MITIGATION MEASURES FOR SUSTAINABLE WATER ABSTRACTIONS IN ALPINE STREAMS

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1. INTRODUCTION

Water from Alpine streams is valuable natural resource used for drinking water supply, irrigation, hydropower production, aquaculture etc.; however with **unsustainable water abstractions** other ecosystem services such as habitat provision, nutrient cycling, water retention, climate mitigation and cultural services can be reduced or eliminated.

Excessive water abstractions are usually restricted by country specific legislations that define the amount of water that should remain in the river or stream after abstraction. Nevertheless, legally established ecologically acceptable flows are difficult to be assured in small Alpine streams with highly fluctuating torrential water flows. Besides this, newly established ecologically acceptable flows are often economically unacceptable for **small hydropower plants** that have been in operation before the adoption of relevant legislation.

Different **mitigation measures** can be applied in order to increase the capacity of watercourse to retain water and thus contribute to maintenance of sufficient environmental flows. Besides water retention, mitigation measures have to enable other ecosystem services such as habitat provision, nutrient cycling, water treatment and cultural services. Larger water capacity of the stream is beneficial also for hydropower plants' owners.

Conceptual solutions have been developed for mitigation measures to increase water retention capacity on Alpine stream Mošenik, which is affected by water abstractions for the needs of several small scale hydroelectric power plants.

2. MATERIALS AND METHODS

A case study was prepared on implementation of mitigation measures for four consecutive small scale hydroelectric power plants on Alpine watercourse Mošenik, Slovenia. The stream has been inspected during high and low flow conditions in order to suggest implementation of the most appropriate cost-efficient multifunctional natural water retention systems for different sections of the stream.

3. RESULTS AND DISCUSSION

According to hydro-morphological characteristics of the riverbed, Mošenik stream was divided into 4 sections (A, B, C and D). Each section was addressed separately and suitable mitigation measures were suggested.


Alpine stream where all the water has been abstracted for the needs of small hydropower plant (left); Alpine stream during high flow (right).

3.1 Section A

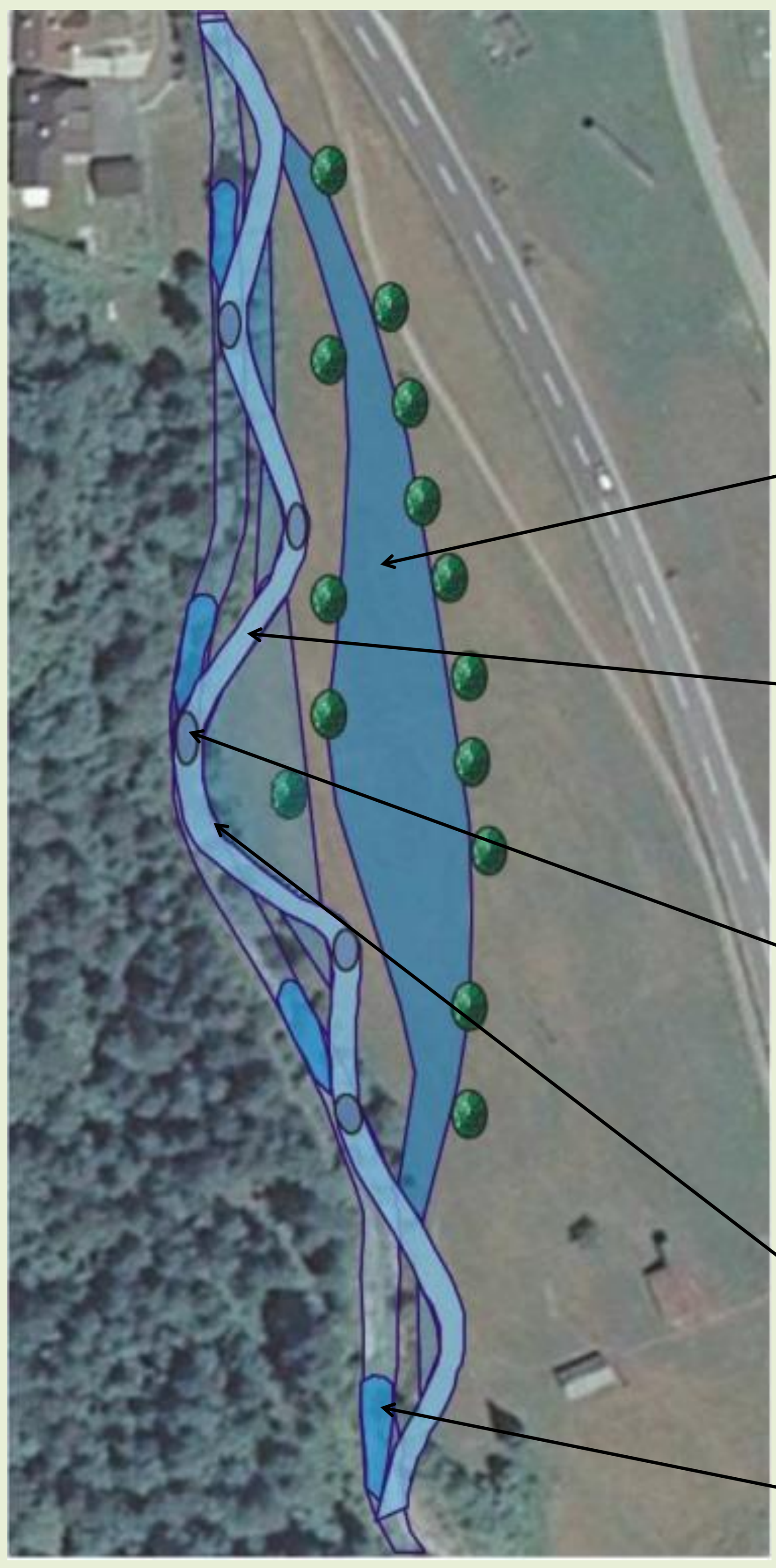
Characteristics:
- large drop and high energy potential
- exchanging rapids and pools
- manmade weirs

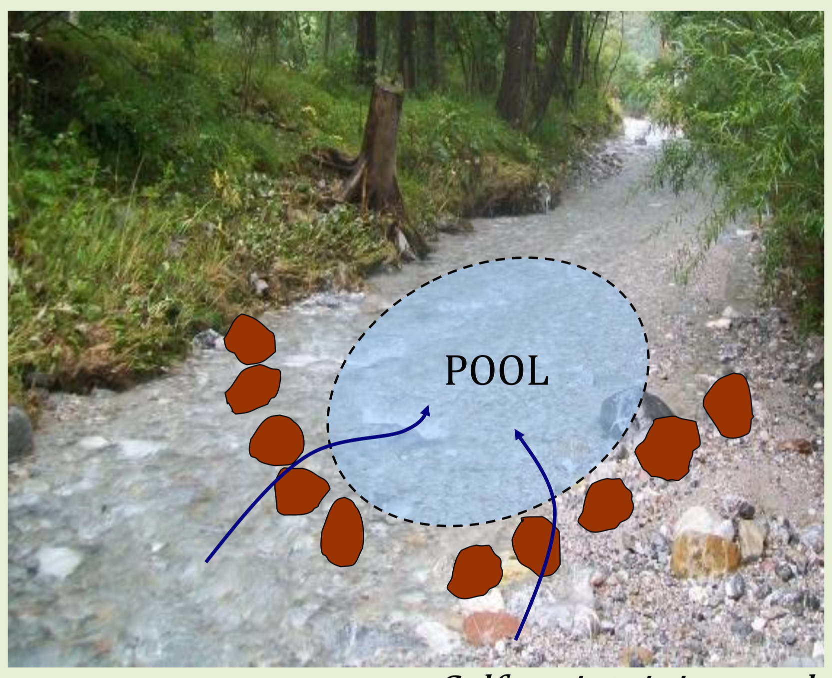
Mitigation measures:
- **Enlargement of pools** down flow of weirs: excavation of sediments in the middle of the river bed.

3.2 Section B

Characteristics:
- long sections of glides and runs
- low hydro-morphological diversity
- small water retention

Mitigation measures:





Self-maintaining pool

New floodplain for retention of water during high flows. Water retained in the floodplain can be controllably discharged back to the stream during low flows.

New riverbed and meanders increase the length of the watercourse and thus water retention capacity in the area.

Self-maintaining pools in the new riverbed: larger boulders are placed into the riverbed which increases the flow. Increased flow causes erosion down flow from the boulder and thus creation of a new pool (picture above).

Lowering of the embankments on the inner side of the meanders enables faster spilling of water to floodplain and increases water retention during high flows.

Backflow areas in the old river bed present a place for water retention.

3.3 Section C:

Characteristics:
- Mild meandering, gravel deposits
- Diverse natural habitats

Measures:
- No need to establish mitigation measures since this section has sufficient water retention capacity.

3.4 Section D:

Characteristics:
- Canalized stream with concrete riverbed and banks
- No hydro-morphological diversity

Measures:
- **Restoration of natural watercourse**: demolish concrete riverbed and banks, establishment of natural watercourse with corresponding hydro-morphological structures including meanders, pools, low embankments which would significantly improve habitats and increase water retention capacity.

New riverbed

Area for potential establishment of **new floodplain**

Low embankments and small floodplains

Larger boulders to create new self-maintaining pools

4. CONCLUSIONS

Proposed measures mitigate flow fluctuations by retaining excess water during high flows and allowing slow release of water to a receiving watercourse during dry periods. By restoration of floodplains, renaturation of stream canal, restoration and establishment of wetlands, backflow areas, river pools, rapids and more a balance between production of energy and environmental conditions can be achieved. The ability of natural features to retain water enables also other crucial ecosystem services including storage and transformation of nutrients, water purification, provision of habitats, increase in biodiversity, improvement of soil quality and reduction/prevention of upstream floods and downstream droughts. Beside mentioned positive environmental impacts, mitigation measures in the catchment of Mošenik will result also in improved efficiency of small hydropower plants due to more constant flows which will be beneficial for the hydropower company and production of renewable energy. Therefore mitigation measures in Mošenik watercourse will contribute to sustainable development on ecological, economic and social level in the local environment.

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