

Stakeholder Workshop on Reservoir Sedimentation

Date: 17.11.2023

Venue: Laboratory of Hydraulics, Hydrology and Glaciology (VAW); ETH Zürich

Participants:

Name	Function	Organisation	Stakeholder Category
Christian Dupraz	Head of Hydropower Section	Federal Office of Energy	Government Authority
Alexandre Pachoud	Supervision of Dams Specialist	Federal Office of Energy	Government Authority
Lucien Stern	Operations Manager	ewz	Hydropower Operator
Rico Senti	Head of Dam Department	Axpo	Hydropower Operator
Daniel Ehrbar	Senior Engineer Dam Analytics	Axpo	Hydropower Operator
Jonathan Fauriel (online participant)	Head of Civil & Env. Engineering Division	Alpiq	Hydropower Operator
Andrea Baumer	Head of Dams and Environment Section	Ofima/Ofible	Hydropower Operator
Andrea Balestra	Team Leader Hydraulic Engineering	Lombardi SA	Consultant Engineer
Christian Kopeinig	Engineer Sediment Solutions	illwerke vkw	Hydropower Operator
Lucas Fürst	Engineer Sediment Solutions	illwerke vkw	Hydropower Operator
Giovanni De Cesare	Operational Director	PL-LCH, EPFL	Research
David Felix	Consultant Engineer	Aquased	Consultant Engineer
Sudesh Dahal	Doctoral Researcher	VAW, ETH Zürich	Research
Carolin Friz	Doctoral Researcher	VAW, ETH Zürich	Research
David Vetsch	Group Head	VAW, ETH Zürich	Research
Ismail Albayrak	Senior Research Engineer	VAW, ETH Zürich	Research
Robert Boes	Director / Professor	VAW, ETH Zürich	Research
Frederic Evers	Senior Research Engineer	VAW, ETH Zürich	Research

Activities

1. Presentation by Robert Boes:
Sediment research for Hydropower at VAW
2. Presentation by Christian Dupraz:
Energy Strategy and Storage
3. Presentation by Sudesh Dahal:
Sustainable storage hydropower for a resilient future energy system
4. Presentation by Carolin Friz:
Controlled fine sediment venting via waterways of storage hydropower plants with Francis turbines as a strategy to counter reservoir sedimentation (Sedvent)

5. Group Discussion

The following specific topics were discussed to have a common understanding among all participants:

- a) Perception on reservoir sedimentation (How severe is the sedimentation problem?)
Reservoir sedimentation has been impacting not only energy storage capacity but also dam safety issues caused by impaired operation of dam outlets. The degree of impact depends on the processes of sedimentation which varies widely from one reservoir to another. Some reservoirs may currently have no issues related to sedimentation, but continuous accumulation of sediment will certainly cause more problems in the future.
- b) Status of data monitoring and plans for better sediment measurements in the future
Generally, bathymetry measurements are conducted at certain intervals. Sediment measurements are performed only if there are any problems related to sediment. There is no concrete plan or policy implications to expand sediment measurements in the future.
- c) What kind of sediment management activities have been implemented in Swiss reservoirs?
Pressure flushing is conducted to free the area near the bottom outlet. If there is a severe sedimentation problem, then other more effective measures such as dredging, drawdown-flushing, bypassing, etc. are carried out. But a regular sediment management practice is still not well defined by the operators, and there is also no strict policy to enforce regular sediment management actions.
- d) What are the perceptions on climate scenarios in terms of sediment yield?
It is highly uncertain how climate change will affect the sediment yield. In general, the sediment yield is anticipated to increase. However, the change in river flow regime may cause less sediment transport because of lower discharge in summer months. Also, the sediment yield is strongly related to the catchment characteristics such as land cover, glaciated area,

topography, etc. It is therefore difficult to have a general assessment of climate change impact on sediment yield. A case-by-case investigation needs to be done.

e) Are there already some plans for future operation scenarios?

Generally, reservoir operations are adapted as per the need of the energy market. There are no concrete plans for adapting the reservoir operation with the impacts related to climate change.

f) What is the perception about the numerical modelling aspect? What are the challenges?

As reservoir sedimentation processes are quite complex to study analytically, numerical models are very useful for a systematic investigation. However, there are many challenges related to strongly varying topography and rapidly changing hydraulic parameters, which should be overcome by the numerical solvers. In any case, it is highly essential to have some field data from monitoring campaigns that can validate the performance of numerical models. Also, it is necessary to investigate more on the governing processes and implement related features in the models.

g) What can be done to derive a better value for integrated sedimentation rate in Switzerland? Which reservoirs are more important?

A major impact of reservoir sedimentation is the loss in energy storage capacity. Thus, it is essential to prioritize the reservoirs having higher energy content, and then analyze the sedimentation rate based on direct measurements or an indirect approach related to catchment sediment yield. The sedimentation rate can be integrated by taking a weighted average of individual reservoirs, where the weighing factor is given by the energy storage capacity.

h) Do newly planned dams already include sediment management in the design phase?

There is still no strict policy for implementing sediment management techniques during the design phase of a dam. Therefore, some newly planned dams still lack proper sediment management strategies. Some of them are mainly focused on designing more dead storage which can accommodate more sediment without affecting the active storage volume.

6. Workshop

The workshop participants were divided into three subgroups to discuss and identify relevant issues or ideas related to reservoir sedimentation. The participants were asked to assign the issues to the following categories: Processes, Technology, and Policy. Finally, the participants were asked to prioritize by providing a vote for each topic relevant to their institution. The following table summarizes the issues and their corresponding number of votes received.

Category	Issue / Idea	No. of Votes
Processes	Highly uncertain climate change effects	3
	Uncertain future evolution of catchment sediment yield	8

	Abrasion of bottom outlets during sediment flushing may cause dam safety related issue	2
	Cohesive sediment may block bottom outlets (dam safety issue)	4
	Excavation of consolidated sediment is challenging	2
Technology	There should be better measurement techniques for sediment grain size distribution	5
	Better hydrological forecast models required	5
	Better monitoring techniques required for every aspect	1
	Monitoring from space could be a future prospect	2
	Monitoring required for macrozoobenthos affected by dam structures	1
Policy	No strict policy to keep reservoirs sustainable for future	5
	Uncertain limits for Suspended Sediment Concentration (SSC) released downstream of dam (not enough scientific basis based on biological limits)	12
	What to do with fine sediment extracted from the reservoir?	1
	How much gravel can be released downstream of dam?	1
	What to do with the gravels excavated from the reservoir?	1
	Planning of concession end period should be clarified	4

The most voted issue/idea on each category are briefly commented here:

- Processes: uncertain future evolution of catchment sediment yield

This means the effect of climate change on sediment yield is highly uncertain, and more research is required to have a better understanding and reduce the uncertainties. Sediment yield is highly related to catchment characteristics such as land cover, precipitation, soil properties, glacier area, etc. The impacts will be different on glaciated and non-glaciated catchments. Glaciated catchments will experience more glacier melt that may release more fine sediments. Non-glaciated catchment may not have significant change in sediment input, but the change in river flow regime will impact the sediment transport capacities. Thus, more interdisciplinary research is required on this topic.

- Technology: Better hydrological forecast models required

Hydrological forecasts are required for proper planning of different activities in a river basin such as reservoir operation, flood safety management, data monitoring, etc. For example, the operation of a reservoir should be adapted during an incoming flood to safely release water towards downstream and also to mitigate any sedimentation issue. Sediment transport in a river is highly sensitive to flood peaks, so it is essential to plan for sediment monitoring during

flood peaks. Thus, better hydrological forecasts will be quite valuable and more emphasis should be given to improve such forecasting technologies.

- Technology: Better measurement techniques required for sediment grain size

The size of a sediment particle has a pronounced effect on the magnitude of sediment transport in both modes of bedload and suspended load. Currently practiced monitoring techniques are mainly focused on collecting samples from some discrete events at a certain location, and then analyzing the particle size in the lab. A more effective and convenient approach would be to have a real time monitoring of sediment grain size in the field which can perform multiple measurements during an event. More emphasis should be given on research and development of such sediment monitoring technologies.

- Policy: Uncertain limits for SSC released downstream of dams

Sediment management in reservoirs often involves release of large sediment concentrations into the downstream reach. High SSC will have a negative impact on the downstream ecosystem depending on the biological limits of aquatic species. However, it is difficult to quantify and provide a threshold for the released sediment concentrations. Thus, more scientific research is required to identify the impact of SSC on aquatic species, ideally for both fish and macroinvertebrates. Eventually, the related policies should be formulated based on the scientific evidence.

Zurich, January 11, 2024

Sudesh Dahal