high uncertainty/variability)

for comparison:
portion of discharge to weir channel
on average:
ca. 21 %



Results II & Further considerations

Influence of changes in reservoir operation (e.g. additional turbines)

4 turbines:

Estimate via discharge duration curve:

- Portion of susp. load weir channel on average: ca. 40 – 45 %
- Portion of discharge weir channel on averge: ca. 21 %

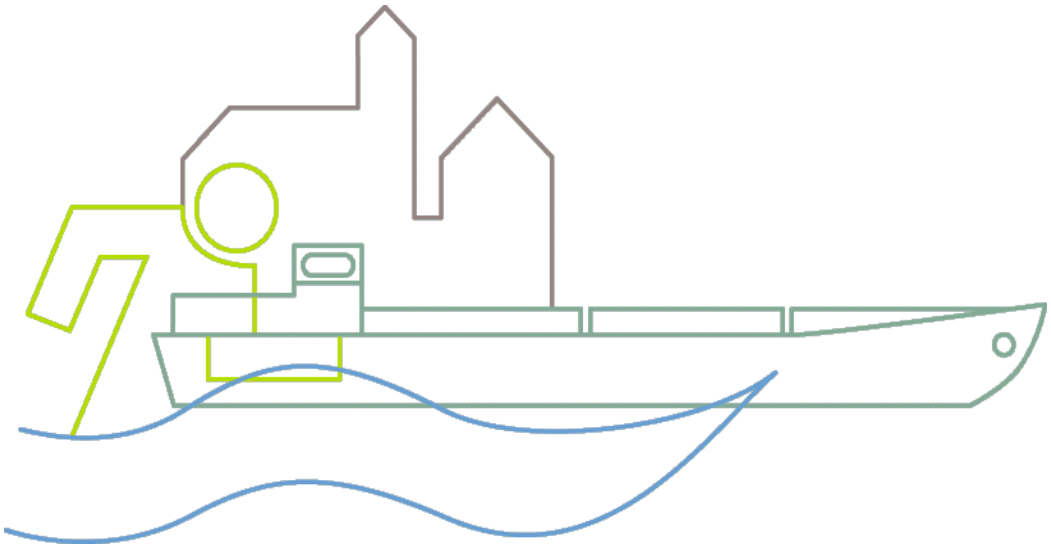
5 turbines:

Estimate via discharge duration curve :

- Portion of susp. load weir channel on average: ca. 20 – 25 %
- Portion of discharge weir channel on averge: ca. 9 %

- less sediment input to deposition areas
  → lower deposition rates
- but: lower discharges in deposition areas
  → potentially less erosion

$\Sigma = ?$



Thank you!

Dr.-Ing. Gudrun Hillebrand

Federal Institute of Hydrology

Department M3 – Groundwater, Geology, River Morphology

56068 Koblenz, Germany

e-Mail: hillebrand@bafg.de

www.bafg.de