

A checklist for assessing the hazard potential of glacier lakes

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Background & motivation

Glacial lake outburst floods (GLOFs) have the farthest potential reach of glacier hazards and typically are parts of chain reactions, for instance when a mass movement hits a lake and causes an impact wave that leads to a rupture of the lake dam. Assessments of glacier-lake related hazards should thus not exclusively focus on lake and lake-dam properties itself, but include a comprehensive evaluation of potentially interacting processes in the lake surroundings, both up- and downstream.



The S:GLA:MO (Slope Stability and Glacial Lake Monitoring) project, funded by the European Space Agency (ESA), aims at assessing the hazard potential of glacier lakes based on Earth Observation (EO) data and products, in-situ data, and flow modeling (see poster from Strozzi et al.). In order to provide these hazard assessments as objective and transparent as possible, a generic checklist-like structure is developed according to which the analyses are conducted for each case.

Example: Laguna 513, Peru

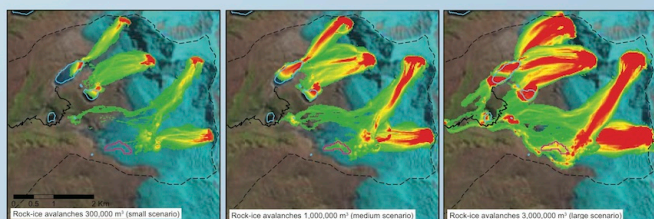
To demonstrate the concept, the checklist was applied to Laguna 513, a proglacial lake in the Cordillera Blanca, Peru, which burst out in April 2010 after a rock-ice avalanche hit the lake.

Please note that only two excerpts from the list (potential triggers and dam properties) are shown here. See attached document or the project website for the full checklist.



Laguna 513 and Mount Hualcán
(Grupo de Investigación en Geografía Física de Alta Montaña, Complutense University of Madrid)

POTENTIAL TRIGGERS



RAMMSS model results of potential ice avalanches at Mt. Hualcán.
(D. Schneider)

3 Assessment of the current hazard			
3.3 Potential lake outburst triggers			
Item	Data / evidences	Assessment	Remarks / recommendations
Possibility for...			
• ...rock/ice avalanches impacting the lake? (indicated by steep hanging glaciers, unstable rock formations)	High potential for rock/ice avalanches from various potential starting zones at Mount Hualcán (cf. historic events).	Rock-ice avalanches are possible anytime, also of large volumes (> 1 Mio m³).	An early warning system is currently being installed. Geophones have been deployed to register larger mass movements in the surrounding of Laguna 513. Cameras observing the dam and the flanks of Mt. Hualcán are constantly taking pictures of the situation (accessible online at http://inkanautas.com).
• ...debris-flow or GLOFs from upstream regions impacting the lake?	DEM data available (Worldview DEM from 2012, 8m resolution), suitable for mass movement modeling (see figure)	If such a mass movement impacts the lake, a displacement wave with the potential for overtopping the dam and causing a lake outburst can be formed.	IN-SAR satellite data is being collected in order to detect terrain displacements in the lake surrounding that indicate potential mass movements.
• ...rapid landslides impacting the lake? (indicated by terrain displacements)	Inlets of drainage tunnels have the potential for being blocked by floating ice.	A blockage of the drainage tunnel would cause an increase of the lake level by ~10 m and immediately raise the hazard potential.	Fences could be installed around the inlets of the tunnels to prevent blockage.
• ...high water level (caused by intense precipitation, intense snow melt, blockage of the lake outlet, or reduced outflow)			

Aim of the checklist

- Reflect the state-of-the-art
- Provide a reference document that is supported by 'the scientific community'
- Provide a tool for assessing the hazard potential of glacier lakes

Checklist structure

The checklist has four columns (see below for an example)

[PREDIFINED]

1. Description of checklist item (e.g., landform, process), cf. annexed document

[TO BE FILLED FOR EACH ITEM]

2. Data and evidences

3. Assessment of the hazard potential, possibly under varying circumstances.

4. Recommendations, remarks, possibilities for monitoring

DAM PROPERTIES



Photos: Rock dam of Laguna 513, ~25 m high, morainic material on top. Drainage tunnels have been drilled through the bedrock in the 1990s, indicated by the red arrows in the right photo. The lake level is therefore constant. The right photo was taken two days after the outburst in 2010 (note the avalanche ice still floating on the lake).

3 Assessment of the current hazard

3.1 Dam

Item	Data / evidences	Assessment	Remarks / recommendations
Characteristics	Rock dam with morainic material on top (see photo). A breach exists in the moraine.	Dam considered as stable. However, overtopping is possible in case of an impact wave (cf. past events and traces)	Inlets of the drainage tunnels need to be checked regularly.
Conditions	High freeboard (> 25 m), stable lake level (controlled by tunnels in the bedrock). Blocking of the lowest outlet tunnel possible (-> increase of lake level by 20 m)		Construction of another, lower tunnel planned by the municipality. This would further increase the freeboard and lower the hazard potential
	Surface outlet existing? Potential for blocking of outlet by ice blocks or floating snow?		

Potential & limitations

- This list helps experts to not overlook known processes and potential developments.
- It is not a method (e.g., there is no weighting of the items or similar).
→ Does not replace the expertise needed for a hazard assessment!
- Allows for a systematic assessment and comparison between sites.
- Could be extended to other glacier and permafrost hazards.
- Could be published on the GAPHAZ-website after community feedback (reference in potential lawsuits)

Scan this QR code to get a PDF of the draft of the checklist:



We want your feedback!

Any comments and suggestions are welcome!

Feedback can be given by...

... writing directly into the copy in this envelope

... sending an email to holger.frey@geo.uzh.ch

To get a copy of the draft of the checklist...

... take one of the copies provided

... go to <http://sglamo.gamma-rs.ch/index.php/publications> and download a PDF

... scan the QR code to the left



 GAMMA REMOTE SENSING

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