Methods for measuring and modelling plastic transport and accumulation in large rivers

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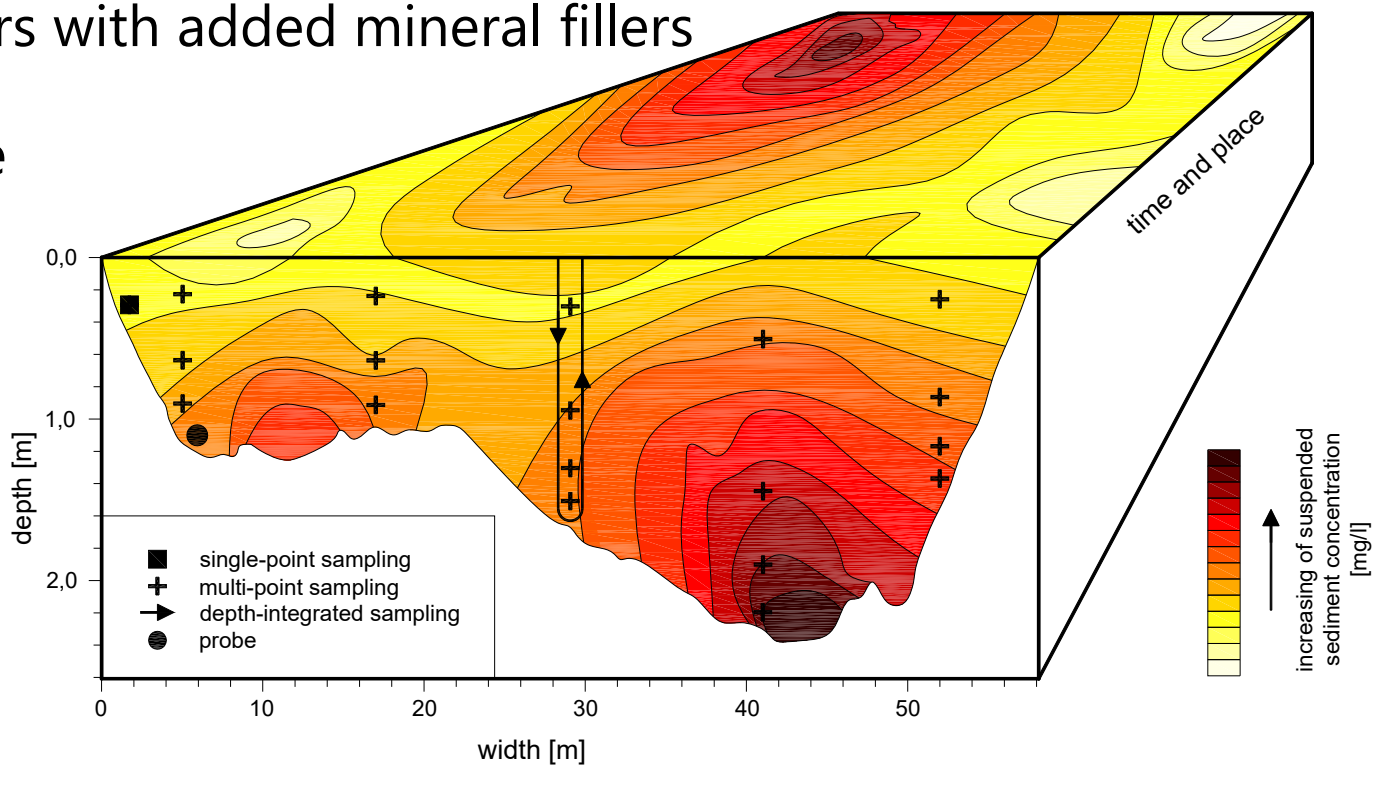
Measurements

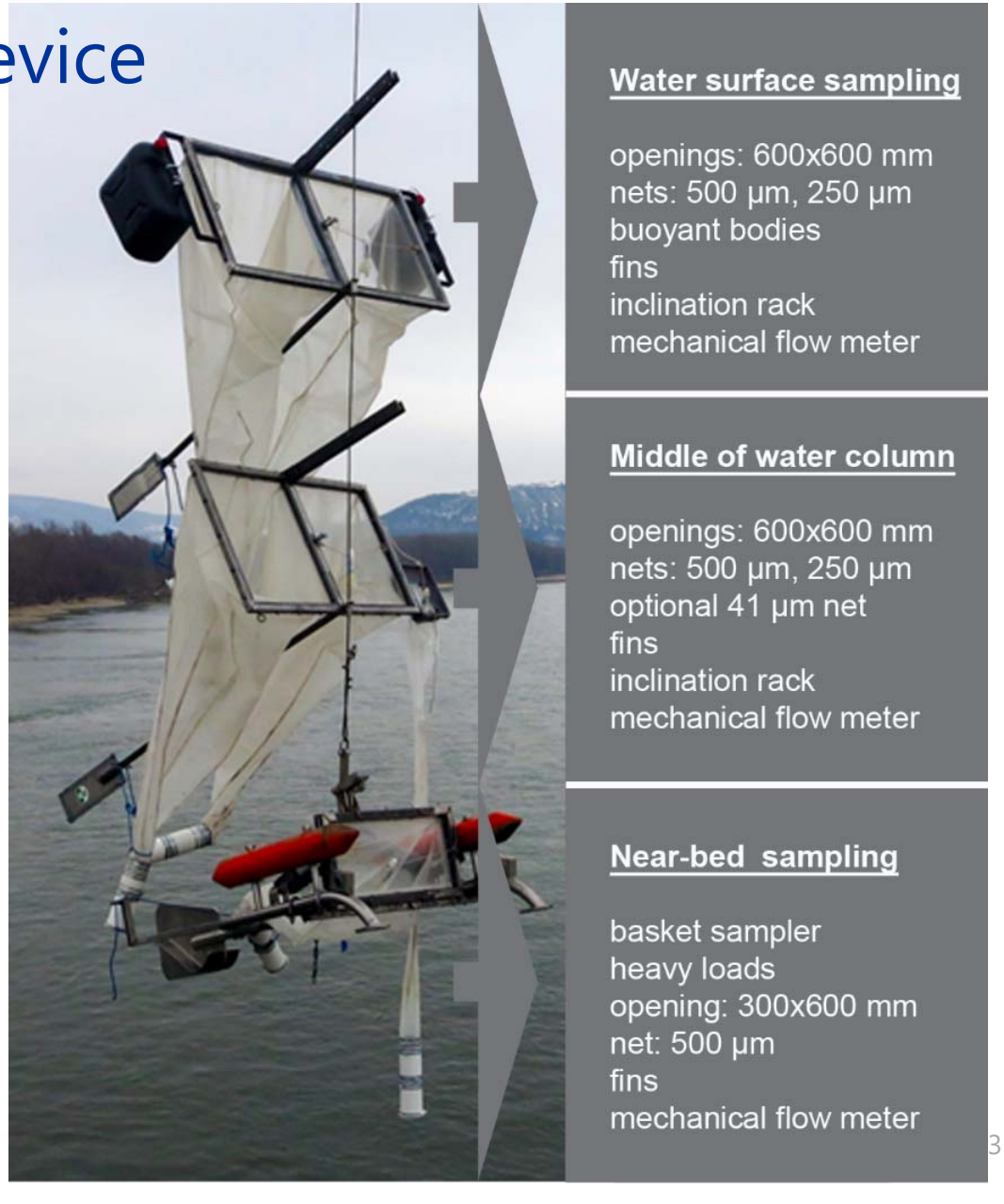
- Plastics consist of different polymers that can be buoyant, neutral, or sink (Anderson et al., 2016; Cole et al., 2011)
- Higher density polymers with added mineral fillers
- Plastic particles change in size and density by aggregation or by the growth of biofilms
- → A methodology addressing multiple depths is needed (comparable to suspended sediment sampling)



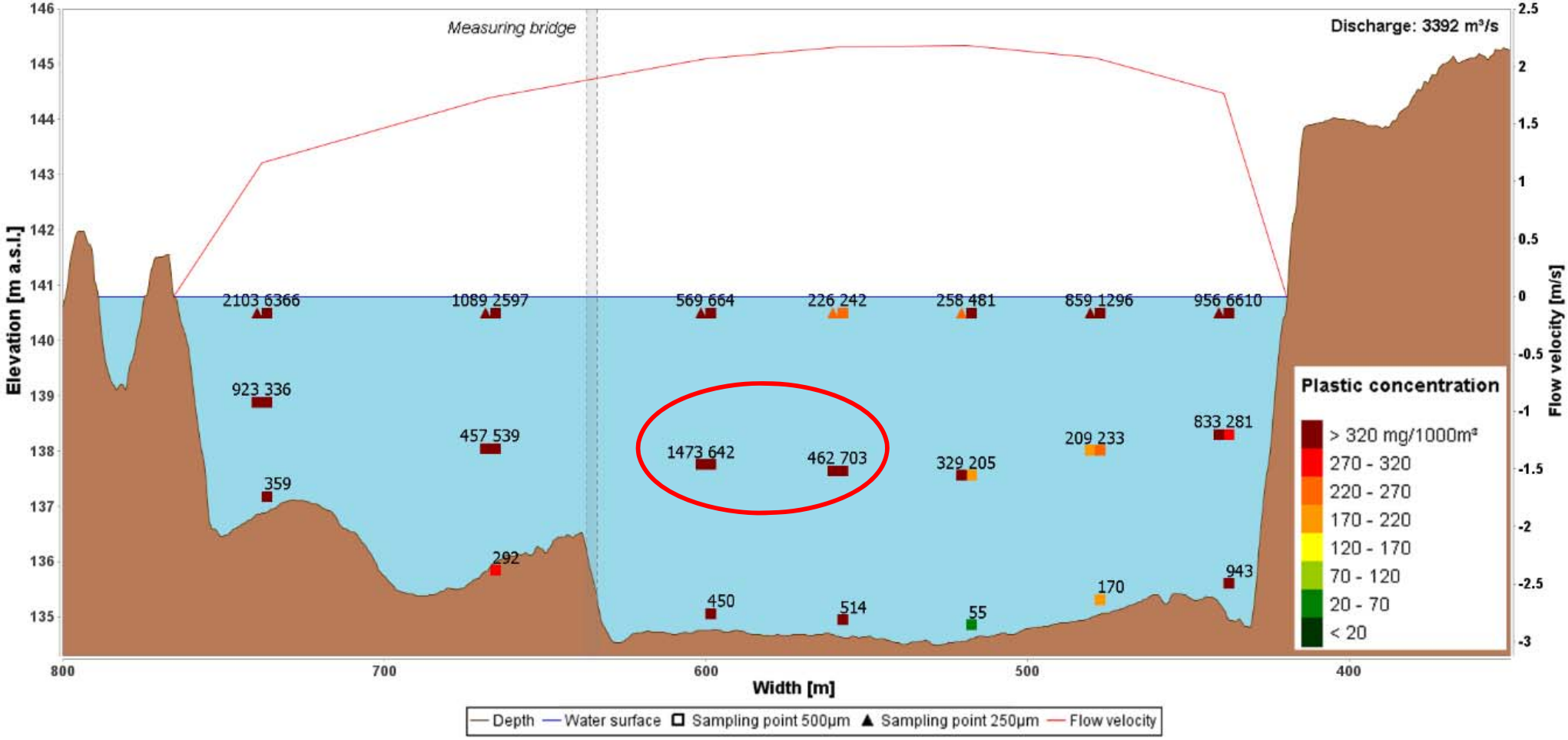
(Haimann et al., 2014)

Measurements - New device

- New device was constructed for collecting measurements in medium- and large-sized natural streams
- High flow velocities and turbulence provide a demanding environment especially when handling large-sized nets
- Adapted basket sampler (BfG sampler) currently used by the Federal Institute of Hydrology in Koblenz, Germany

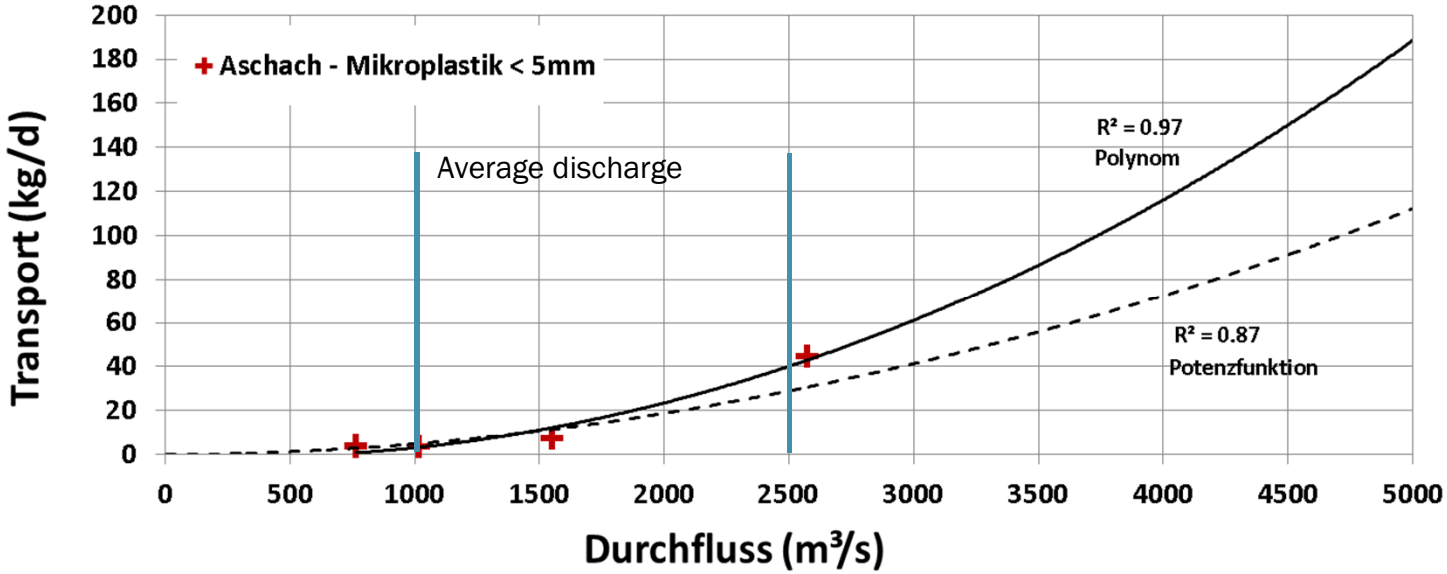


Measurements – Results Danube Hainburg



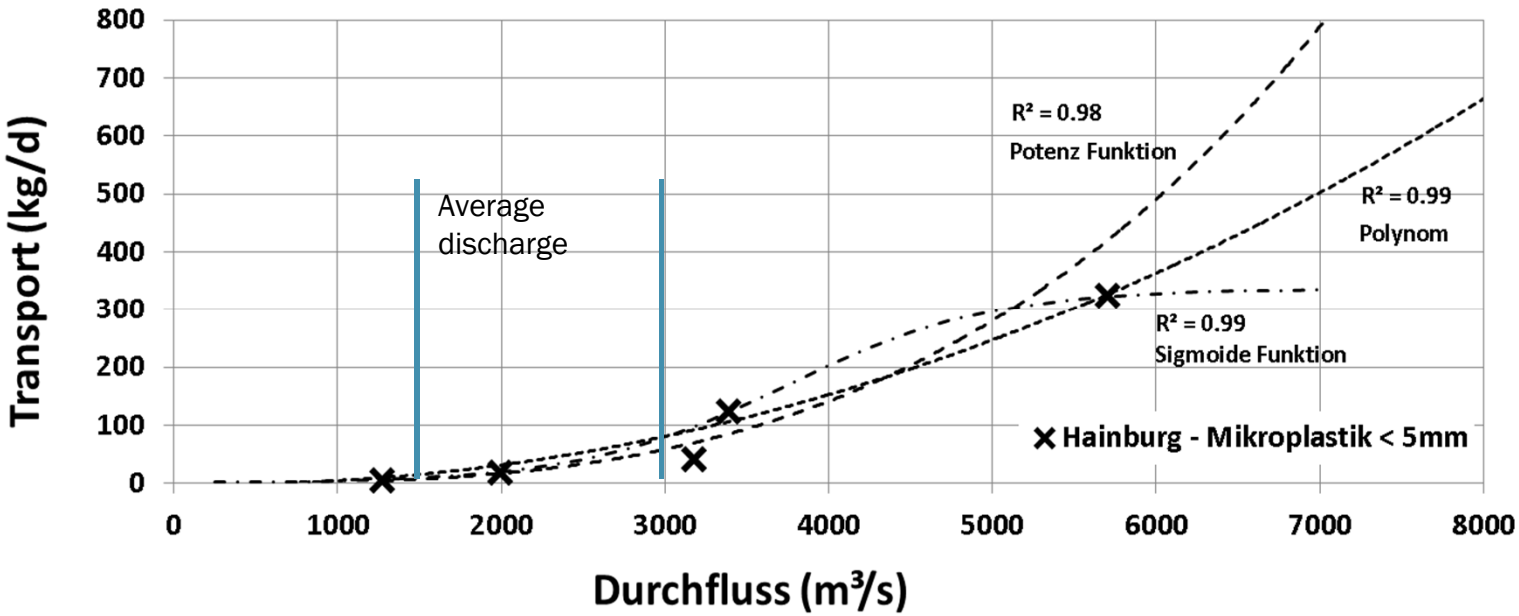
- Example multi-point measurement (Danube, Hainburg); 13.01.2015 at a discharge of 3.392 $m^3 s^{-1}$; Plastic conc. [mg/1000m^3] is displayed for each net

Measurements - Results – yearly yield Microplastic (0.5-5mm)



Yield Hainburg (micro-plastic) in an average year < 20 t/a
(may vary drastically depending on flow conditions and flood events)

- Micro-plastic transport at Hainburg at average discharge values: 15 - 80 kg /d
- more measurements are needed !!



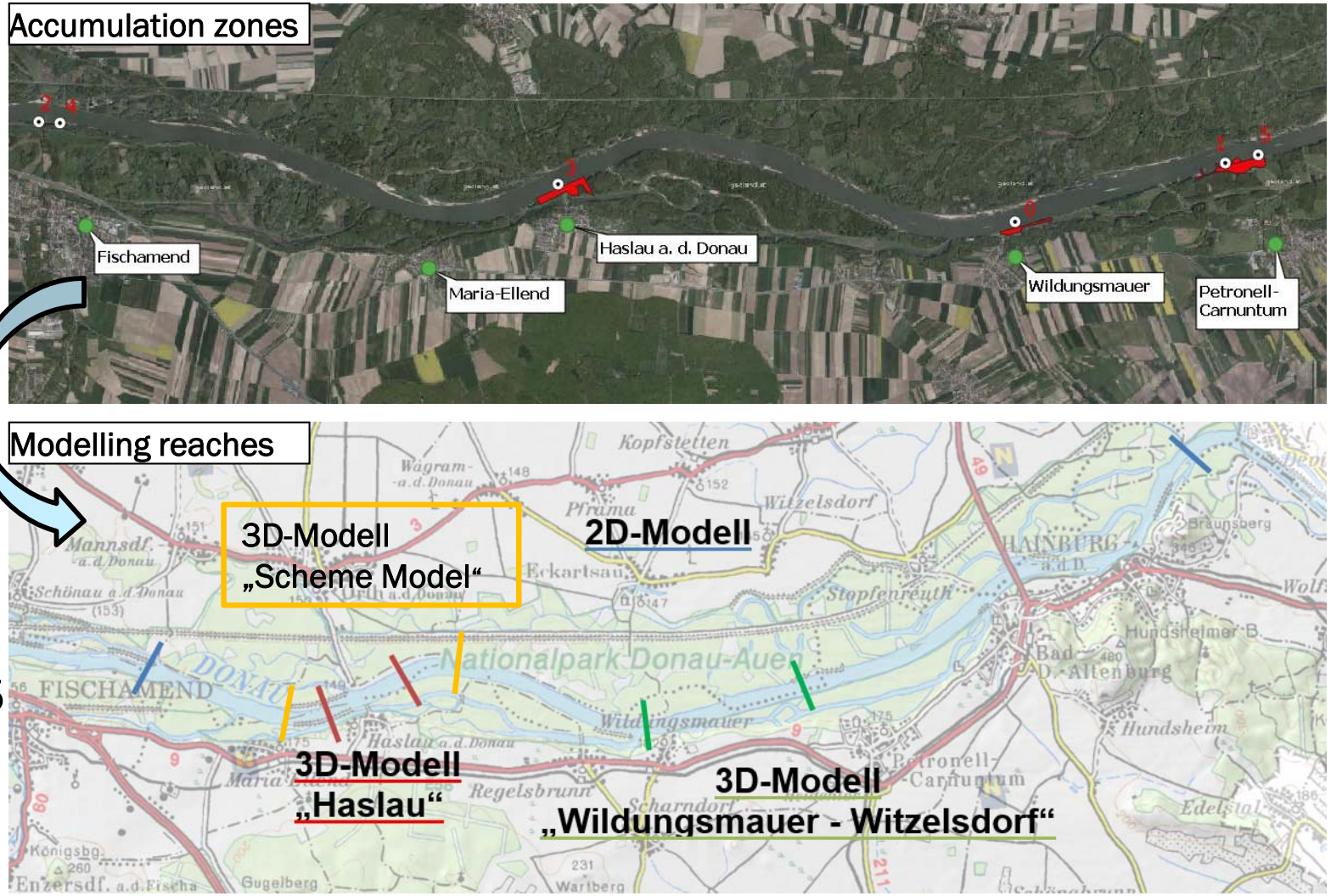
Measurements - Waste water treatment plants

A relevant quantity of micro plastic in rivers can be explained by plastic passing waste water treatment plants

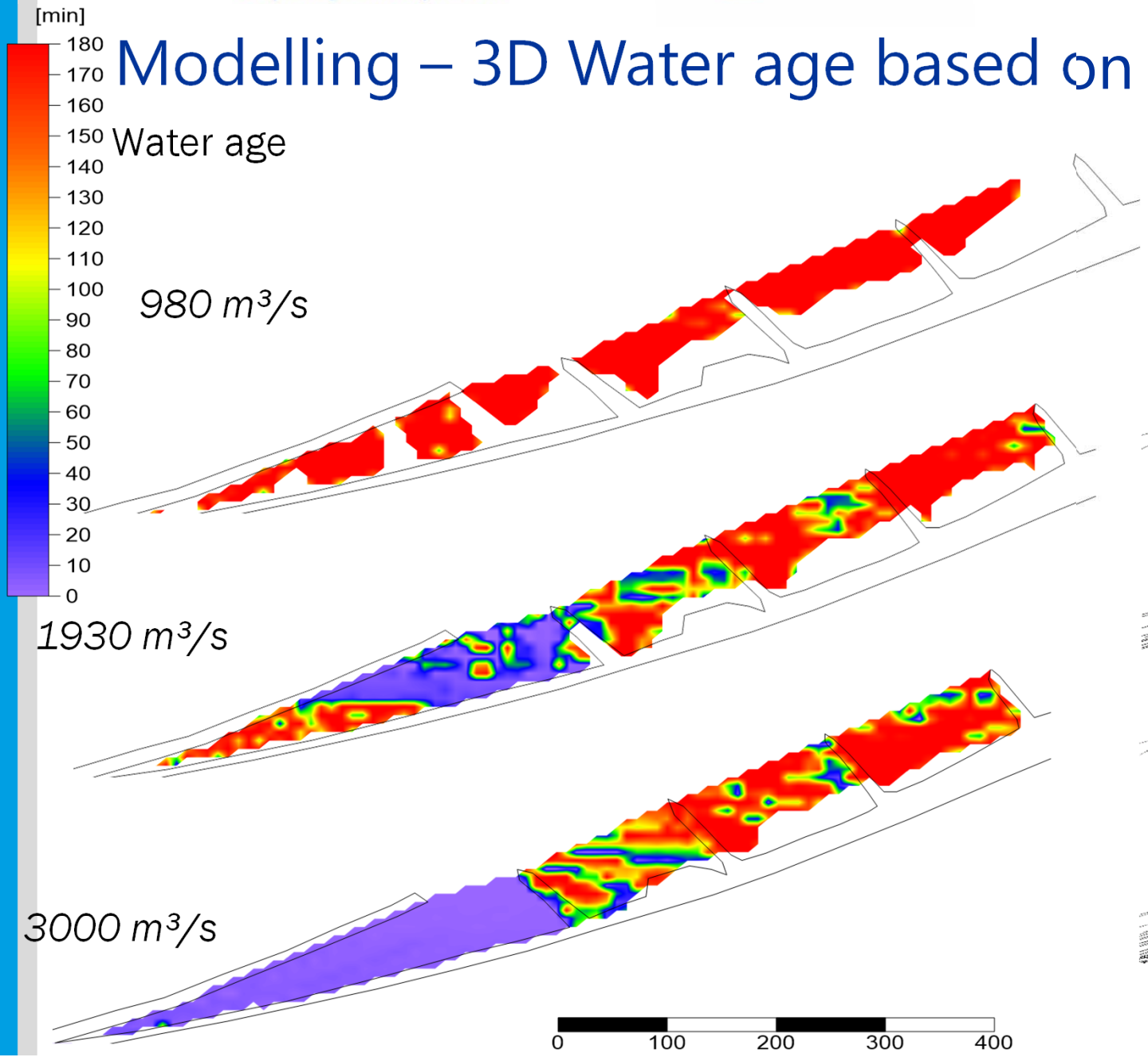
Measured micro-plastic:
96 - 320mg/1000m³

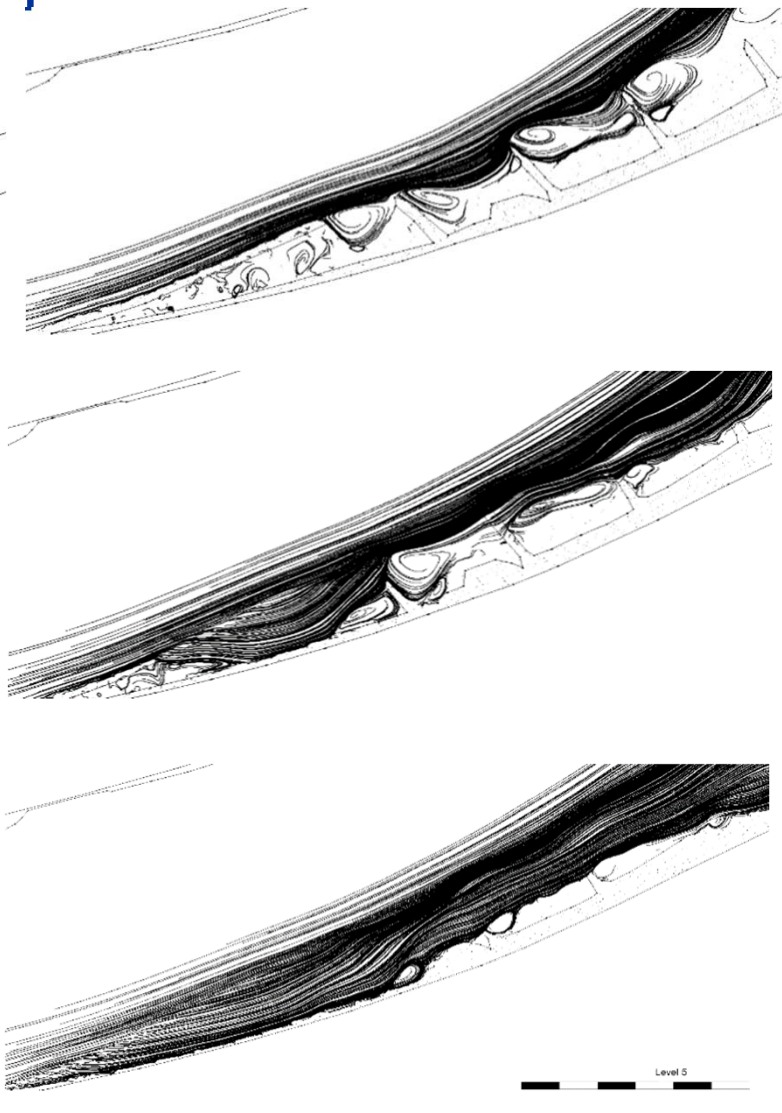
Modelling - Accumulation Zones

- 3D numerical model Haslau (2,5 km)
- 3D numerical model Wildungsmauer-Witzelsdorf (4,2 km)
- 2D large scale model Vienna-Bratislava (25,6 km)



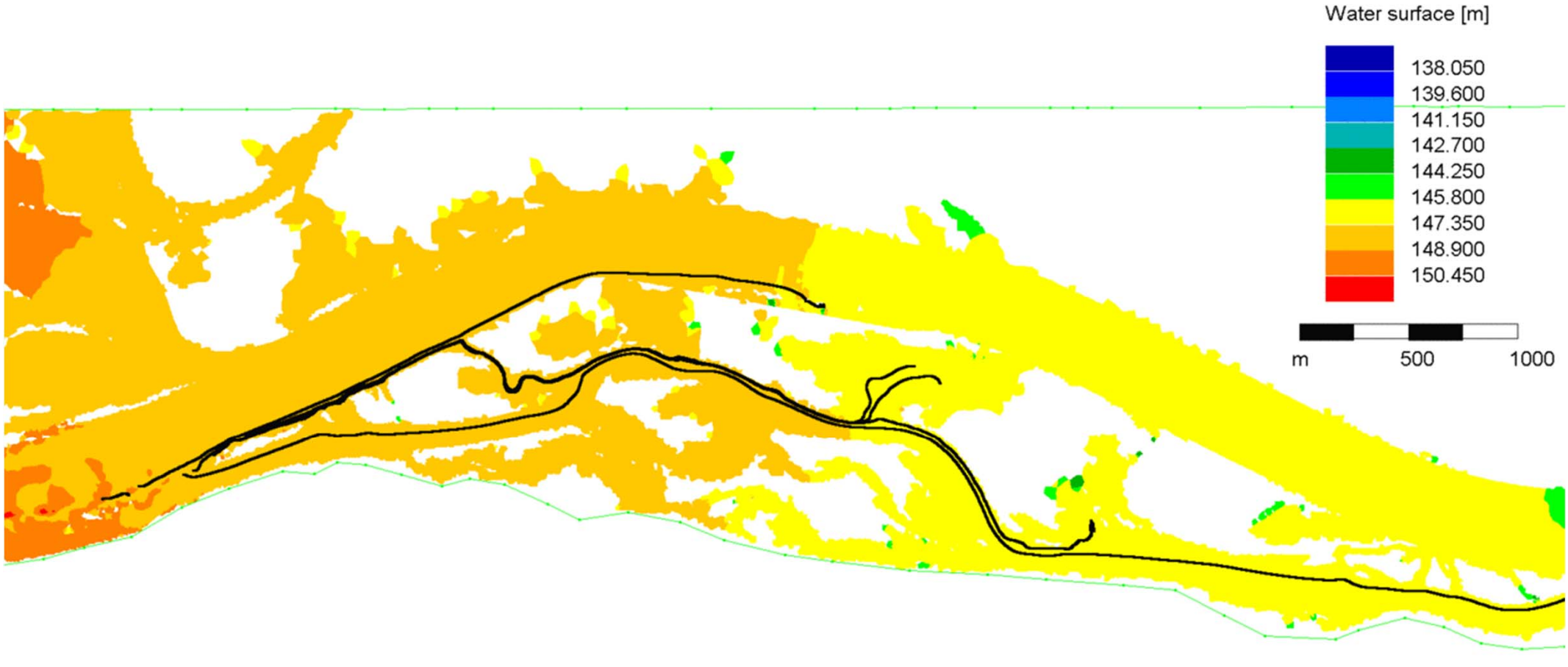
Modelling – 3D Water age based on particles





Modelling – 2D Large Scale model – Particle movement

Particle Tracing (2D) – Innundation area

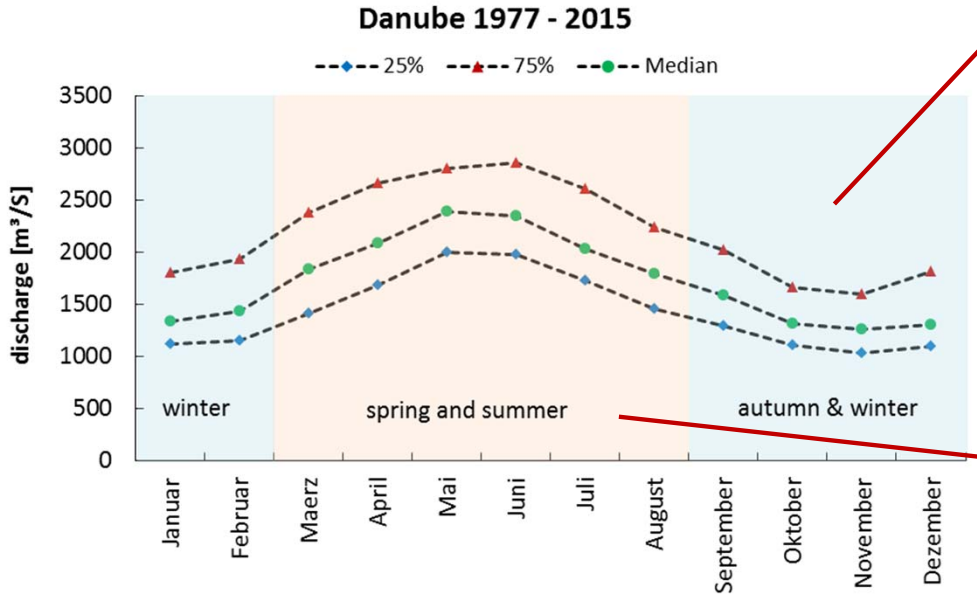


Modelling – shore line splash zone

Autumn & Winter: Q1000 – Q2000

Characterisation of accumulation zones

- Bank near/shore line accumulation
  - Classification of discharge periods based on 25% and 75% quartiles

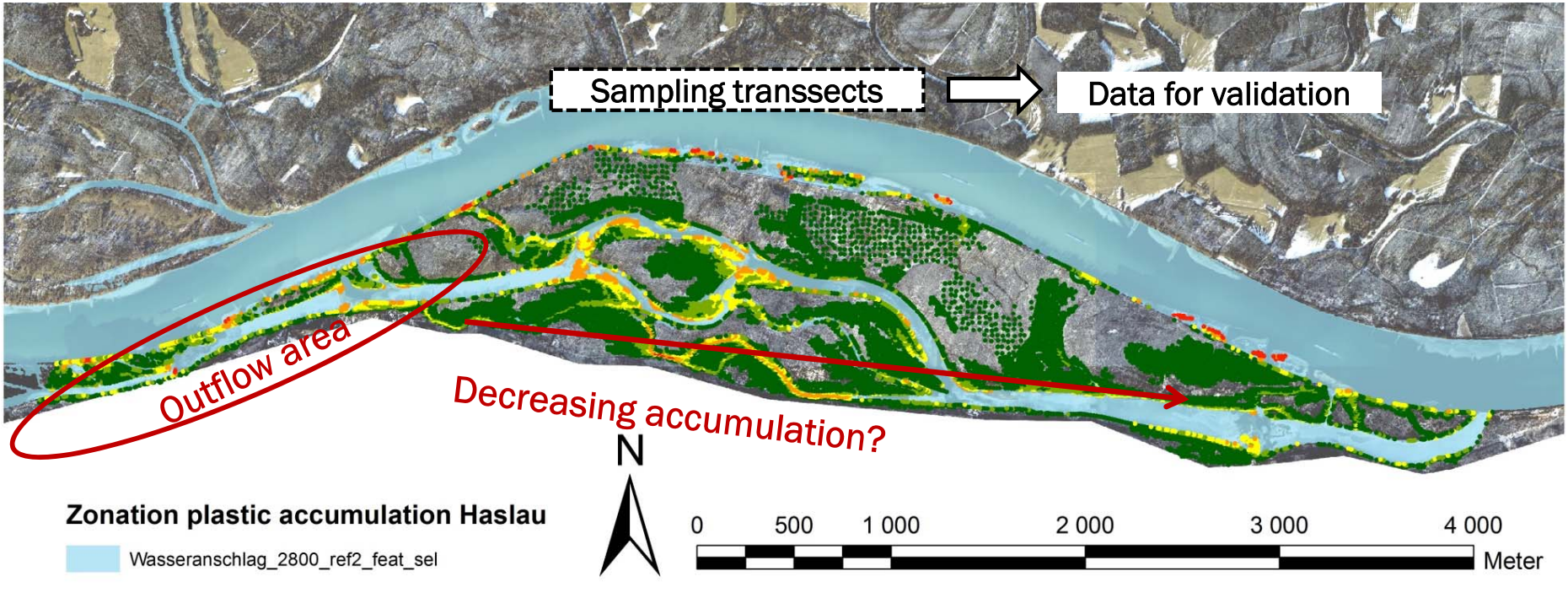


Spring & Summer: Q1450 – Q2850

Numerical Model

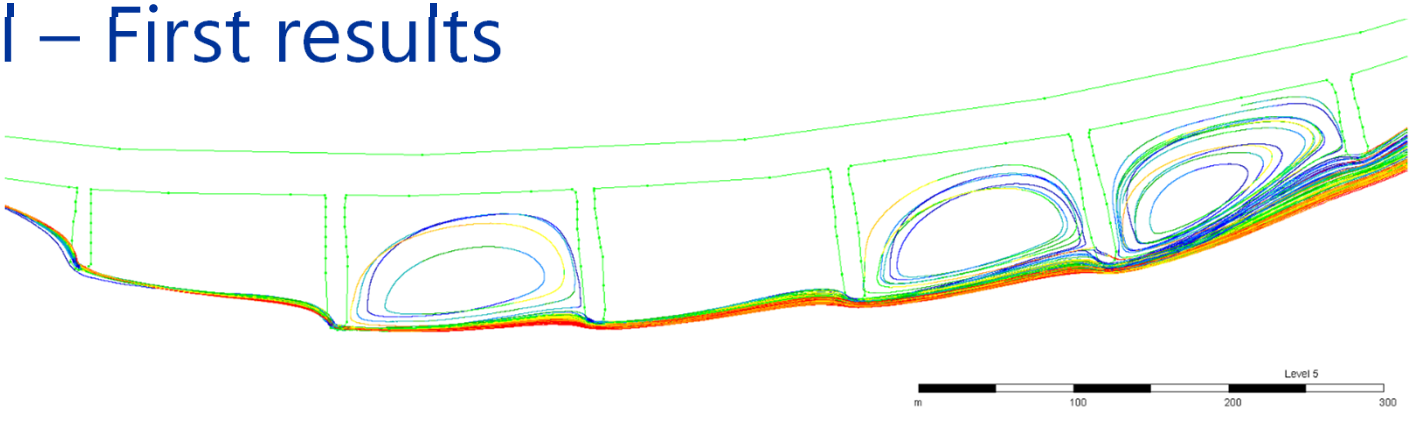
- Flood plain accumulation
  - High accumulation potential related to specific discharge
  - Decreasing accumulation potential depending on the distance from the outflow caused by filtration effect of vegetation

Specific discharge (m^3/m^2) in the innundation area Haslau at Q6000 m^3/s

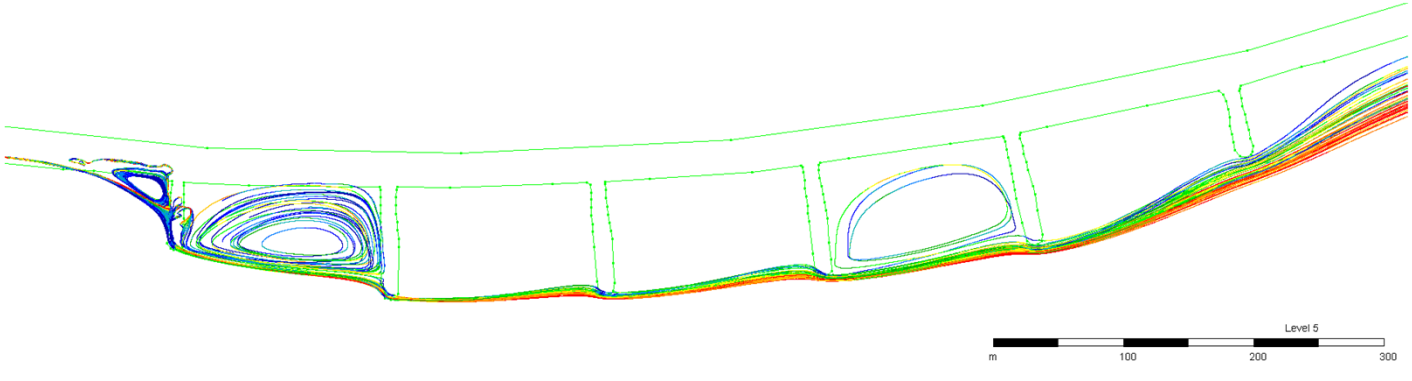


Schematic model – First results

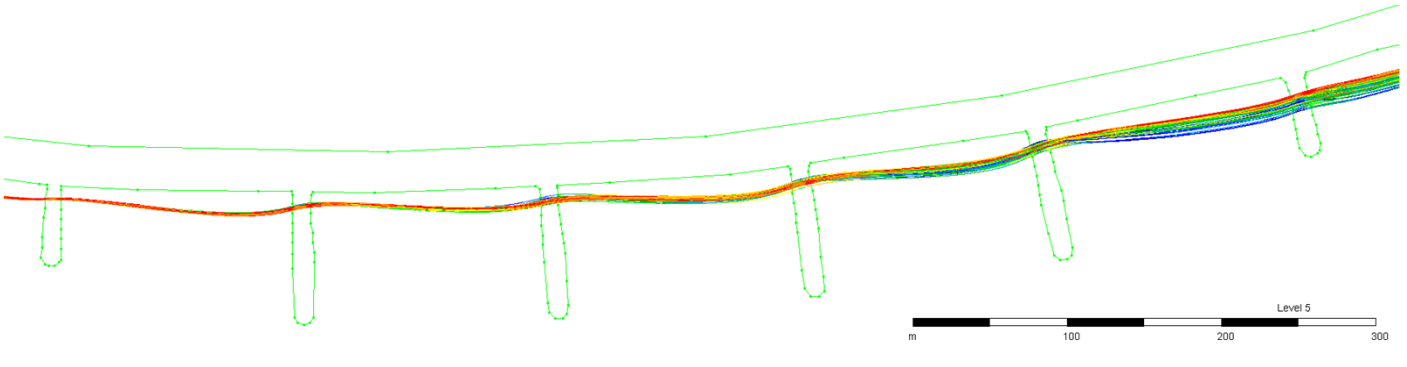
Q: 1800 m^3



MQ: 1930 m^3



Q: 3000 m3



Conclusions

- New device was developed for measuring plastic transport at multiple depths in medium and large natural streams
- The methodology is applicable and leads to profound results (Liedermann et al., 2018)
- Comparably measured data from other Rivers would be interesting!
- Plastic transport at the Danube varies between 15 to 80 kg / day; Yearly loads at Hainburg (micro-plastics) in an average year < 20 t/a
- A relevant quantity of micro plastic in rivers can be explained by plastic passing waste water treatment plants
- Particle movement can be reproduced by numerical models
- Hydrodynamic modelling serves as a perfect tool for explaining acculumation zones and finding particle paths (where does it come from, where does it go?)

Thank you for your attention!