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Innovations in the water sector in Austria

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Part I: *Powering a large wastewater treatment plant with renewable energy*

Photo: Christian Houdek, ebswien

Background: Renewable Energy Directive (RED)

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

- establishes a common framework for the promotion of energy from renewable sources
- sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport
- lays down rules relating to statistical transfers between Member States, joint projects between Member States and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources
- establishes sustainability criteria for biofuels and bioliquids

EU targets and national targets for Austria

Share of renewable sources in gross final consumption of energy:

- 2005: National target: 23% / EU-target: 8.5%
- 2020: National target: 34% / EU-target: 20%
- 2030: National target: 45% / EU-target: 32%
  → proposal in 2021 expected to raise EU-target to 38-40%
  → national target for electrical energy: 100% in 2030
- Achievement value in Austria in 2020: approx. 33%

➔ In order to achieve targets for 2030, sharp increase in share of renewable sources is required!

Wastewater treatment plant Vienna

- 99.8% of Viennese households connected to WWTP
- Vienna has a combined drainage system (stormwater + wastewater)
- Maximum capacity: 4 million resident equivalents
- Average capacity: 3.1 million resident equivalents
- Average inflow discharge: 6 m^3/s
- Maximum inflow discharge: 18 m^3/s
- Minimum removal efficiency: BSB_5 >95%, CSB >85%, TOC >85%, Nitrogen >70%
- Mechanical treatment, 2 stages biological treatment, sludge treatment
- Annual electrical power consumption: 60 GWh (equivalent to 1% of total electrical energy production by Vienna‘s public power utility)

Project E_OS: Energy optimization sludge treatment

- Project run-time 2015 to 2020
- Phase 1: Renewal of existing biological treatment basins → volume increased by 50%, but on smaller area (higher basins)
- Free area used for sludge treatment


Photo: Christian Houdek, ebswien

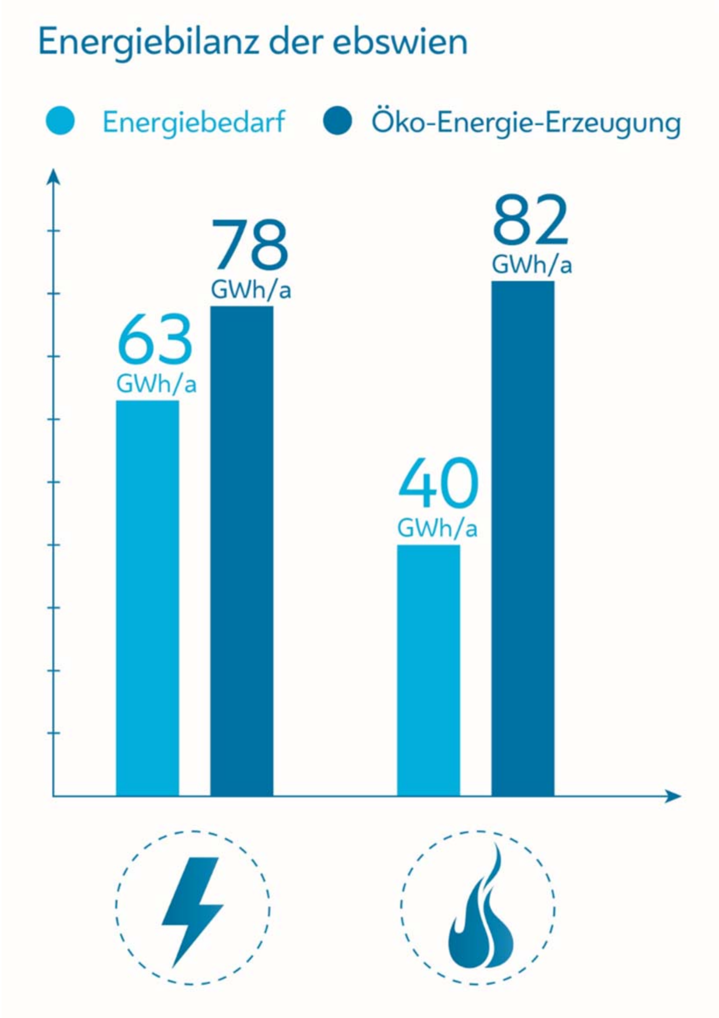
Project E_OS: Energy optimization sludge treatment

- Phase 2: Building of six new digestion tanks
- Height: 30 m, volume 75.000 m³
- 25 days digestion period → digester gas (2/3 methane)
- 20 million m³ digester gas annually
- Usage of biogas in combined heat and power plant with 80% energy efficiency

Photo: Christian Houdek, ebswien

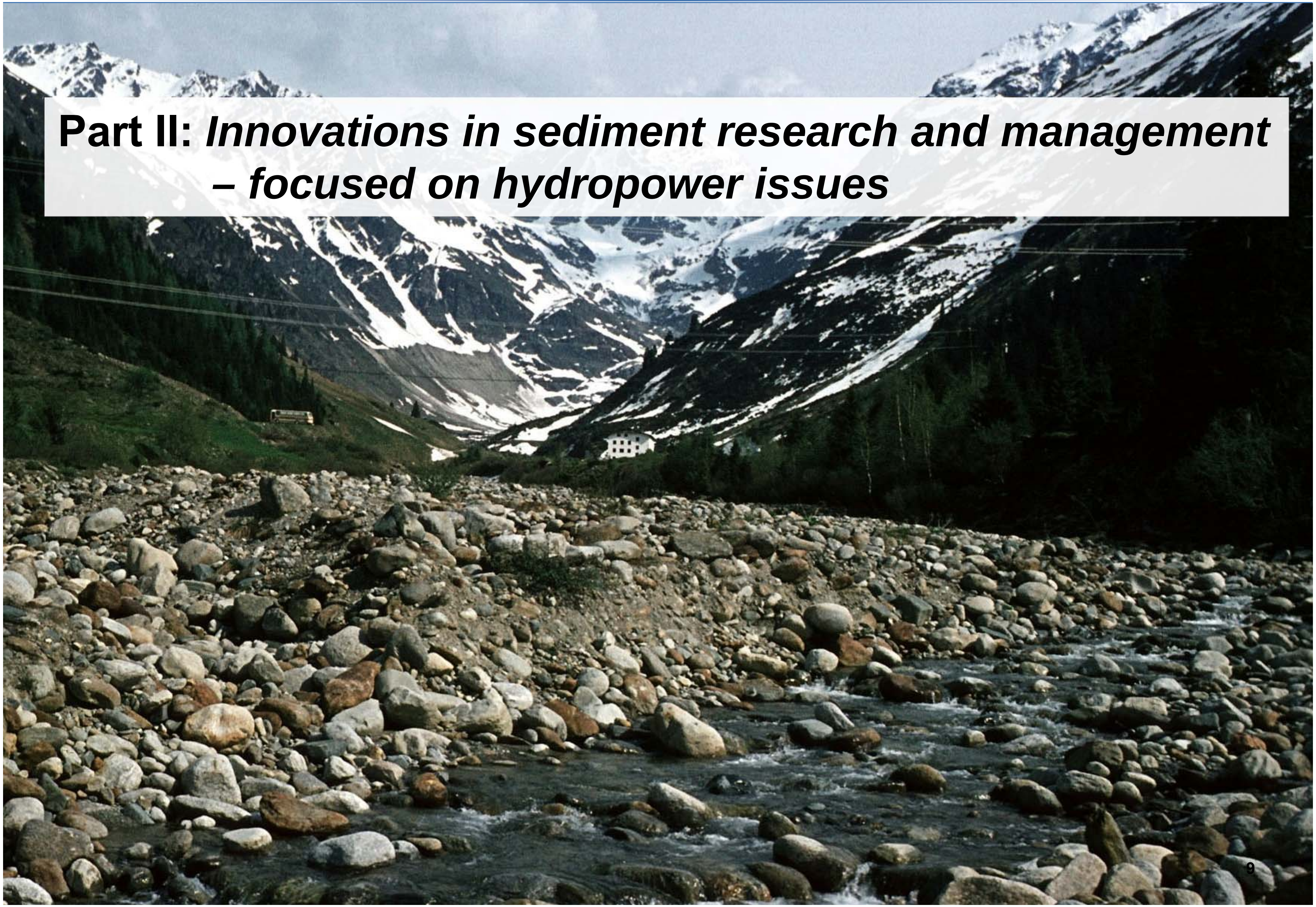
Project E_OS: Energy optimization sludge treatment

- Project inauguration: June 2020
- WWTP powered now completely by renewable energy (both electrical and thermal energy)
- Surplus energy used in municipal network



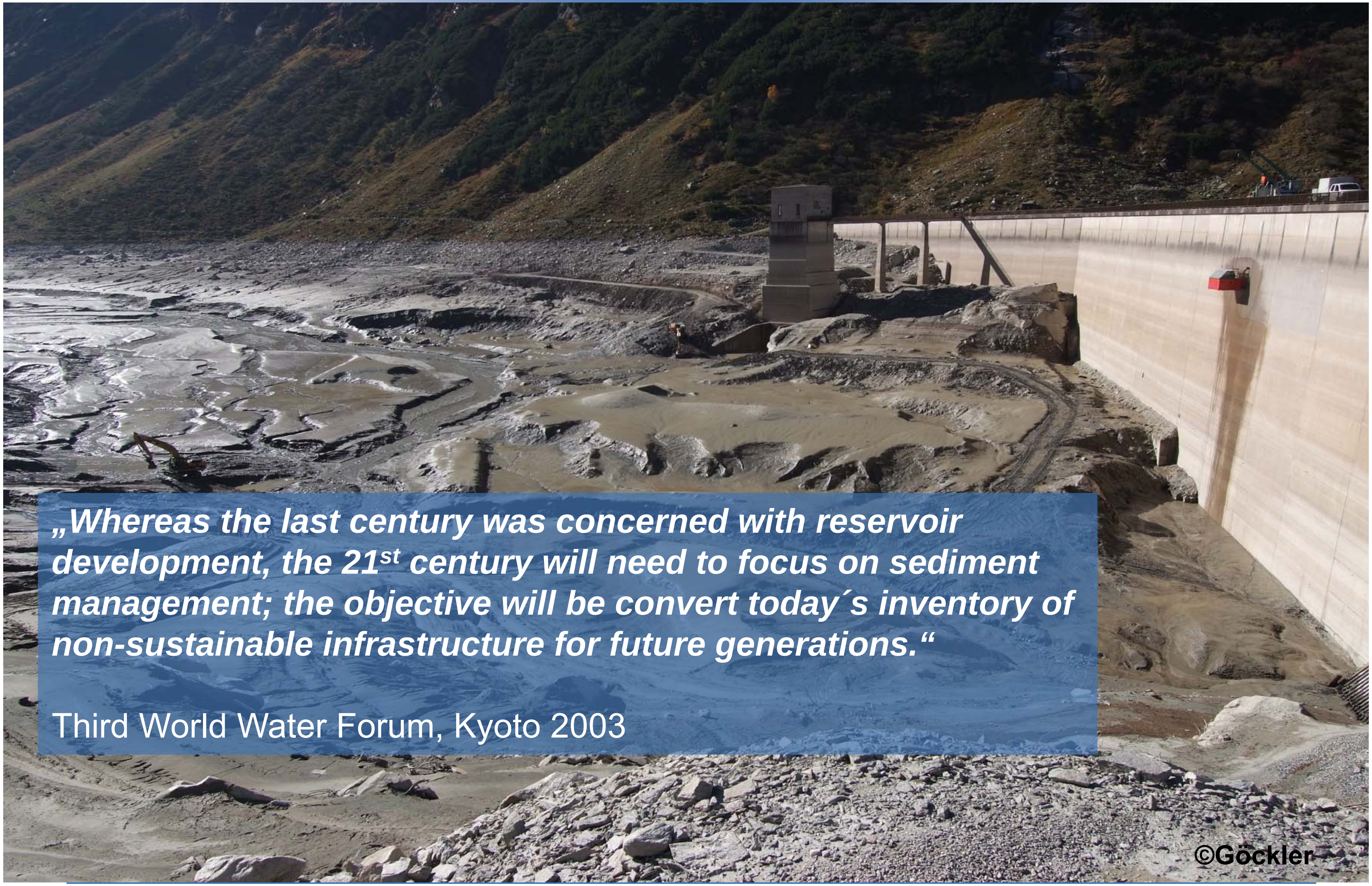
Source: ebswien

Part II: *Innovations in sediment research and management – focused on hydropower issues*



Background: Hydromorphological Quality Components according to the Water Framework Directive

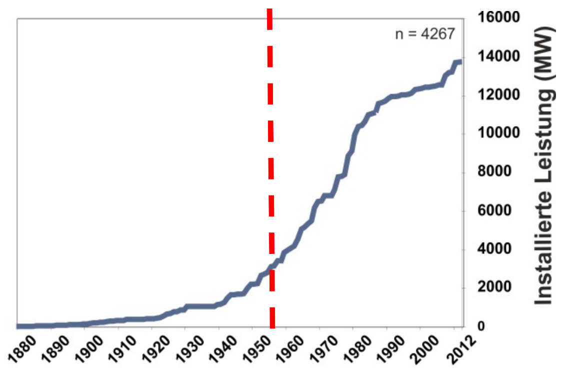
Element	High Status
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.



„Whereas the last century was concerned with reservoir development, the 21st century will need to focus on sediment management; the objective will be convert today´s inventory of non-sustainable infrastructure for future generations.“

Third World Water Forum, Kyoto 2003

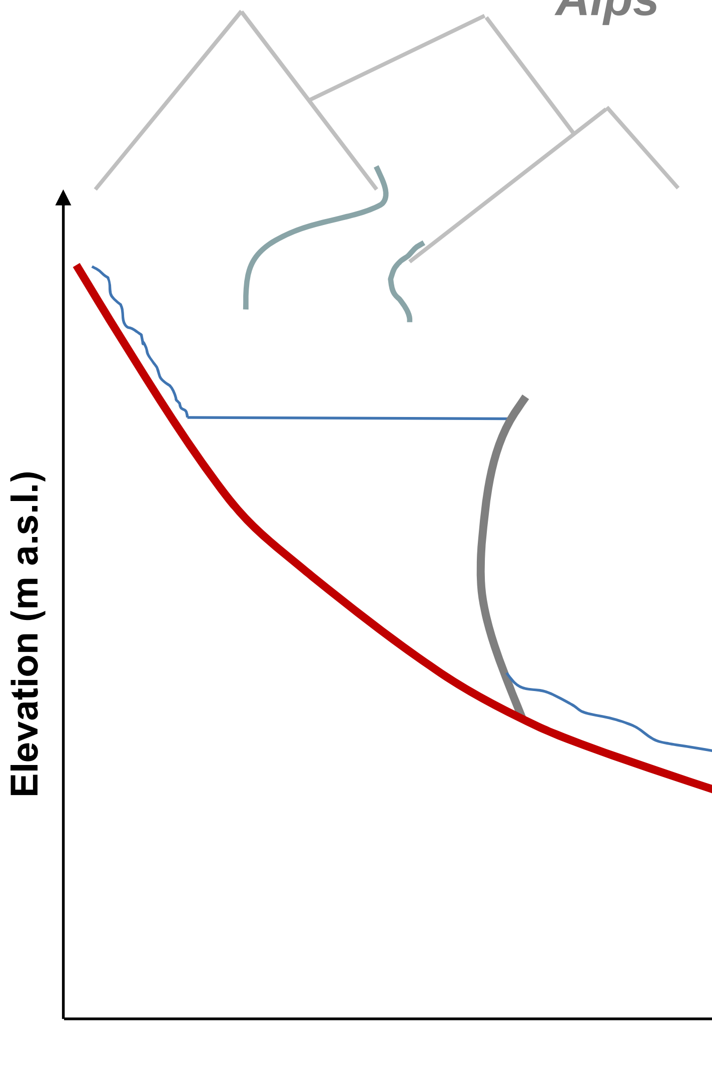
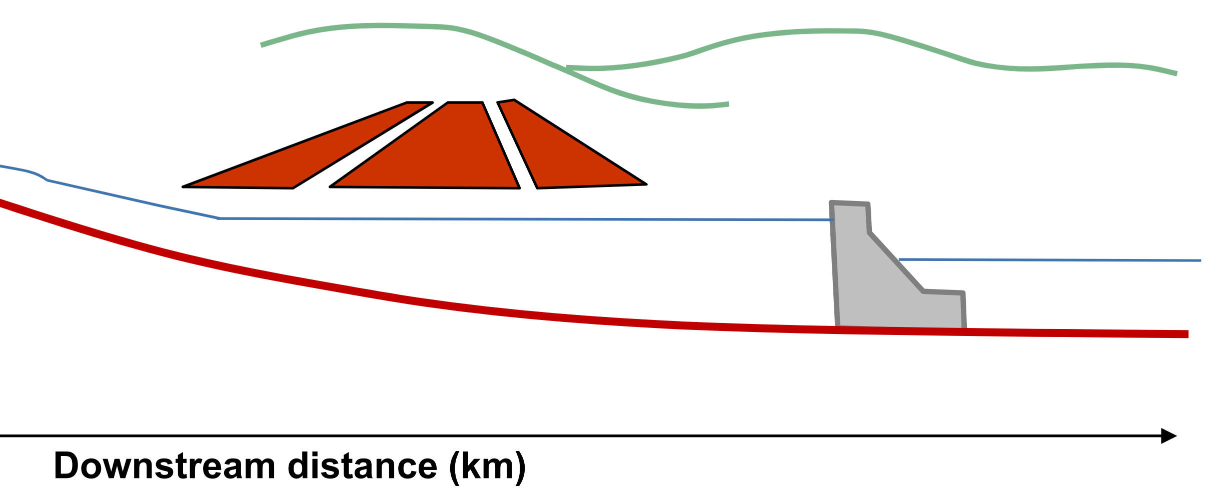
Hydropower in Austria



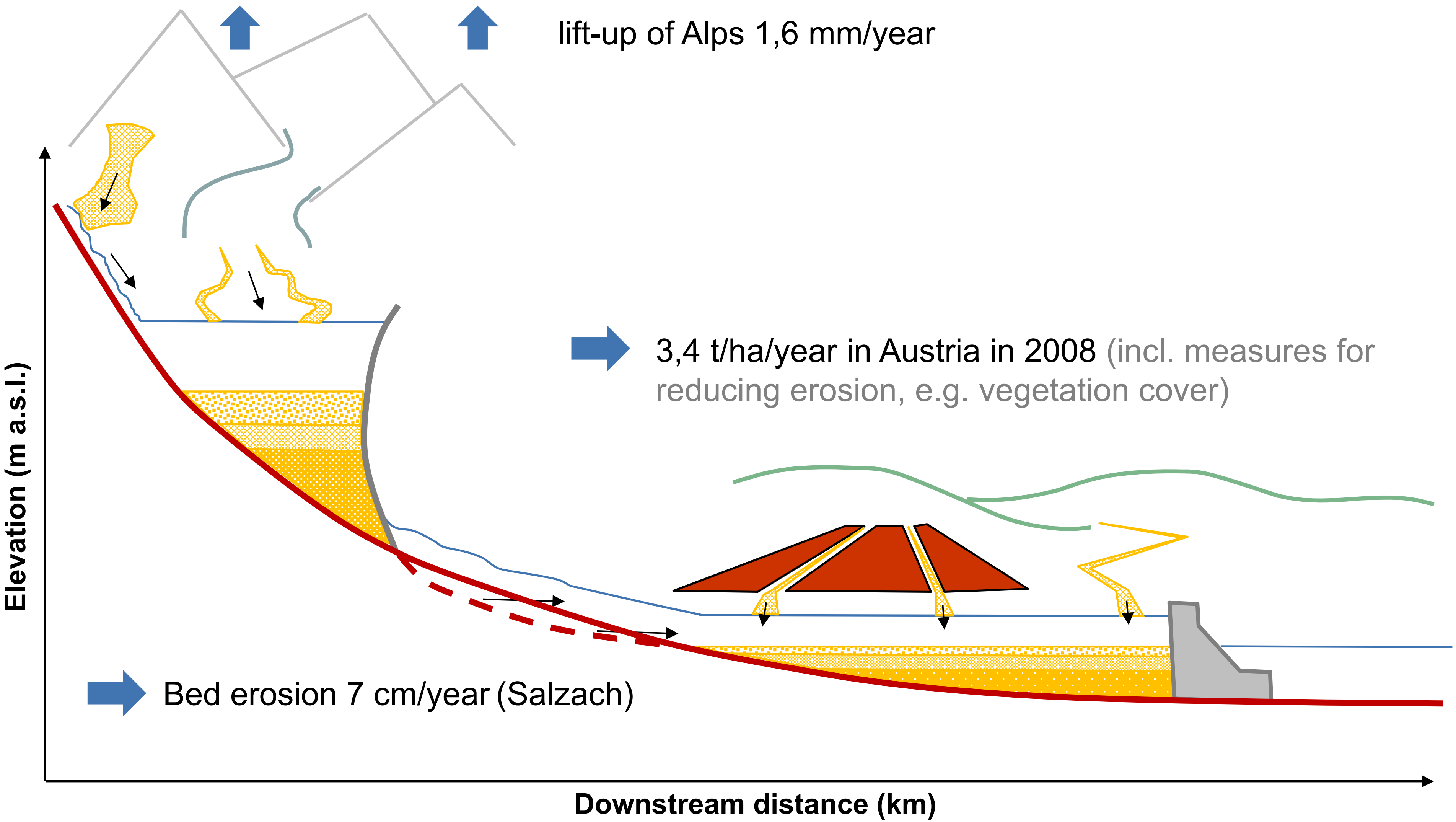
(Wagner, et al., 2015)

Kaprun (1952)

Ybbs-Persenbeug (1959)

Hydropower / sedimentation



Sedimentation in reservoirs (global view)

Region	Storage capacity for hydropower use: 80% of the reservoir is filled up with sediment
Africa	2100
Asia	2035
Australia & Oceania	2070
Central America	2060
Europe	2080
Middle East	2060
North America	2060
South America	2080

ICOLD, Basson (2009)

measures / costs

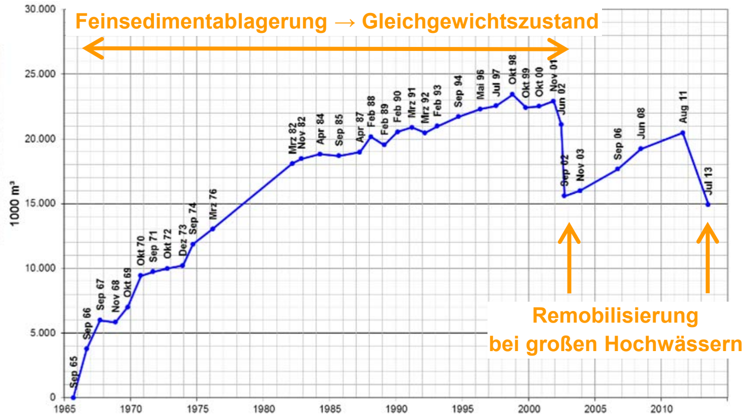
economic importance

At the moment **costs** for **depositing** of dredged material in Austria **10 – 20 €** per m³.

dredging

flushing

Flood impacts

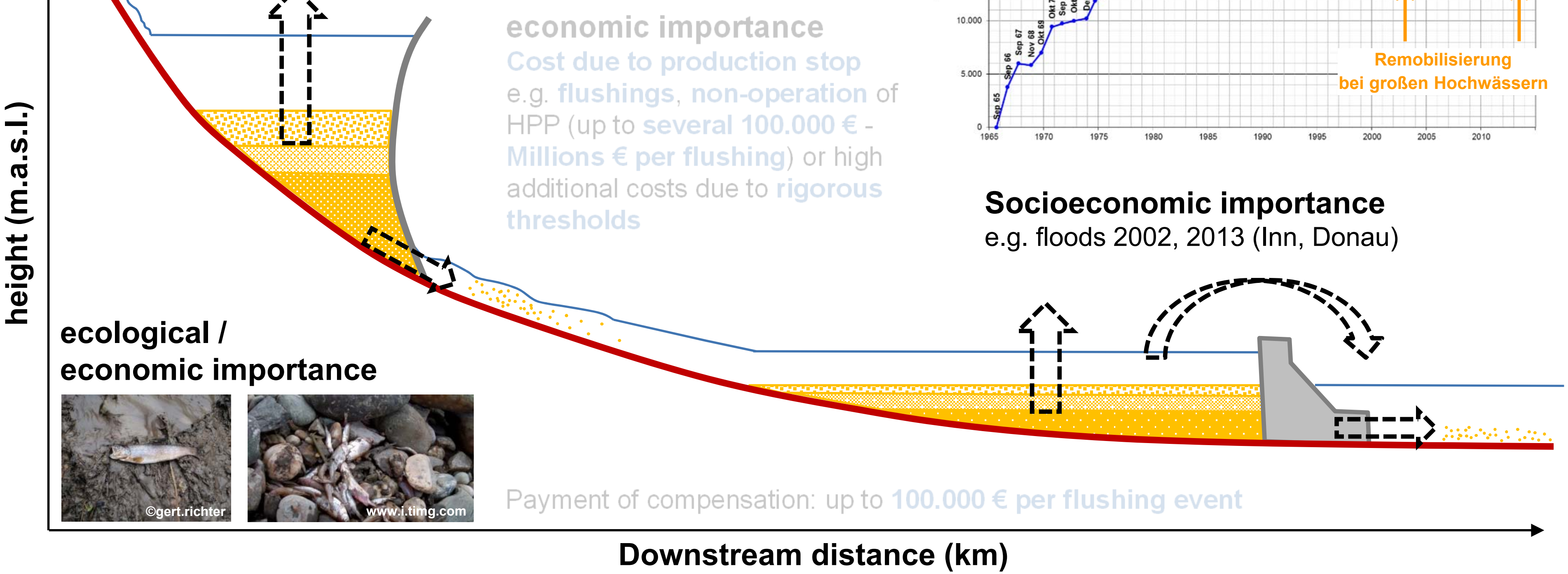


economic importance

Cost due to production stop
e.g. **flushings**, **non-operation** of HPP (up to **several 100.000 € - Millions € per flushing**) or high additional costs due to **rigorous thresholds**

Socioeconomic importance

e.g. floods 2002, 2013 (Inn, Donau)



ecological / economic importance

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Payment of compensation: up to **100.000 € per flushing event**

Sustainable sediment management not possible up to now:

(i) Lack of basic information / technologies for reservoir management

(ii) Lack of process understanding

(iii) Missing adjustment of sediment management opportunities in reservoirs

(iv) Insufficient infos of the interaction sediment dynamics / aquatic ecology

(v) No concepts concerning the (re-)use of deposited sediments

CD-Laboratory „Sediment research and management“

Module 1 (Verein für Ökologie und Umweltforschung)

Verbund, Vorarlberger Illwerke AG, tiroler wasser kraft, Salzburg AG, kelag, ÖBB, ENERGIE AG, Ennskraft, EVN, oesterreichs energie.

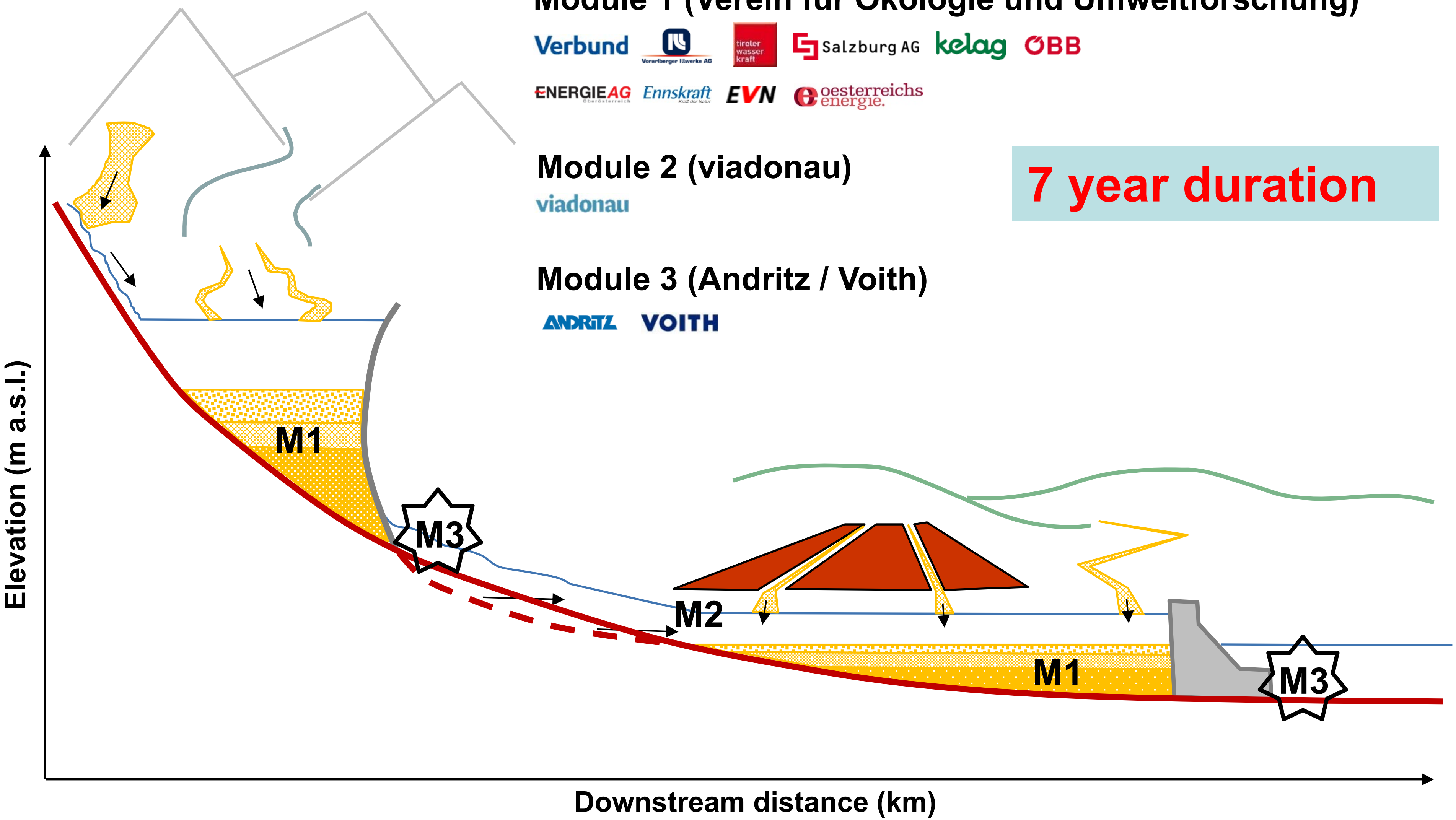
Module 2 (viadonau)

viadonau

Module 3 (Andritz / Voith)

ANDRITZ, VOITH

7 year duration



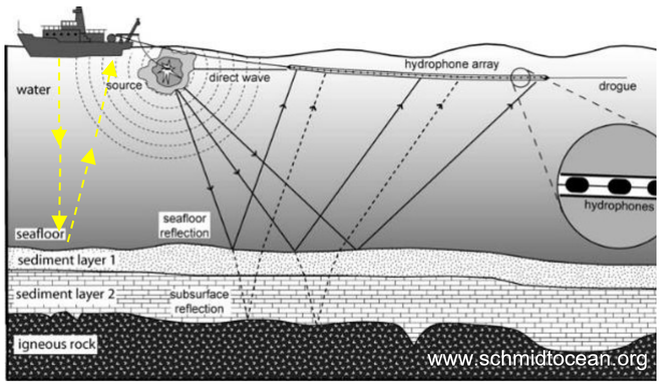
Module 1 – Hydropower

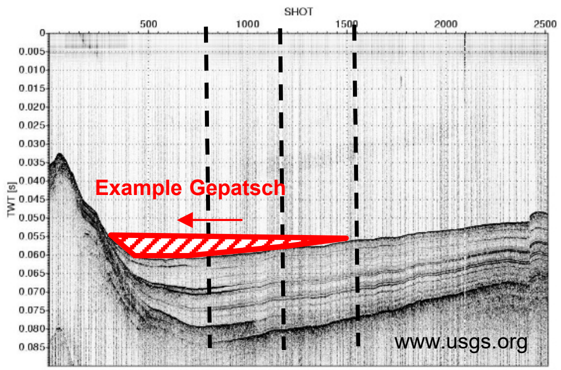
(i) Lack of data for sediment management

Insufficient data of sediment deposits (degree of density, layer-depths, etc.) in reservoirs (basic data for management / numerical modelling)

Methods in the CD-Laboratory:

Testing and development of **new** and **innovative technologies**: **Seismic profiling (offshore-technology)**





Cruise RAFA02031 Chirp Line I41f1 SHOTS 1-2422

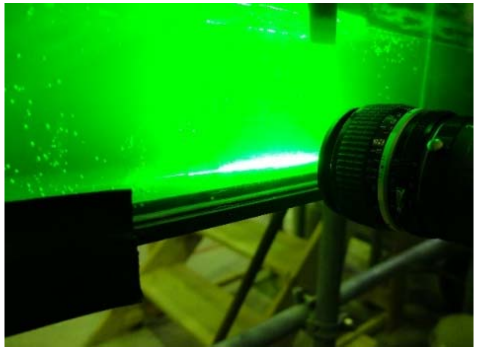
- To standardize seismic profiling according to (i) GSD, (ii) degree of (iii) density and layer depths
- Data for physical laboratory studies according to erosion, remobilisation and consolidation of sediments

(ii) Lack of process understanding

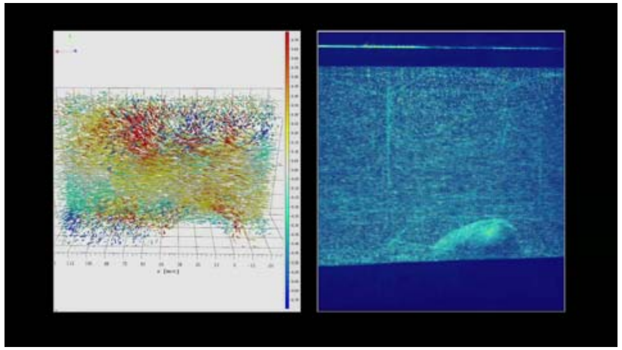
Interaction sediment transport and turbulence / cohesive material and mathematical descriptions:
PIV – measurements in combination with LES (Large Eddy Simulations)

(PIV) BOKU: 1000 hz (detection of coherent structures) – analysis Reynolds-Stress terms

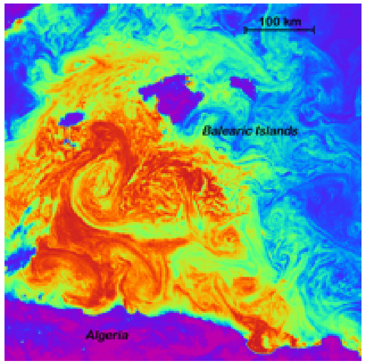
Measurements of shear stress and flow velocity

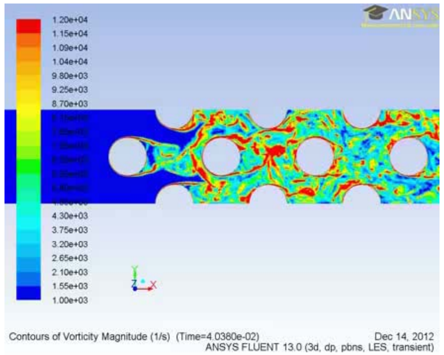


PIV and PTV measurements of sediment dynamics (IWHW – BOKU Wien)

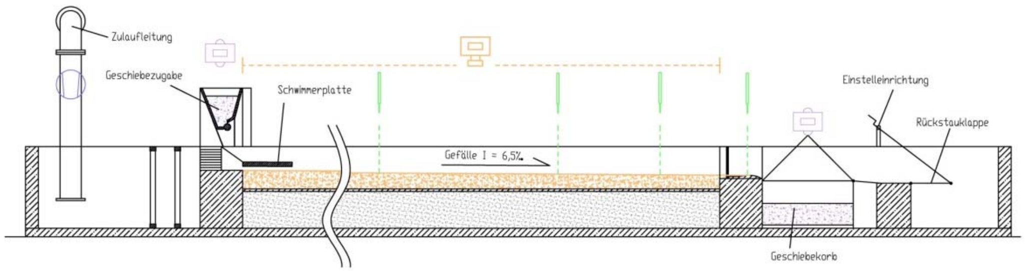


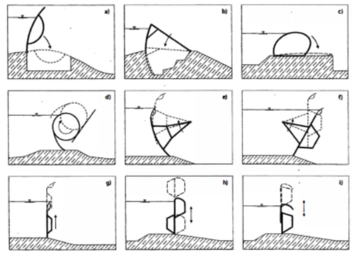
Large Eddy Simulations (LES):

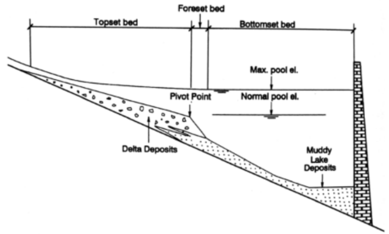




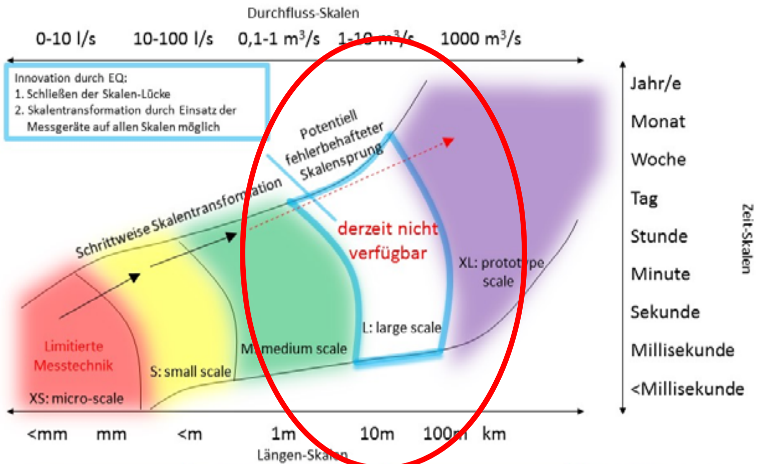
(iii) Missing adjustment of sediment management opportunities in reservoirs

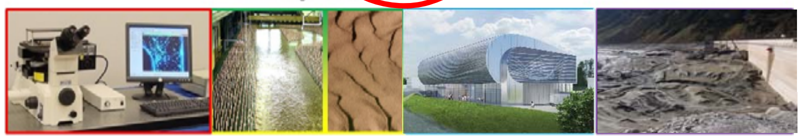


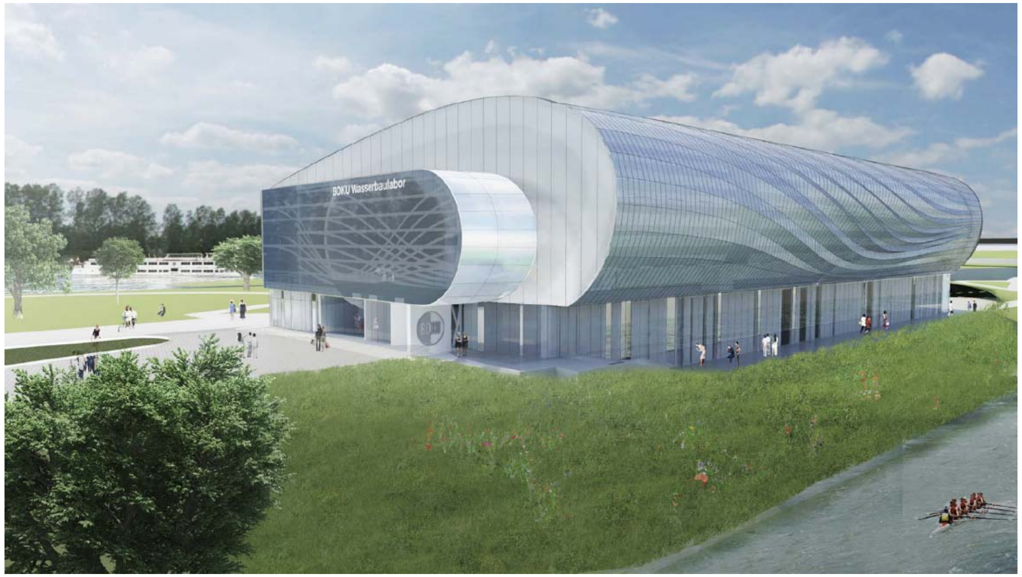




➡ in **small scale physical models** it is not possible, to reproduce **variables** (**viscosity**, **hydraulic-jump**, **roughness**, …) **correctly**. Thus, the **Transferability** of results to nature contains **unavoidable errors**. – especially for **experiments** including **sediment dynamics**.

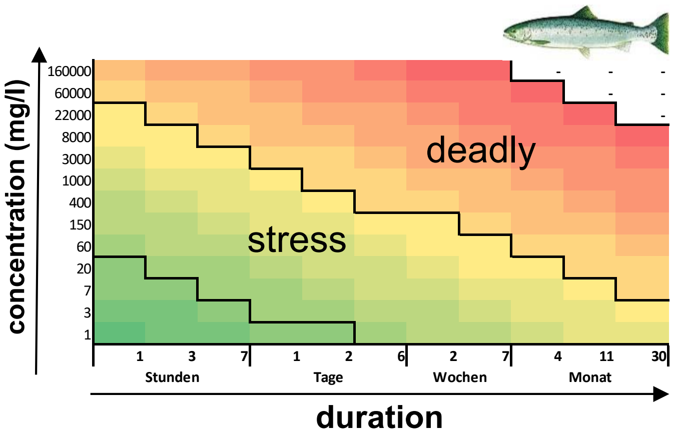






(iv) Insufficient infos of the interaction sediment dynamics / aquatic ecology

Lack of scientific based methods for the evaluation of the impact of sediment management measures on aquatic ecology



Jacob & Jensen (1996)

⟹ moderate stress: $\mathbf{y = 327{,}8x^{-0{,}9}}$

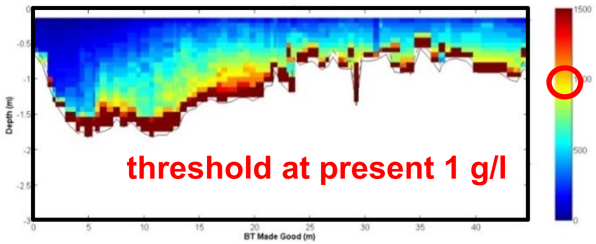
⟹ loss in habitats: $\mathbf{y = 2616{,}7x^{-0{,}8}}$

⟹ deadly: $\mathbf{y = 48008{,}5x^{-0.9}}$

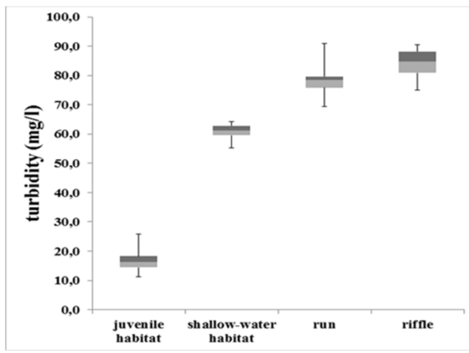
Investigations CD-Laboratory:

flume (Laboratory)

suspended sediment distribution Inn River

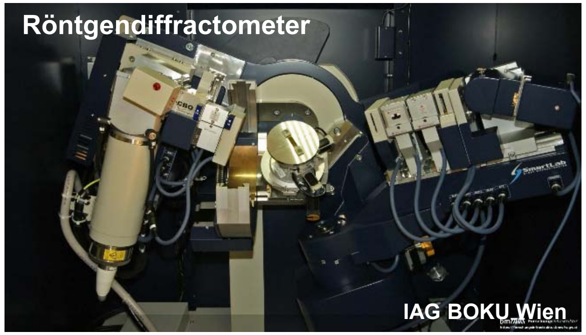


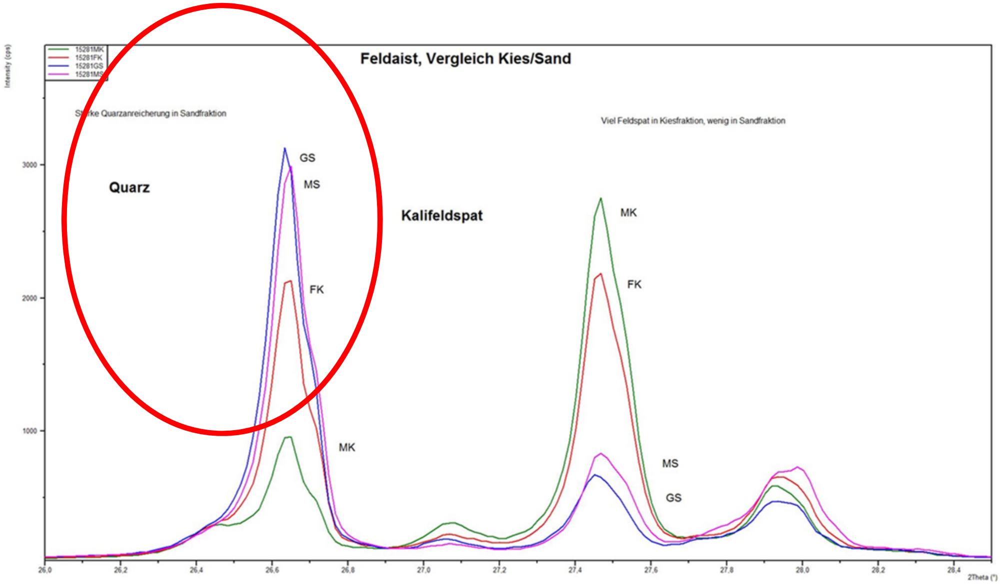
Variability in hydro-morphological units



➡ ***Aim: „rivers getting fit for more sediments“***

(v) re-use of dredging material





Hauer et al., 2015

Use of quartz-sand in industry:

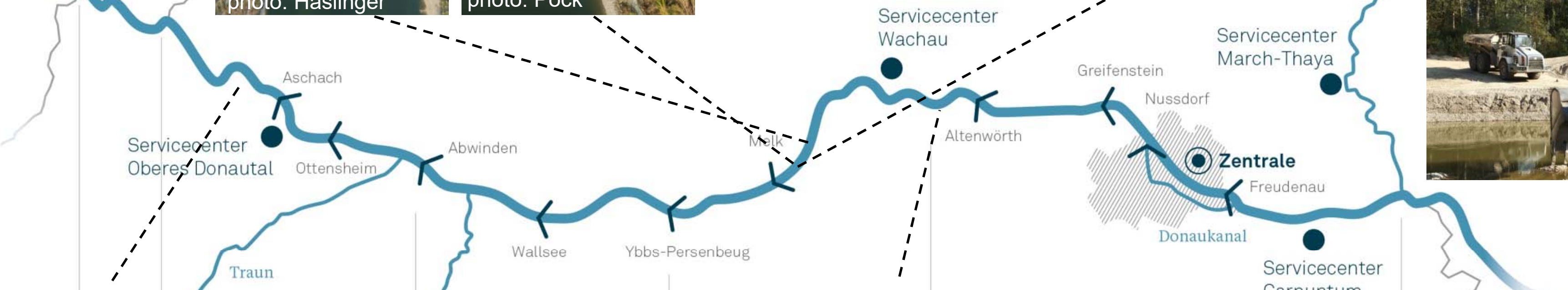
- **Construction industry:** grout, concrete
- **Water supply industry:** filter
- **Glas industry:** resource
- **Synthetic material industry:** crushed quartz-sand
- **Fire-proof industry:** casting house technology
- **Chemical industry:** resource for SiO_2

Module 2 (Sediment management in river engineering / hydropower)

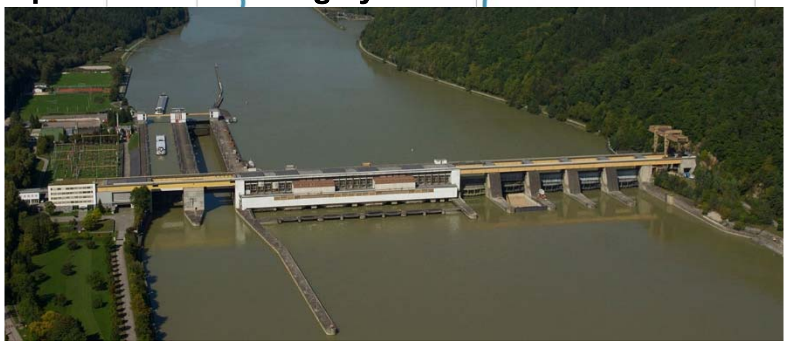
Sustainable management for reconnection of aquatic habitats

Concepts for revitalisation

Abrasion



Optimized measuring systems in reservoirs



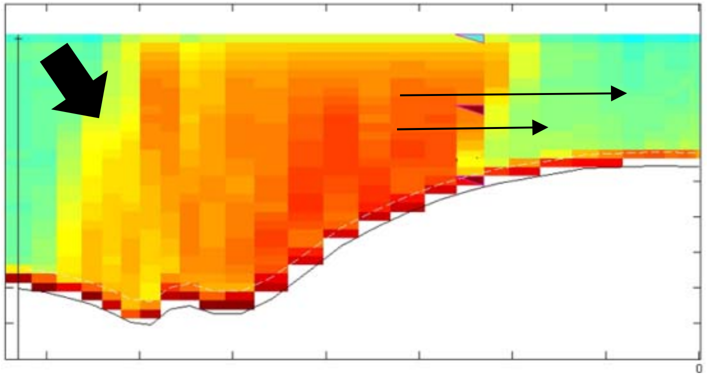
High-efficient reservoir-management

Module 2 (Sediment management in river engineering / hydropower)

Dredging and dumping of material as one sediment management opportunity
(reservoirs / free flowing section)

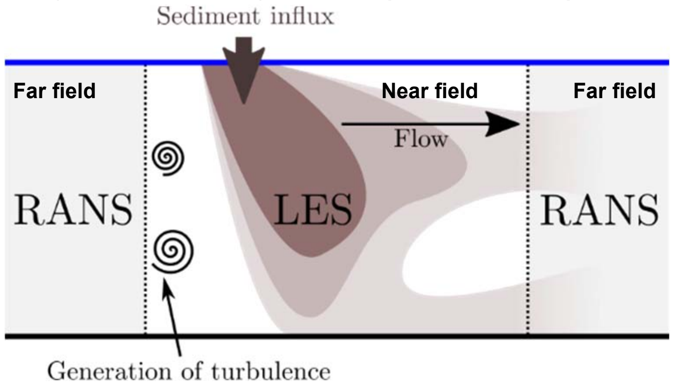
dredging in winter harbour Linz

Suspended sediment concentration after deposition

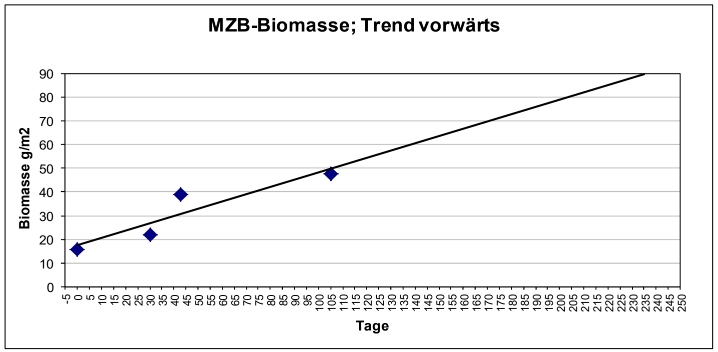


Implementation in the Laboratory:

New hybrid modelling – tools (RANS / LES)



Link to aquatic ecology



Thank you for your attention!