LOCATIONS OF SELECTED MITIGATION SITES IN SWITZERLAND
Mitigation measures: Diversion berm, armoured channel, open check dam

Process type (and basis): Debris flow

General notes: Small basin being expanded to improve capacity

Upgrade project: Current basin capacity is 5000 m³, being upgraded to 20,000 m³ (30 year event). 100 year event is 80,000 m³. A warning system is also installed because this capacity does not meet the protection targets; the village is still at risk from 300 year and extreme events. The system includes geophones in the watershed, linked to lights on the road and in the village. Cost of 1.8 million CHF ($2.4 million CAD) and a cost benefit ratio of 2.9. Designed by the consulting firm wasser/schnee/lawinen.

Diversion and channel: Channel berms are between 2 and 4 m high. Side walls constructed from reinforced concrete. Lower channel armoured with inset boulders.

Open check dam: Outlet is 3 m wide with removeable horizontal beams. New concrete cap to increase check dam height.

Geomorphology: Some blocks up to 1 m.

Site photographs by author, June 2016
DORNIBACH and DORNIURSE, Canton of Schwyz, Switzerland

Dorniurse mitigation Basin; diversion berm
Dornibach mitigation Energy dissipation structure; basin and open check dam
Process type (and basis) Debris flows
General notes Two creeks managed through a combined system

Dorniurse mitigation
There was a 5000 m³ rockfall in the ravine in 2009, which destroyed to old retention basin and a house in the village. New basin is planned with a 4000 m³ capacity. Enough to hold the 30 year event; larger events will be diverted to Dornibach. Debris gates across the road need to be closed manually by the fire brigade.

Dornibach mitigation Basin and energy dissipation structure installed just above the railway. The design was tested with physical model. Breaker required to slow the flow and direct material into the basin. Estimated maximum velocity of 25 m/s; breaker slows flow to 12 m/s. Outlet opening is 7 m wide and 5-6 m high. Openings are 0.4 m wide, between 0.3 m I-beams.

Construction Designed by a private Swiss firm. Cost of 7 million CHF ($9.5 million CAD); cost benefit ratio of 1.1.

Satellite image from Google Earth Pro, dated 2009 (prior to construction)

Site photographs by author, June 2016
GLYSSIBACH, Brienz, Canton of Bern, Switzerland

Mitigation measures

1) Open check dam, 2) diversion channel, 3) retention basin and berm, 4) armoured channel, 5) improved bridge conveyance

Process type (and basis)  
Debris flow; damaged during 2005 event

General notes  
Excellent example of the functional chain concept

Open check dam  
Foundation consists of a 1.5 m thick, 17 m wide and 40 m long concrete slab. The barrier is 2 m thick, and is composed of 2680 m³ of concrete and 222 tonnes of steel rebar. The downstream fins stabilize against tilting and sliding. Intended to pass small events (up to 25,000 m³); larger events are diverted into the retention basin.

Retention basin  
Capacity of around 75,000 m³. The tallest section is about 15 m high.

Additional notes  
Available in German from site visit; can be translated if more technical specifications are required.

Open check dam looking upstream

Diversion channel looking downstream

Sketch of bridge blocking walls (orange). Used to increase channel capacity

Satellite image from Google Earth Pro, dated 2010

Armoured channel

Site photographs by author, June 2015
### ILLGRABEN, Canton of Valais, Switzerland

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<th>Mitigation measures</th>
<th>Large closed check dam in upper watershed; series of check dams; monitoring system. Plan to add overflow weir and diversion structure (Berger et al., 2016).</th>
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<tr>
<td>Process type (and basis)</td>
<td>Debris flow, currently 3-5 per year but up to 7/year</td>
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<td>General notes</td>
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#### Historical construction

In 1961, a 500,000 m$^3$ debris flow prompted the construction of 30 check dams in the channel and a large consolidation dam (40 m high) in the upper watershed. Decreased frequency for a while.

#### Monitoring

WSL monitoring started in 1999. System includes: rain gauges in the upper watershed; geophones; depth sensors; force plate; erosion sensors; and instrumented wall with force plates and geophones. There is also an alert system near the channel, with lights and sirens. If an alert is triggered at the upper consolidation dam, there is 5-10 minutes to escape.

#### Erosion

Very large variation in channel bed. For example, 6 m between two seasons.

#### Planned diversion

Overflow structure planned at the first dogleg below the fan apex. Intended to pass smaller events and divert larger events onto the western, undeveloped portion of the fan.

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**Site photographs by author, June 2016**
TASCHBACH, Canton of Valais, Switzerland

Mitigation measures
Check dams in upper watershed; open check dam; masonry armoured channel

Process type (and basis)
Debris flows, disasters in 1957 and 2001 (according to sign posted on the dam).

General notes
Downstream side of check dam is vegetated. Spillway is about 15 m wide.

Site photographs by author, June 2016
**Mitigation measures**
- 1) Flexible debris net
- 2) armoured channel
- 3) bridge with sidewalls that break when subjected to flows
- 4) moveable bridge
- 5) improved capacity at confluence

**Process type (and basis)**
Debris flows

**General notes**
Excellent example of the functional chain concept. Additional notes in German from site visit; can be translated if more technical specifications are required.