MITIGATION OF HYDROPOWER IMPACTS ON FISH
-
THE AUSTRIAN HYDRO PEAKING APPROACH

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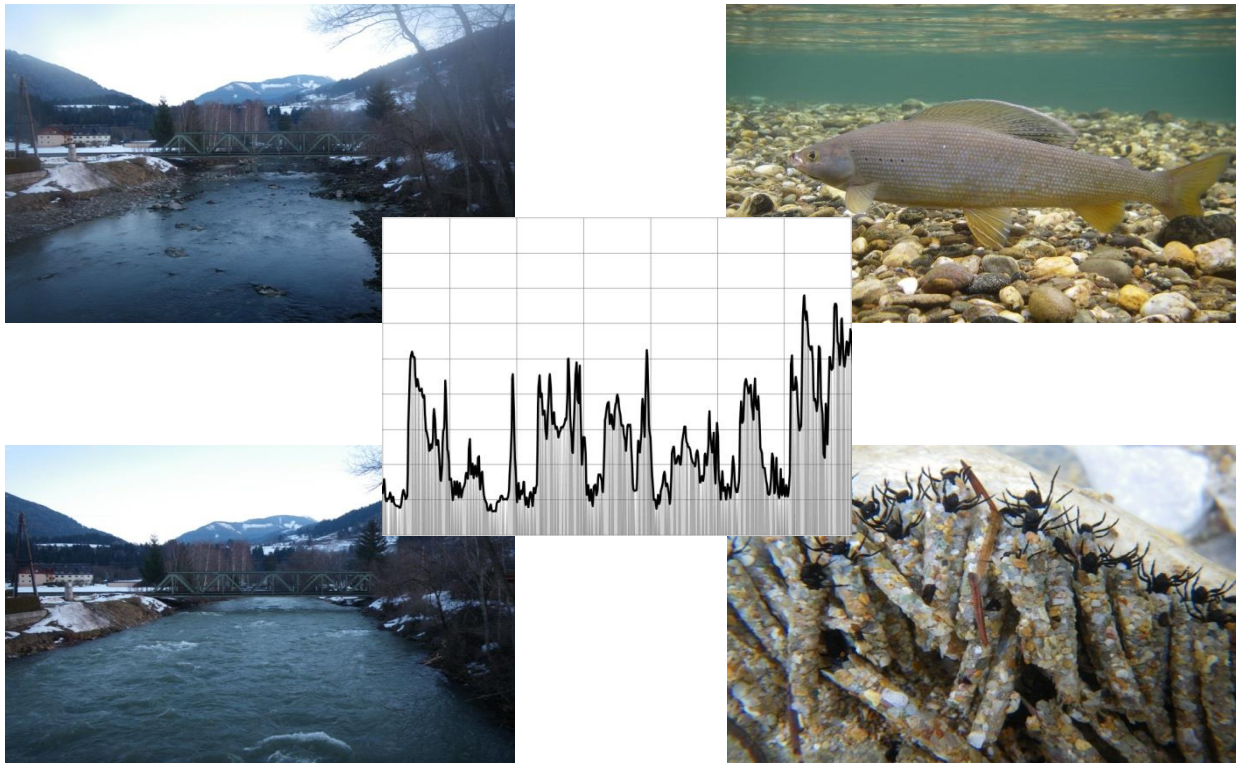
Overview

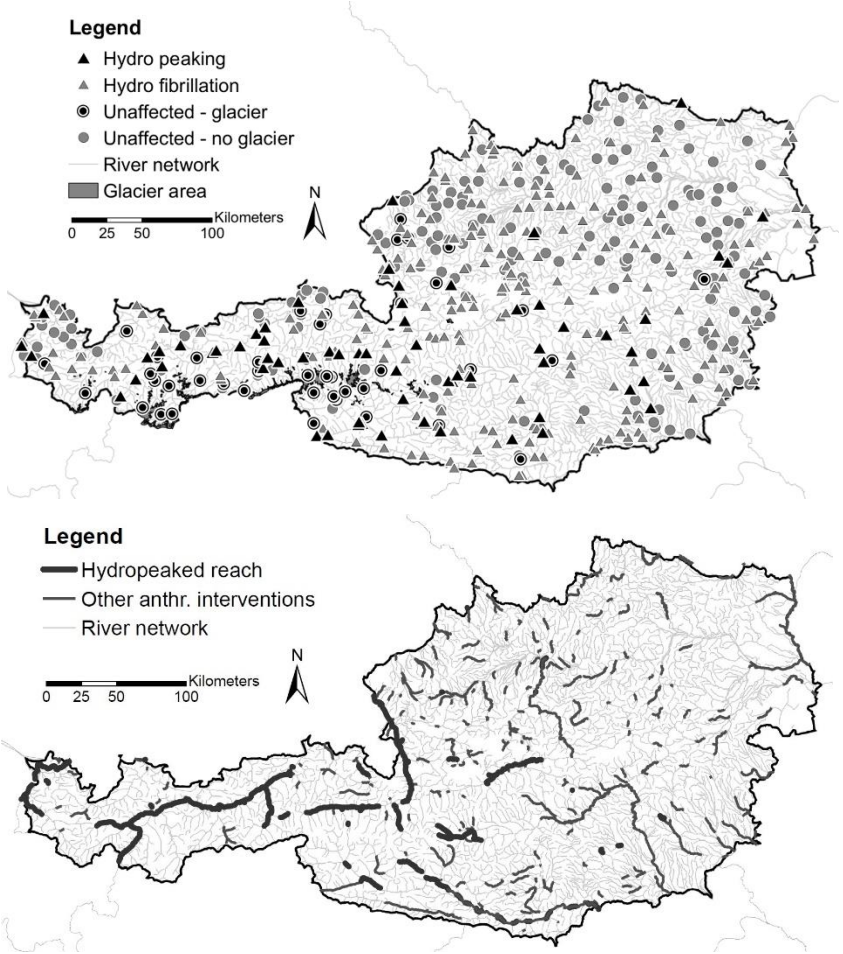
- Introduction
- SuREmMa
  - Goals
  - Evaluation tool
  - Results
  - Summary
- Open research questions and outlook

Introduction

Hydro Peaking causes one of the most important environmental impacts on running water ecosystems in Austria.

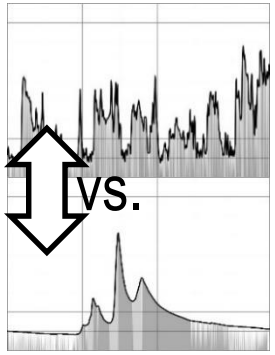


Introduction



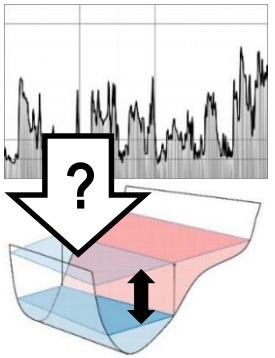
- 59% of Austrian hydrographs are affected by anthropogenic interventions (13% Hydro Peaking, 46% other). (Greimel *et al*, 2015)
- More than 800 km river stretches are affected by Hydro Peaking (caused by high- head storage power schemes).
- At least 3000 km river stretches are affected by other anthropogenic interventions (caused by Schwellbetrieb, run-off-the-river power plants…)
- Short term flow fluctuations and its ecological impacts are probably a more widespread problem than assumed!

Introduction

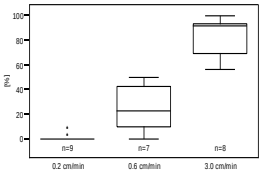


Frequency, intensity and timing of artificial flow fluctuations

Intensity of resulting water level changes



Integrative Hydro Peaking Management



Vulnerability of organism (threshold values)

General habitat availability and potential refugial habitats

SuREmMa

Sustainable River Management – Energiewirtschaftliche und umweltrelevante Bewertung möglicher schwalldämpfender Maßnahmen

Common Goal

Identify **mitigation measures** with **high ecological benefit** and **low economical costs.**

Ecological benefit

- CO^2 Production costs

Integrated approach:

-Water authorithies
-Stakeholders
-Research community

SuREmMa - Goals

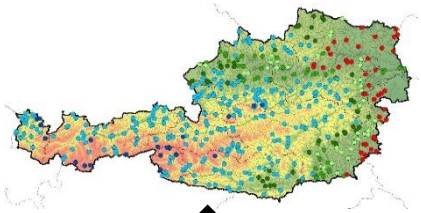
- The development of a nationwide applicable **evaluation tool**…
  - to assess ecological effects of anthropogenic flow fluctuations based on frequency, intensity and timing of flow fluctuations and hydromorphological issues.
  - to evaluate the ecological effects of mitigation measures.

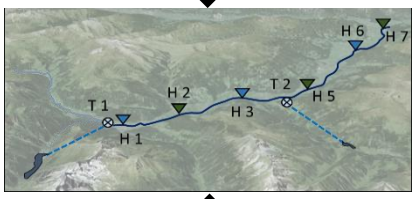
  } Ecological impact assessment

  - to **contrast ecological benefits** and **economic losses** of specific mitigation measures.

  } Matt & Pfleger Session 7

SuREmMa - Spatial scale





- **Nationwide scale**

e.g.: hydrograph characterization, empirical models, threshold definitions

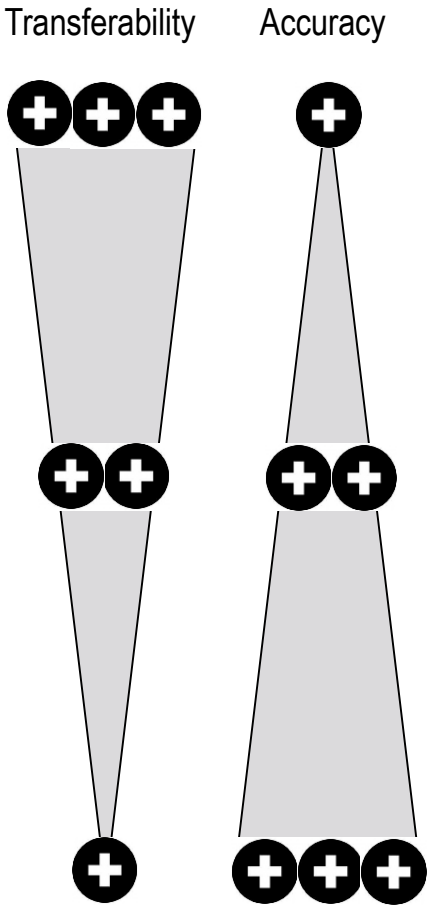
- **River-reach-scale**

e.g.: longitudinal Hydro Peaking assessment, Evaluation tool

- **Point-scale**

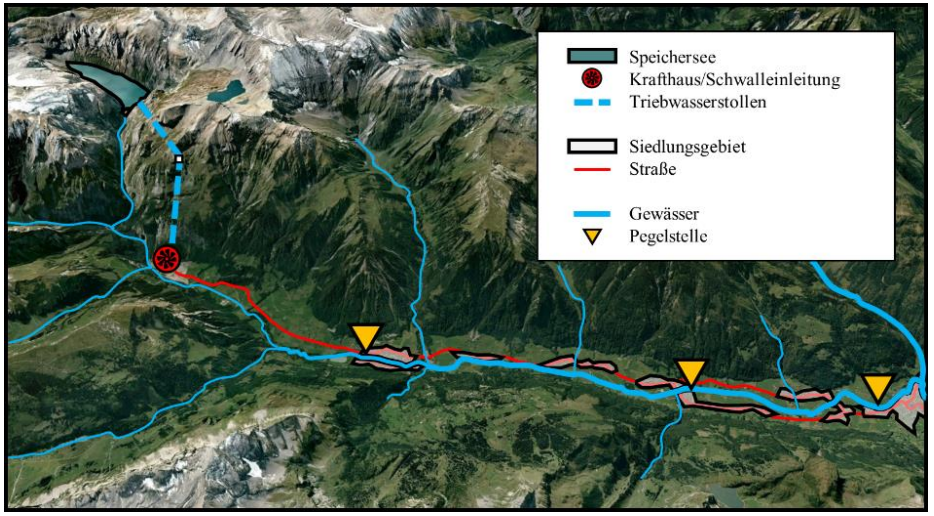
e.g.: hydraulic models, HyTEC experimental channel, hydrographs

Modelloutput

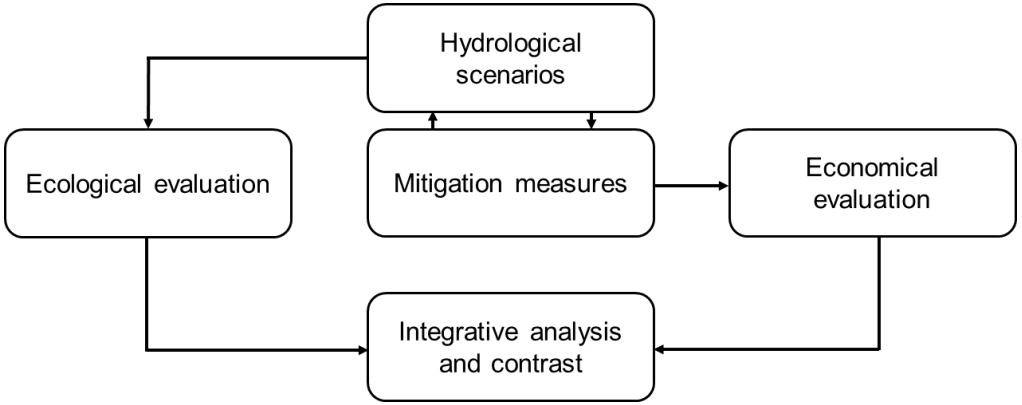


SuREmMa – Mitigation measures

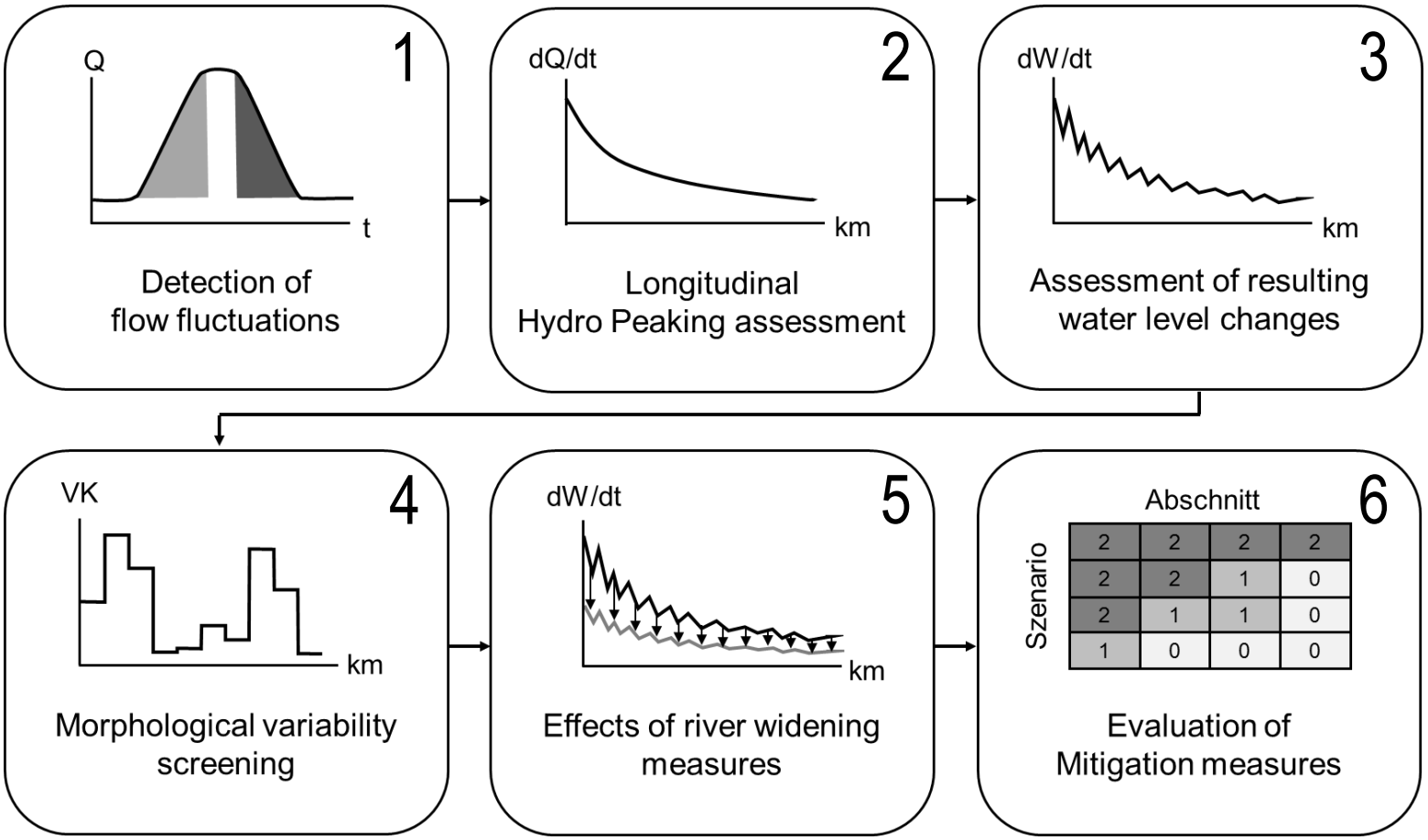
Hydrological scenarios are defined referring to different mitigation measures and evaluated from an ecological and economical view.



- Operational restrictions
- Retention basins
- Hydro peaking diversion
- Morphological measures

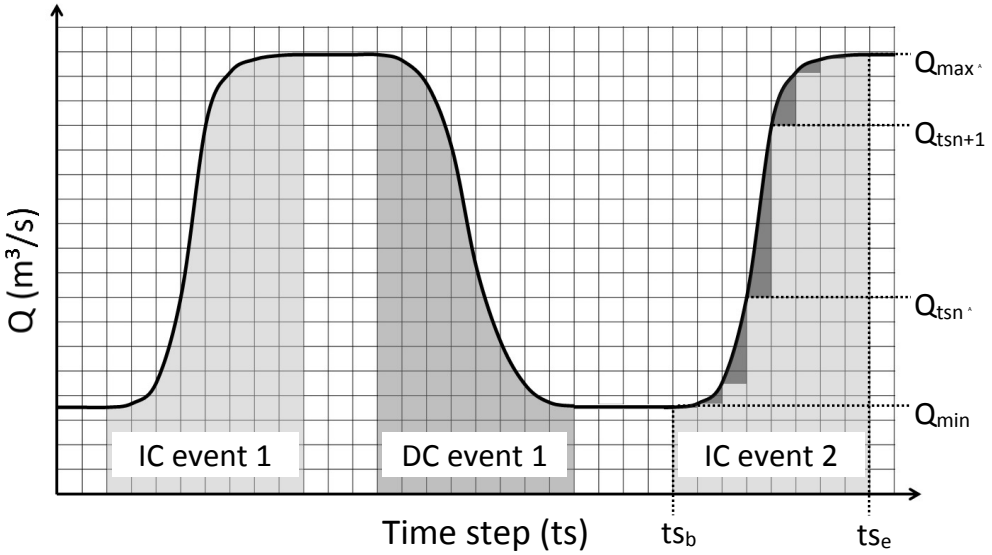


Evaluation tool – Operational steps



Detection of flow fluctuations

(Greimel *et al*, 2015)



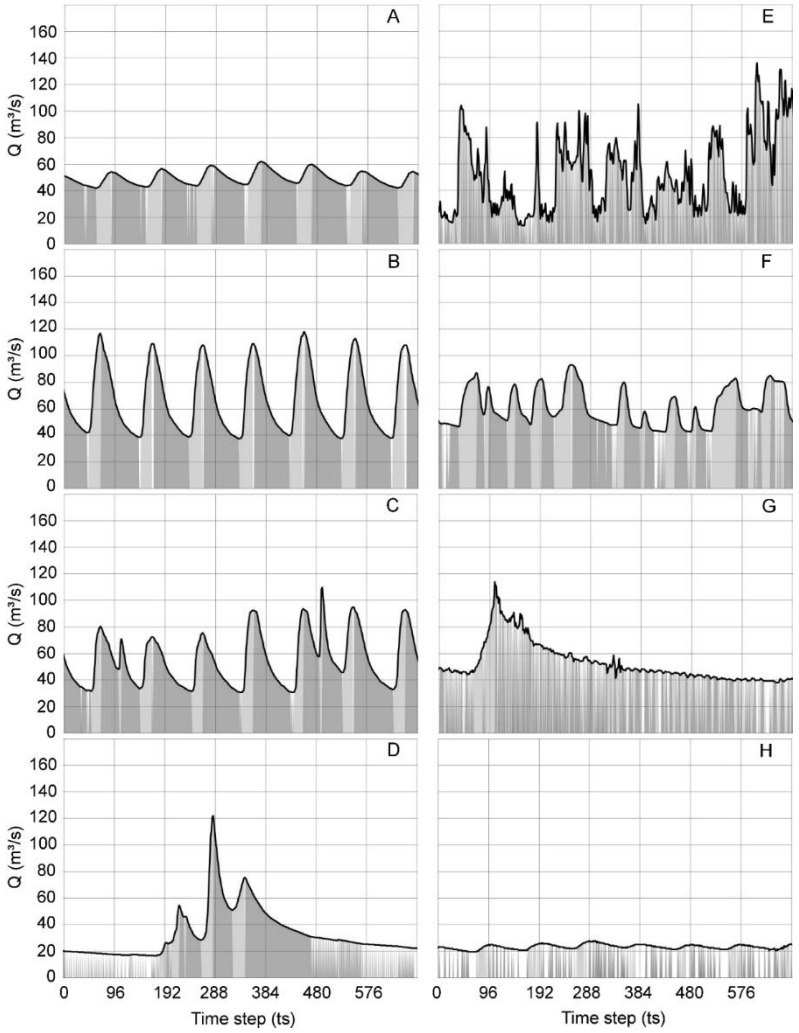
- An algorithm detects several continuous fluctuation events which are recorded in hydrographs.
- Intensity and frequency of increase and decrease events are described by a set of parameters.

Event-based intensity parameters: definitions and units.

Nr.	Parameter	Acronym	Definition	Unit
1	Maximum flow fluctuation rate	MAFR	max(abs((Q_{tsn+1}) - (Q_{tsn})))	m^3/s^2
2	Mean flow fluctuation rate	MEFR	Amplitude/Duration	m^3/s^2
3	Amplitude	AMP	Q_{max} - Q_{min}	m^3/s
4	Flow ratio	FR	Q_{max}/Q_{min}	
5	Duration	DUR	ts_e - ts_b	s

ts_b - time step event beginning, ts_e - time step event ending, Q_{max} - maximum event flow, Q_{min} - minimum event flow, Q_{tsn} - flow of a specific time step, Q_{tsn+1} - flow of subsequent time step, max – maximum, abs – absolute, s – second (1 ts ≙ 900 seconds or 15 minutes).

Detection of flow fluctuations



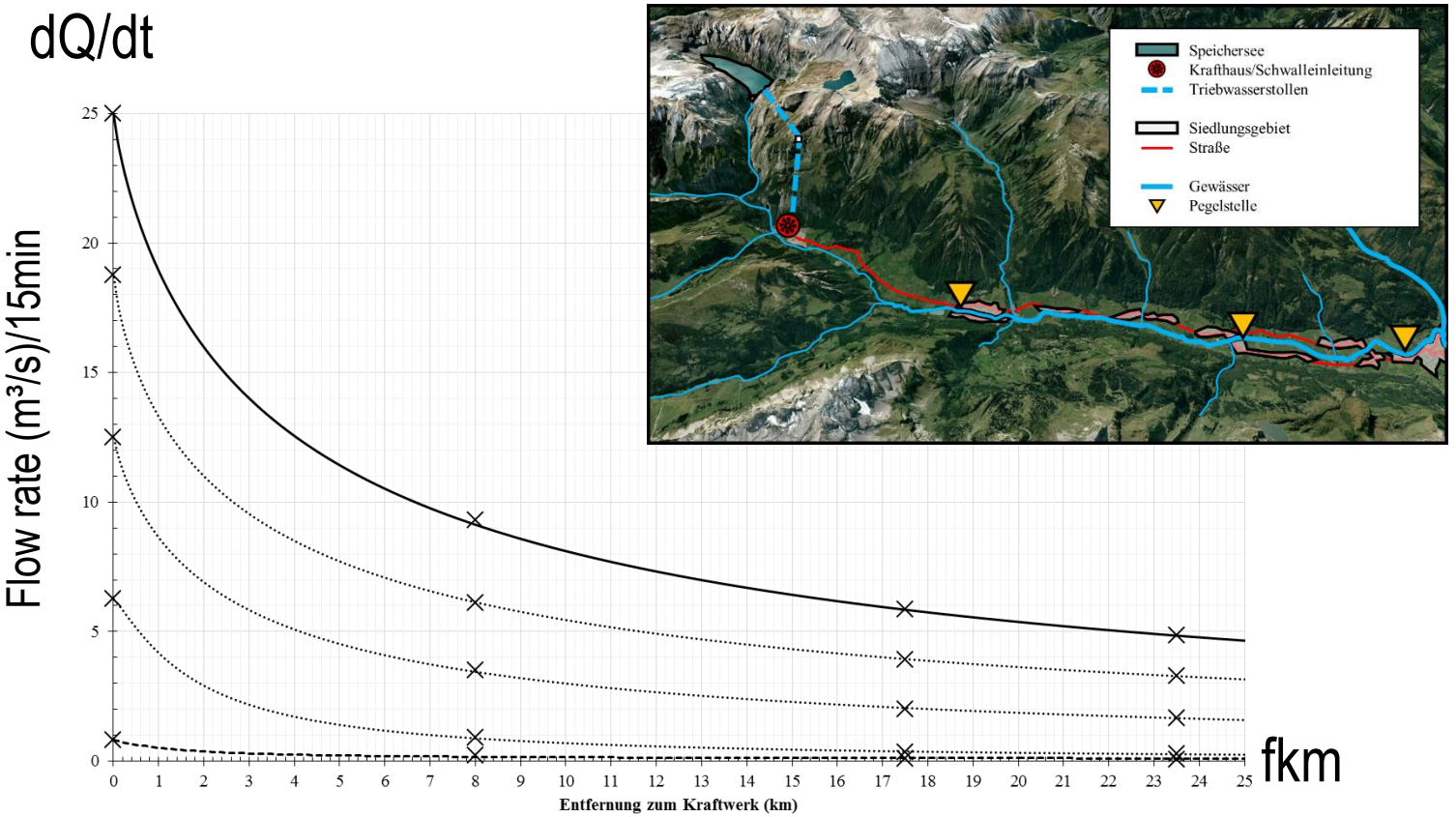
Flow fluctuations caused by…

- Snow and ice melt
- Rainfall
- Hydro Peaking
- Other anthropogenic influences
- Combinations

Sub daily flow regimes can be distinguished statistically. ✓

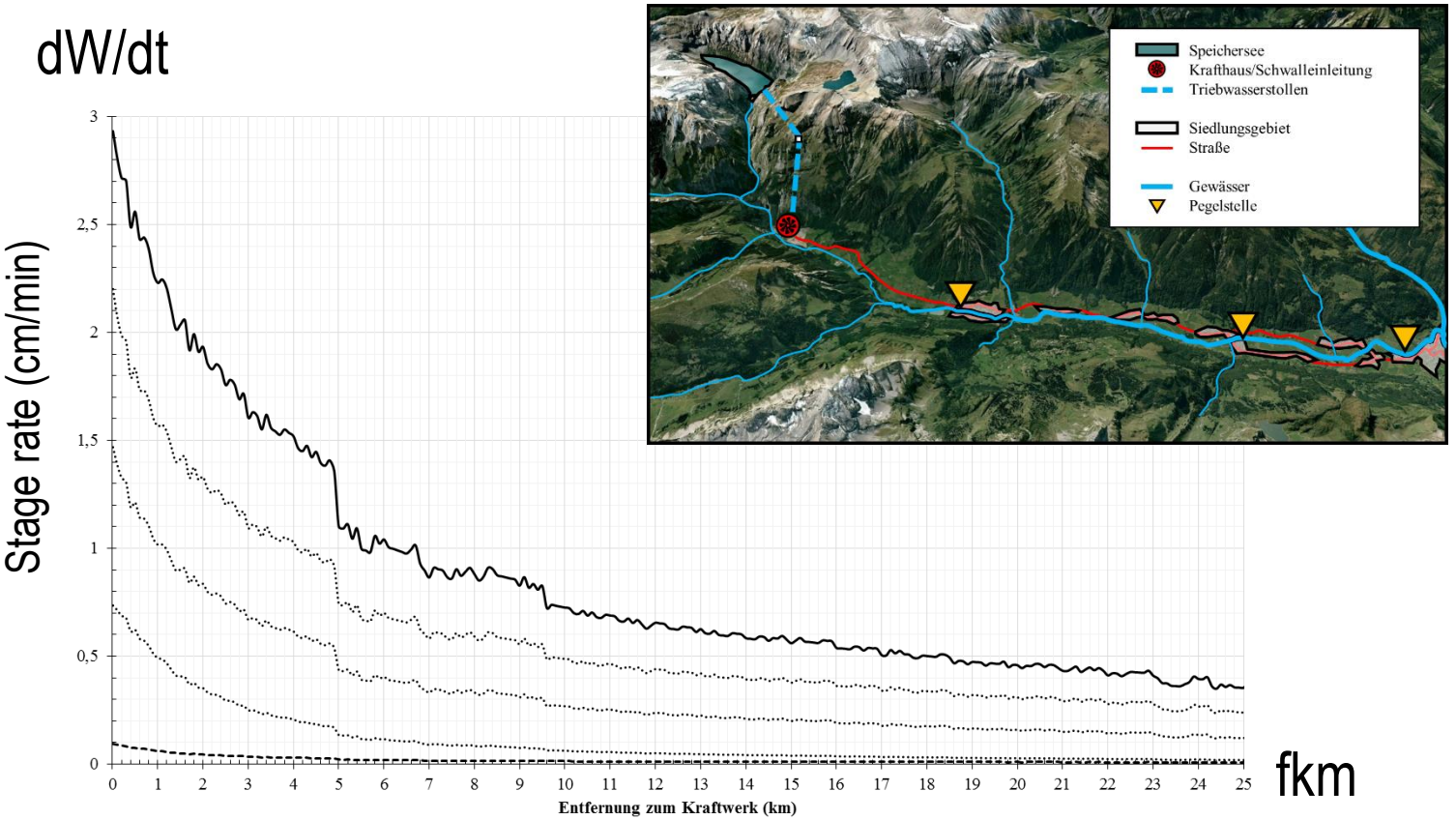
Intensity, frequency and timing of flow fluctuations types can be contrasted. ✓

Evaluation tool – Longitudinal Hydro Peaking assessment



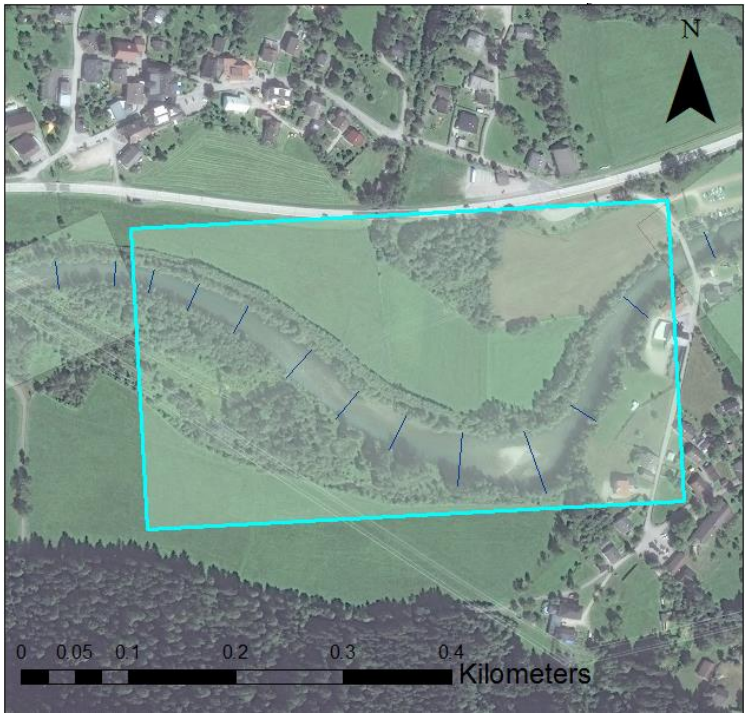
A power plant specific longitudinal assessment of hydro peaking intensity is enabled by the tracking of specific flow fluctuations using multiple hydrographs (Greimel *et al*, in prep.).

Evaluation tool – Longitudinal Hydro Peaking assessment



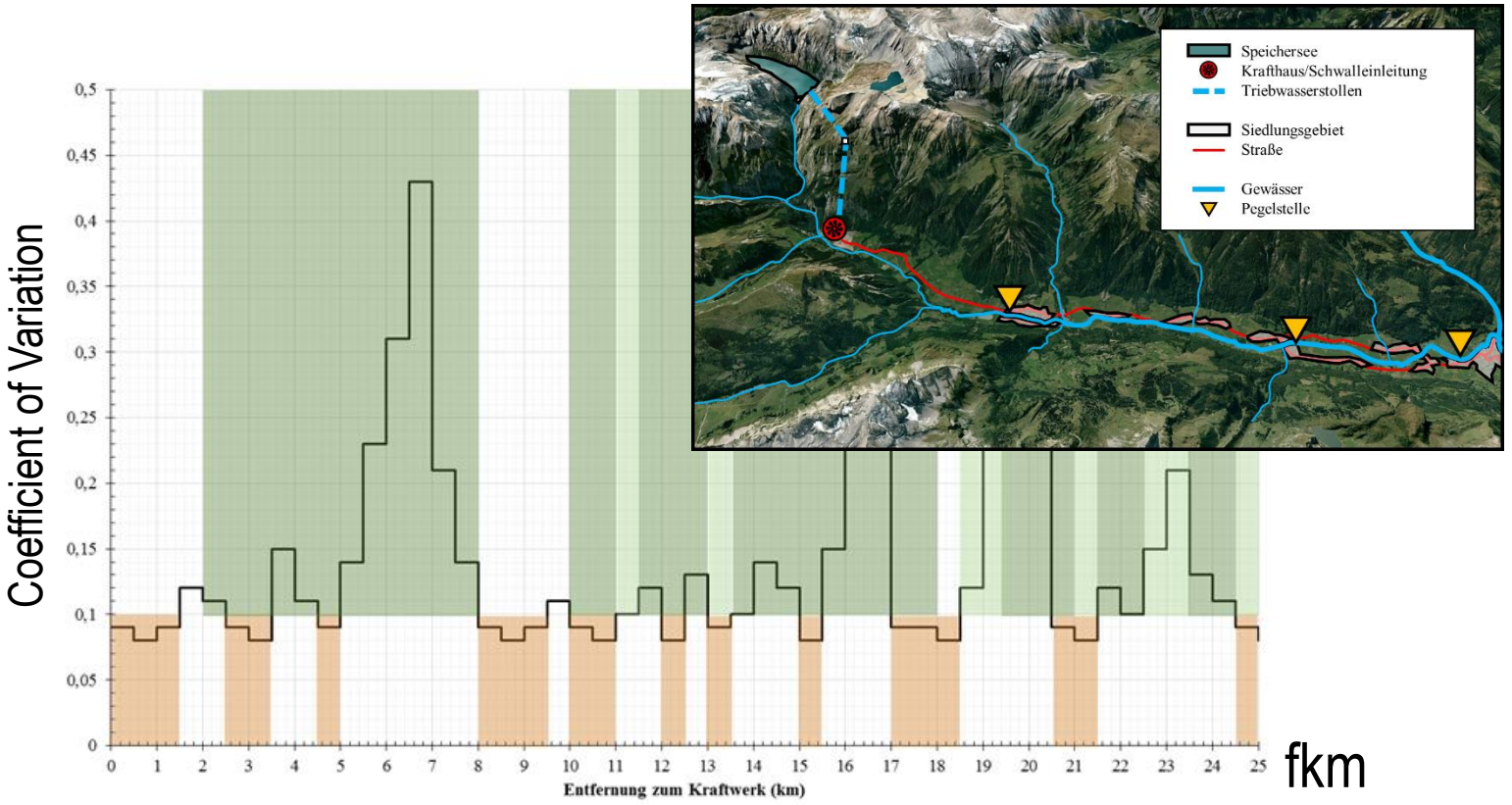
The assessment of resulting water level changes can be carried out by regression models (variables: altitude, mean runoff rate, catchment size, river width) (Greimel *et al*, in prep.) or hydraulic modelling.

Evaluation tool – Morphological variability screening



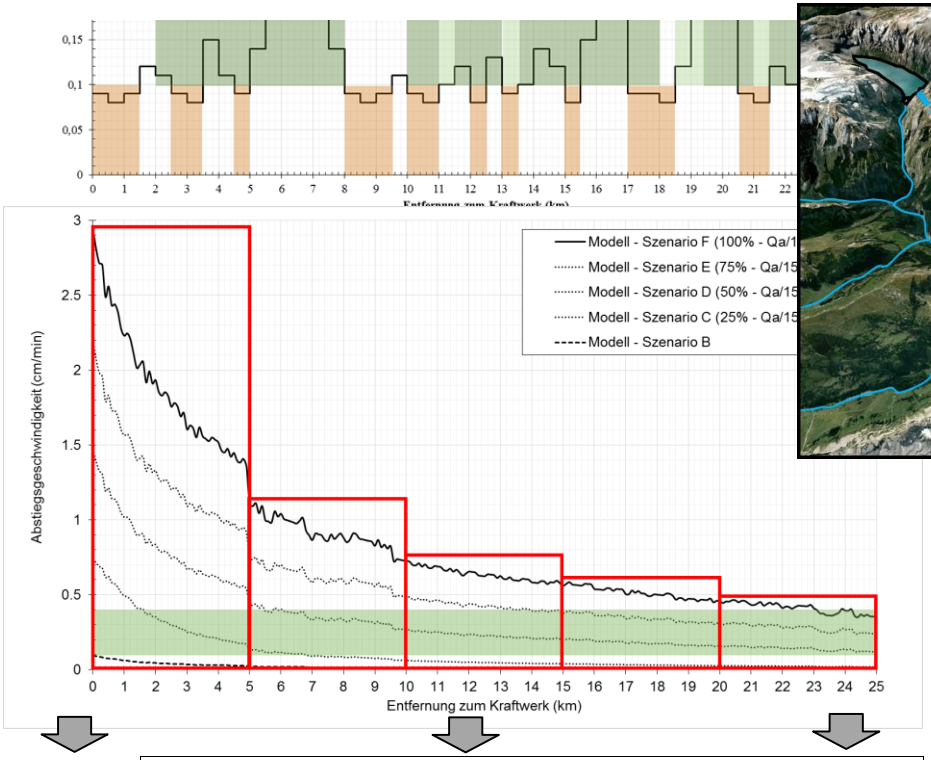
The goal is to differ between natural like river reaches and regulated sections based on an objective approach.
This can be don by continuous measurements of the river with and the referring Coefficient of Variation.

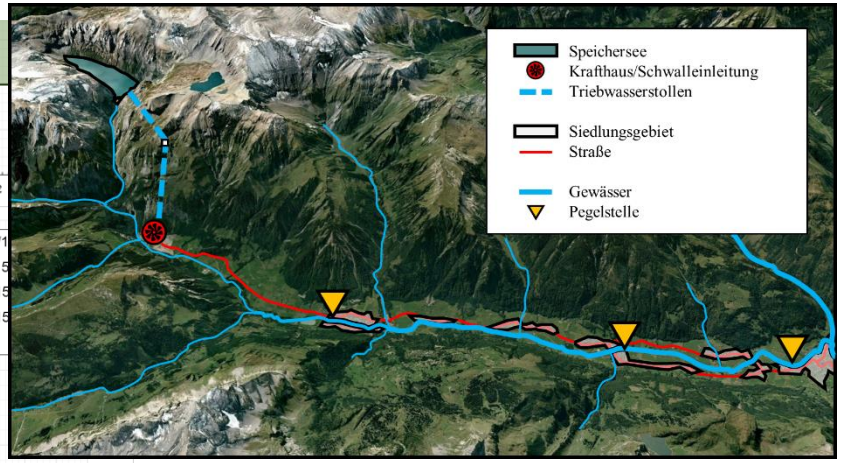
Evaluation tool – Morphological variability screening



It can be assumed that hydrological mitigation measures show no positive ecological effects in river sections with a very low Coefficient of Variation due to missing habitats for juvenile fish and larvaes.

Evaluation tool – Example of application Stranding

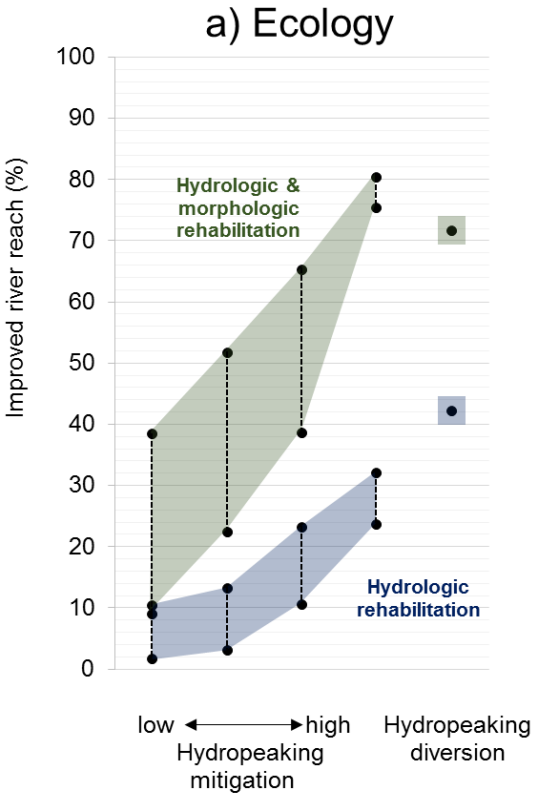




Szenario	Abschnitt (km) 0 - 5	5 - 10	10 - 15	15 - 20	20 - 25
100% (F)	2	2	2	2	2
75% (E)	2	2	2	1	1
50% (D)	2	1	1	1	1
25% (C)	2	0	0	0	0
B	0	0	0	0	0

Ecological effects of mitigation measures can be quantified by integrated analysis of the hydrological and morphological situation in the affected river stretch.

SuREmMa
Results (Stranding)



10 case studies

294 km affected river stretch

Measures:

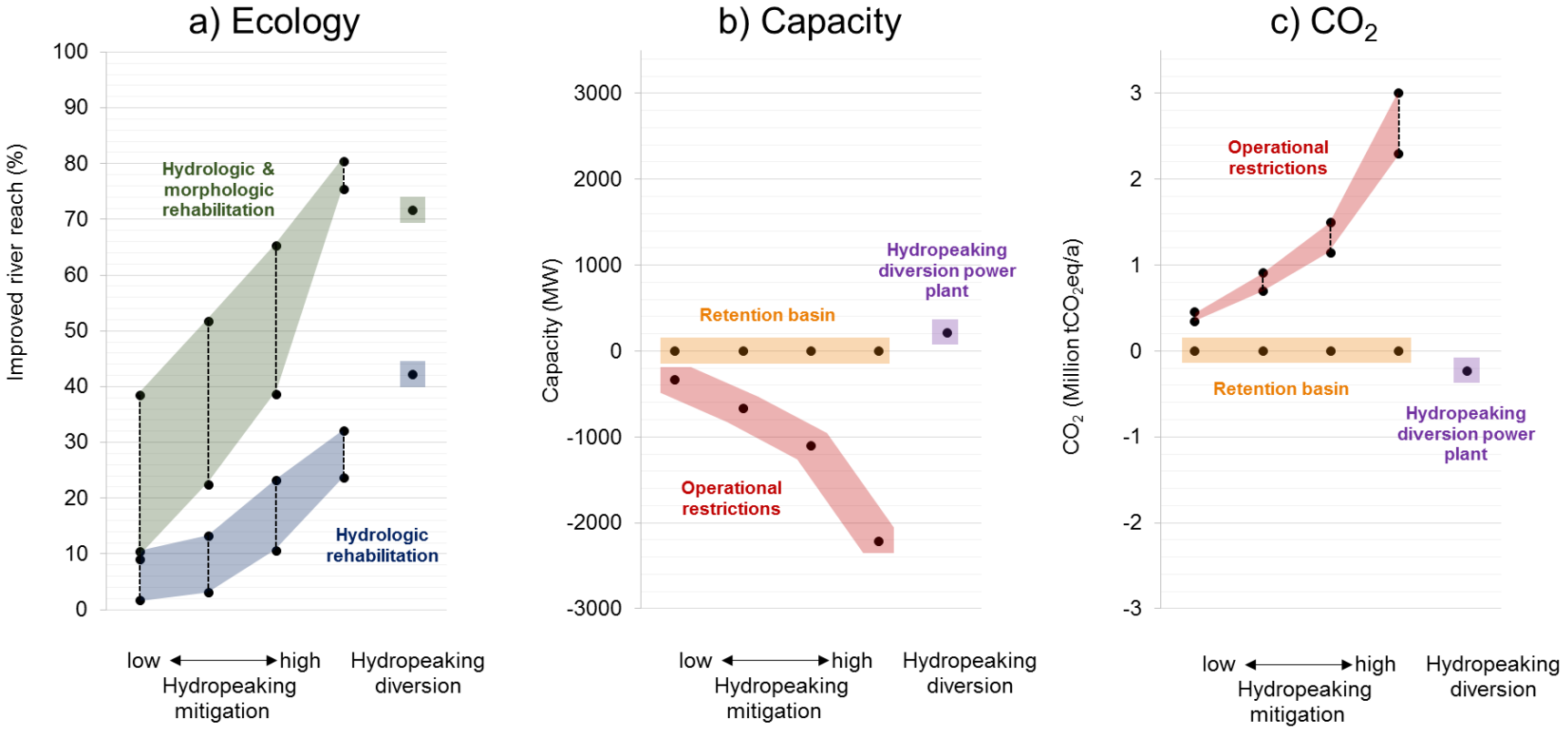
- Operational restrictions
- Retention Basins

} Hydro Peaking mitigation (variable extent)

- Hydro peaking diversion (87 km – 4 case studies)
- incl./excl. morphological measures

The results indicate that habitats could be available without a stranding risk in up to 80% of the analyzed river stretches, if hydrological mitigation measures are combined with morphological habitat improvement.

SuREmMa
Results – Integrative analysis



The ecological impact assessment allows to contrast ecological benefits with economical effects.

SuREmMa
Evaluation tool - Summary

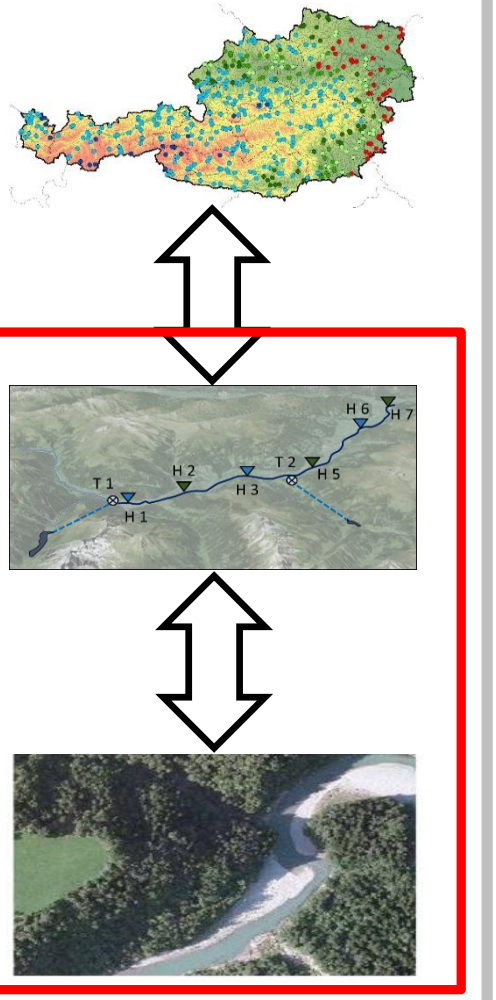
- The presented tool enables to…
  - grasp intensity, frequency and timing of anthropogenic flow fluctuations.
  - contrast highly different hydrological situations (e.g. different operation modes, river sizes, natural hydrological conditions).
  - quantify ecological impacts in a longitudinal view.
  - contrast ecological and economical effects to identify the most effective mitigation measure as a basis to define the river specific good ecological status.

Integrative Hydro peaking management – Outlook

- During the next years the goal will be to apply and to improve the presented tool:

  - The contrast of predicted ecological benefits and actual monitored effects should help to identify knowledge gaps concerning further bottlenecks.
  - The tool should be extended to evaluate potential Hydro Peaking impacts for other species potentially based on other parameters/variables (e.g. Benthos).

Integrative Hydro peaking management – SuREmMa+



Detailed case-by-case studies

Hydrological situation
- Contrast unaffected/affected situation (Intensity, frequency and timing of flow fluctuations)
- Low-high flow situations
- Temperature

Morphological situation
- Effects of small scale structures
- Sediment transport and sediment quality

Ecological situation
- Adapted Monitoring (Spawning grounds, larvaes, Juveniles)
- Further organism groups

Basic information to…

- define the river specific „good ecological potential“ according to the water framework directive.
- identify most effective measures to reach the target state.