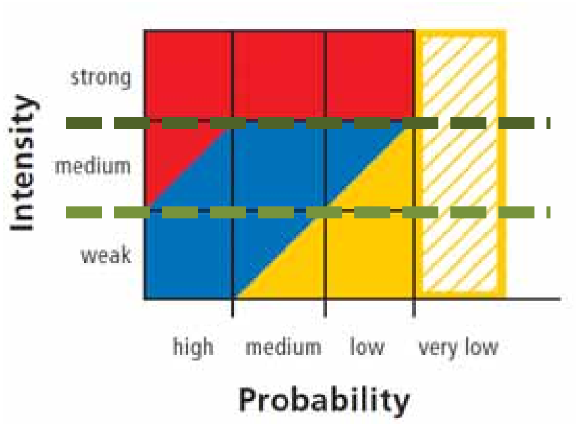
Intensity thresholds

Based on the rock kinematic energy:

$$E_{kin} = \frac{1}{2}mv^2$$

(Velocity usually between 5 and 30 m/s)



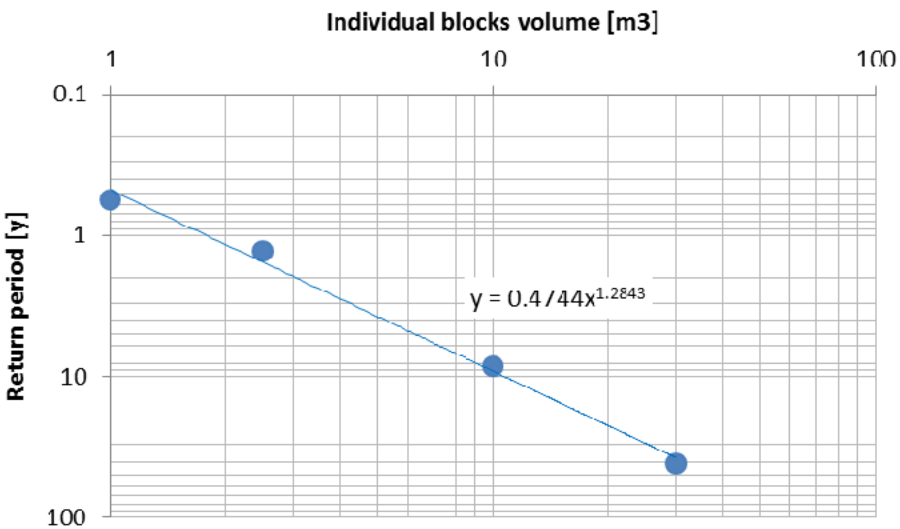
300 kJ: Energy that can be absorbed by a reinforced concrete wall

30 kJ: Energy that can be absorbed by a wooden railroad tie (sleeper)

Source: Lateltin (1997)

Photo: wikipedia

Frequency thresholds



One scenario for each frequency class, representing the bigger individual block falling in the interval class

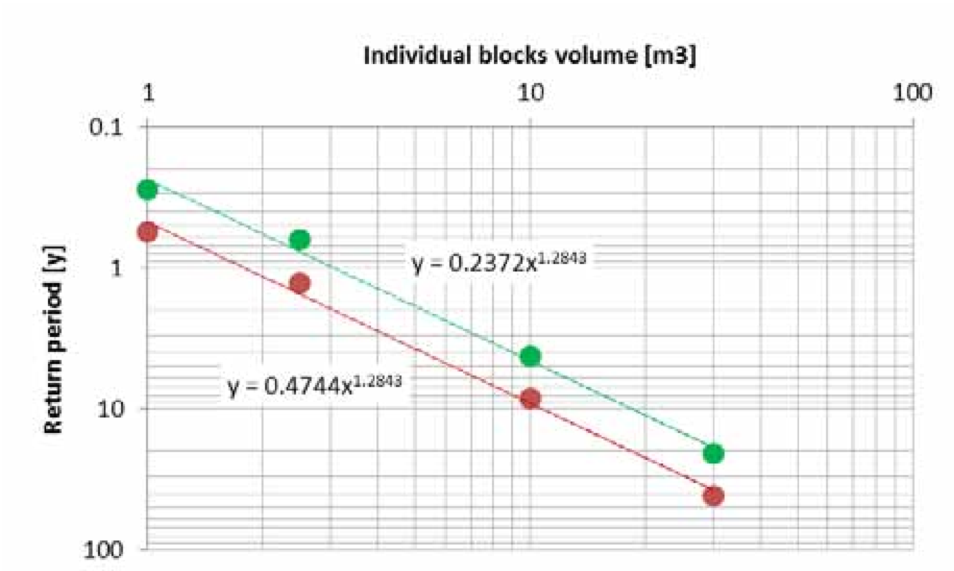
Example in Andora (Corominas et Mavrouli 2013):

0-30 ans → 25 m^3
30-100 ans → 66 m^3
100-300 ans → 152 m^3

The frequency at wich a given block size is overpassed can be approximated by a power-law distribution of the form $T=aV^b$ with :
T: return period
a: scale parameter (position of the line on the graph)
b: shape parameter (slope of the line on the graph, depends on the rock characteristics)
V: volume)

Dussauge-Peisser et al. (2003)

Frequency-size relation



Consequence: the size of the source area matters, since it modifies the parameter « a » of the distribution (Hantz 2010). These statistics are for a big area, but usually, a « normal » individual cliff is considered in the Swiss methodology (although no dimension is prescribed)

Exemple in Andorra (extrapolated from Corominas & Mavrouli 2013):

0-30 years→ 25 m^3
30-100 years → 66 m^3
100-300 years → 152 m^3

If the size of the study area doubles, the frequency doubles (if the conditions are exactly the same). As a result, the volume for a given return period increases :

0-30 years → 43 m^3
30-100 years → 111 m^3
100-300 years → 260 m^3

Propagation analysis

When the scenarios have been identified (i.e. characteristic volumes for each return period), the next step is to estimate the propagation in terms of:

- Affected area (propagation distance)
- Energies
- (Flying height, for mitigation design)

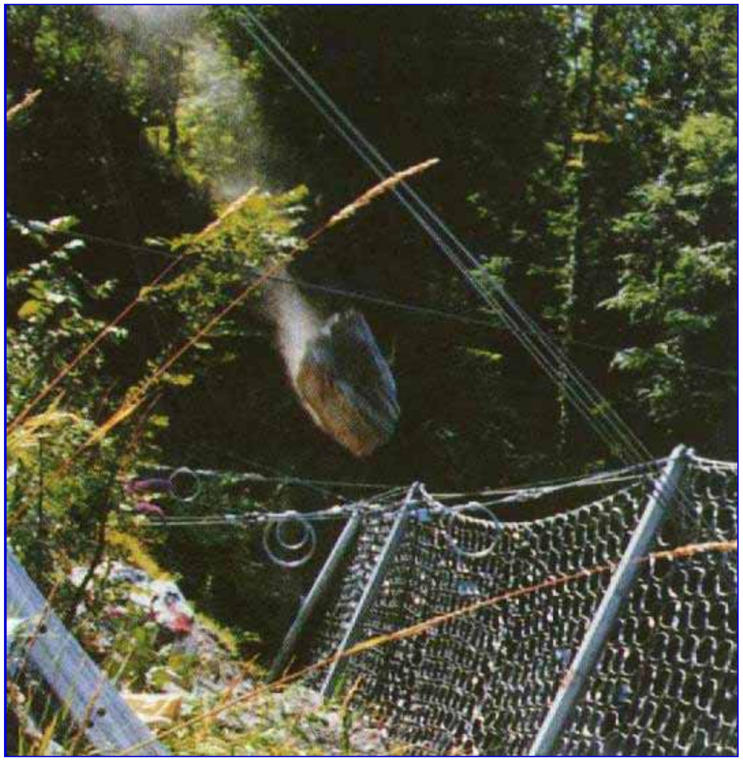
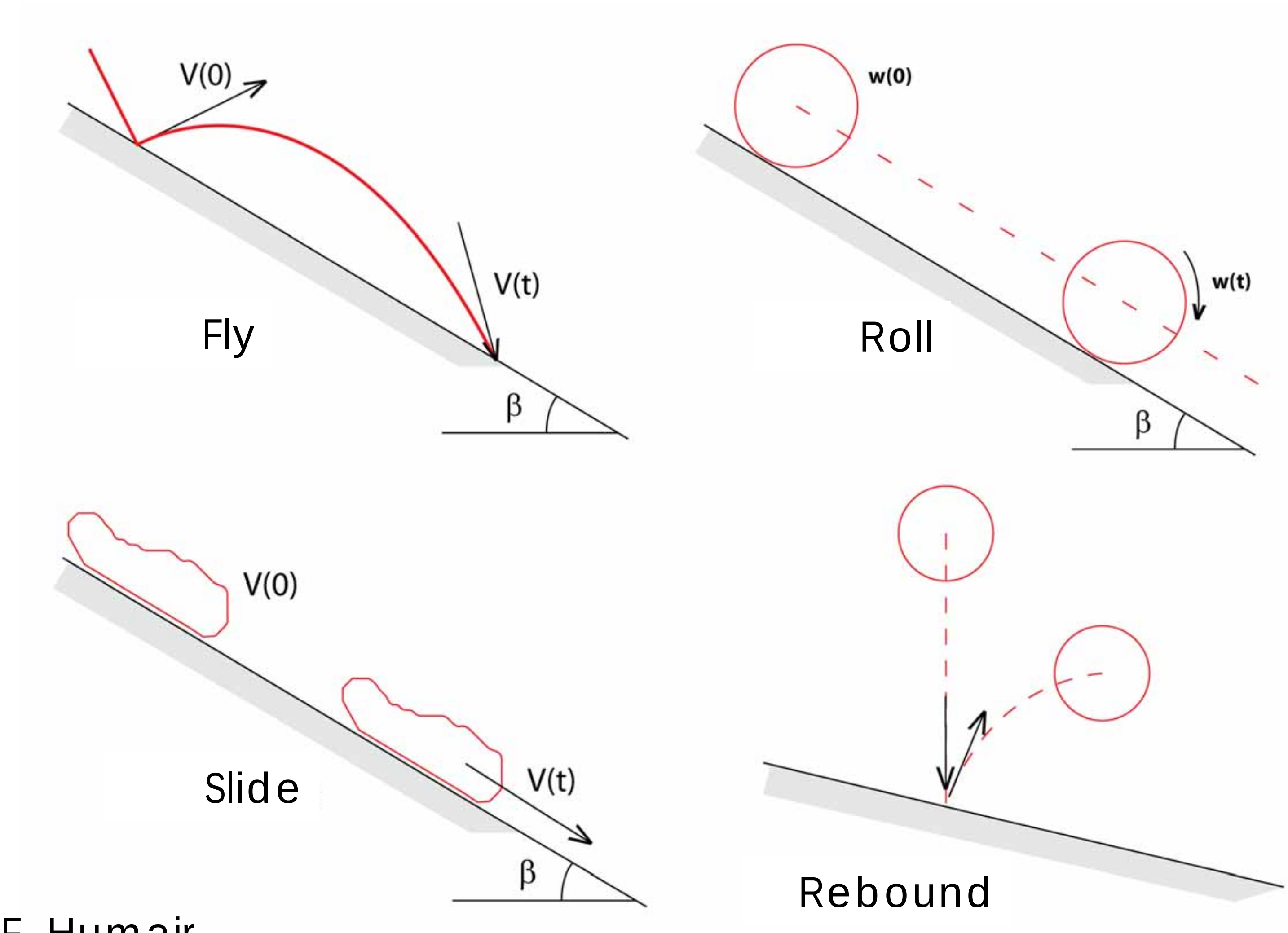


Photo: Guzzetti et al.

Propagation analysis: motion types



Source: F. Humair

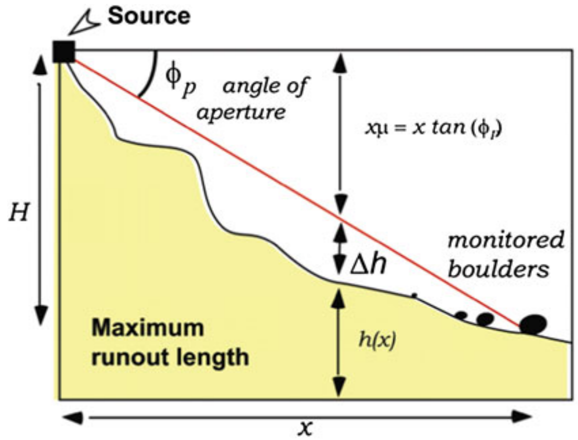
Modeling approaches

Free fall

If the block falls directly on the ground without propagating further, the energy is estimated with:

$$E_{impact} = m \cdot g \cdot h$$

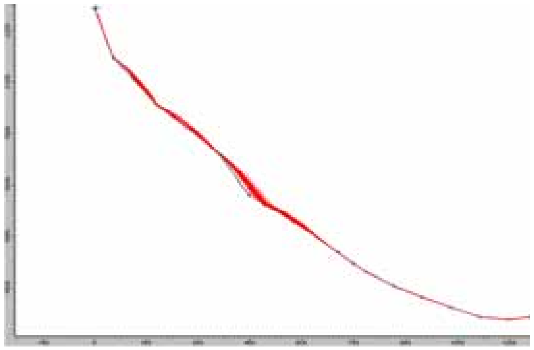
Geometric



Jaboyedoff et al. (2012)

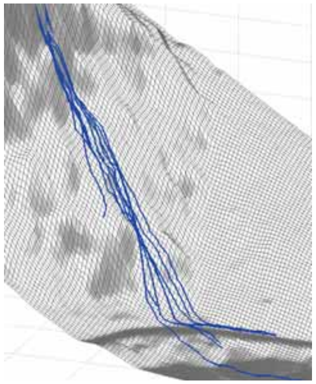
2D

Modeling along a profile



RocFall 4.0

3D



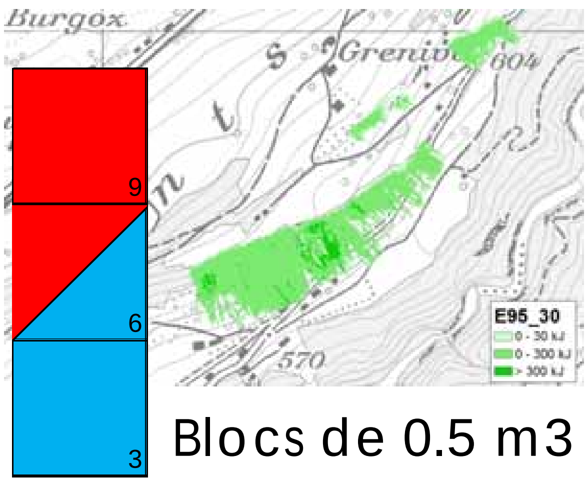
Dorren et Berger, 2012

Intensity zoning

- Intensity maps are based on the trajectographic results
- No consideration of the propagation probability (zoning based essentially on the energy)

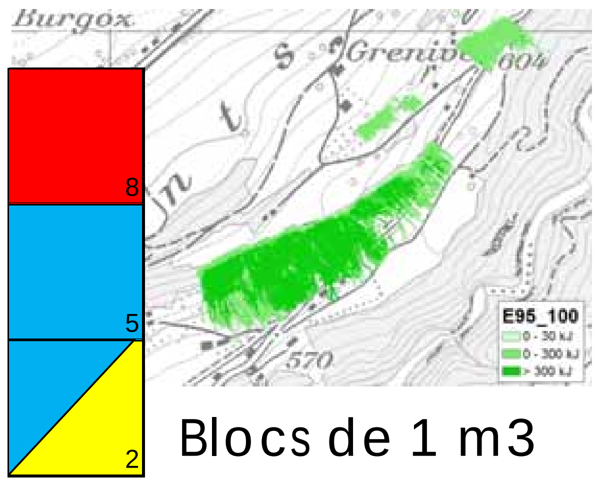
CSD 2012

T30



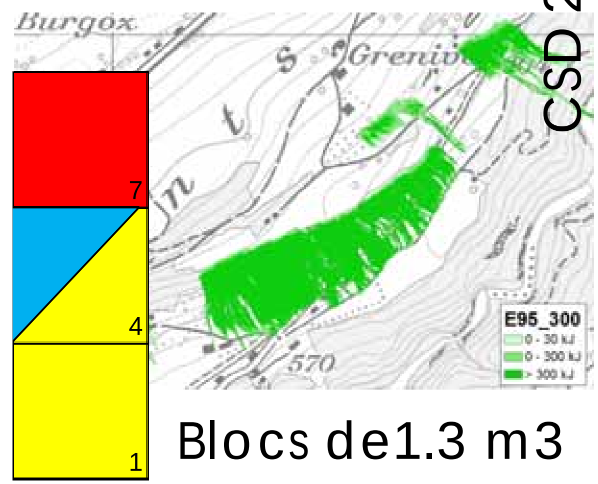
Blocs de 0.5 m3

T100



Blocs de 1 m3

T300

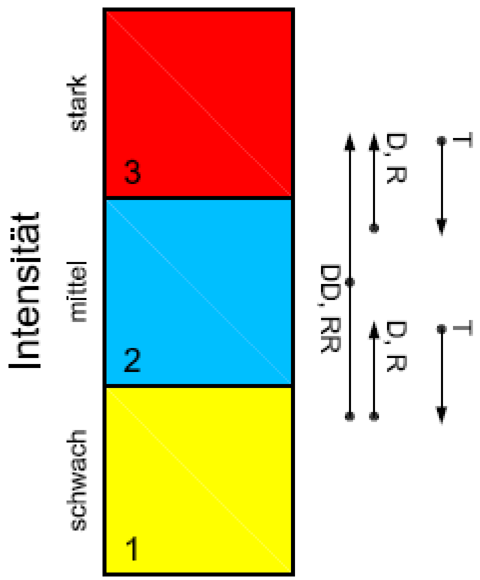


Blocs de1.3 m3

Danger map (higher level is kept, expert judgment for the squares with diagonals)

OVERVIEW OF THE OTHER PHENOMENON

Slow-moving landslides



Zoning based on the velocity...

- Low: 0-2 cm/y
- Medium: 2-10 cm/y
- High: >10 cm/y

...And special conditions :

- D: differential movements (DD: high)
- R: potential of fast reactivation (RR: high potential)
- T: favorable conditions (homogenous movement)

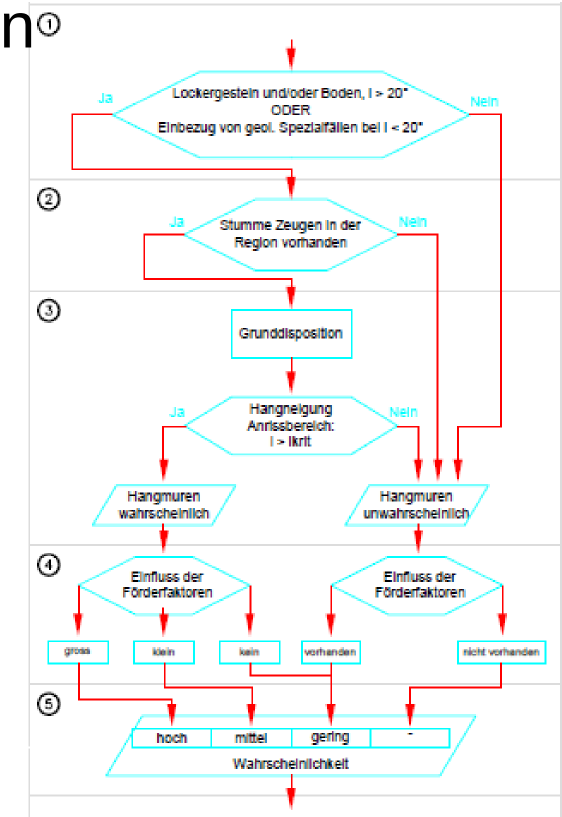
Bollinger et al. (2004)

Shallow landslides and mudflows

Lateltin (1997) recommends to evaluate the danger as follow :

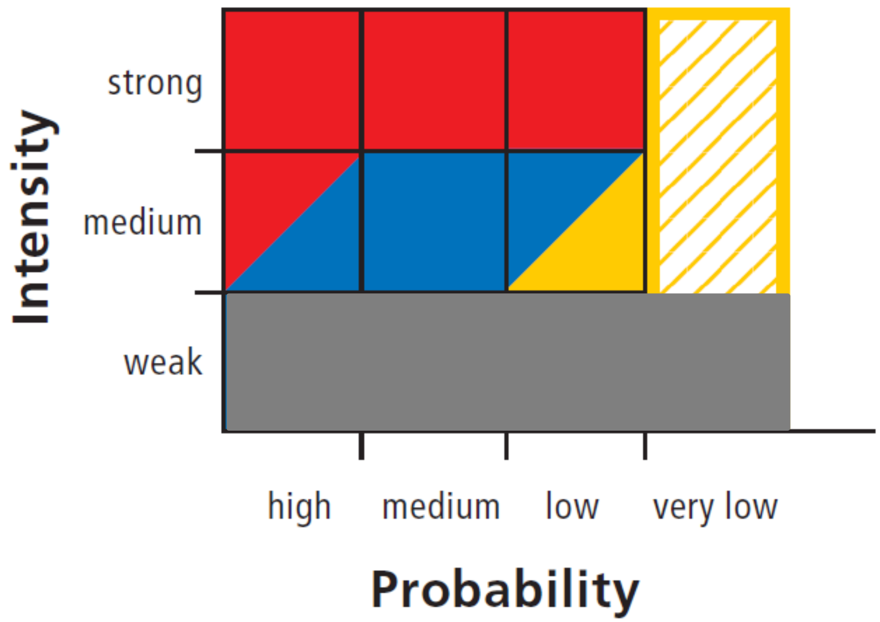
- Red: deposit thickness >1 m or thickness of the mobilizable layer >2 m
- Blue: deposit thickness <1 m or thickness of the mobilizable layer 0.5 m-2 m
- Yellow: thickness of the mobilizable layer <0.5 m

Current developments focus on the susceptibility evaluation



Bollinger et al. (2004)

Debris-flow

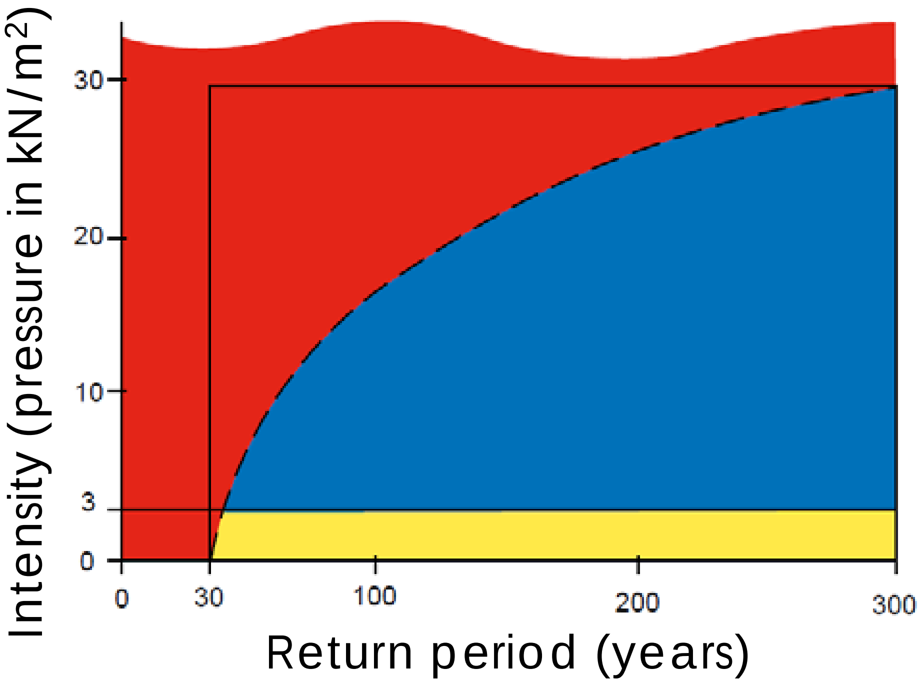


The intensity is expressed in terms of:

- Height of the deposit (high intensity if > 1 m)
- Velocity (high intensity if > 1 m/s)

No low intensity is expected for debris-flows

Snow avalanches



The intensity is expressed in terms of pressure over on object on the way

Canton de Fribourg (2006)

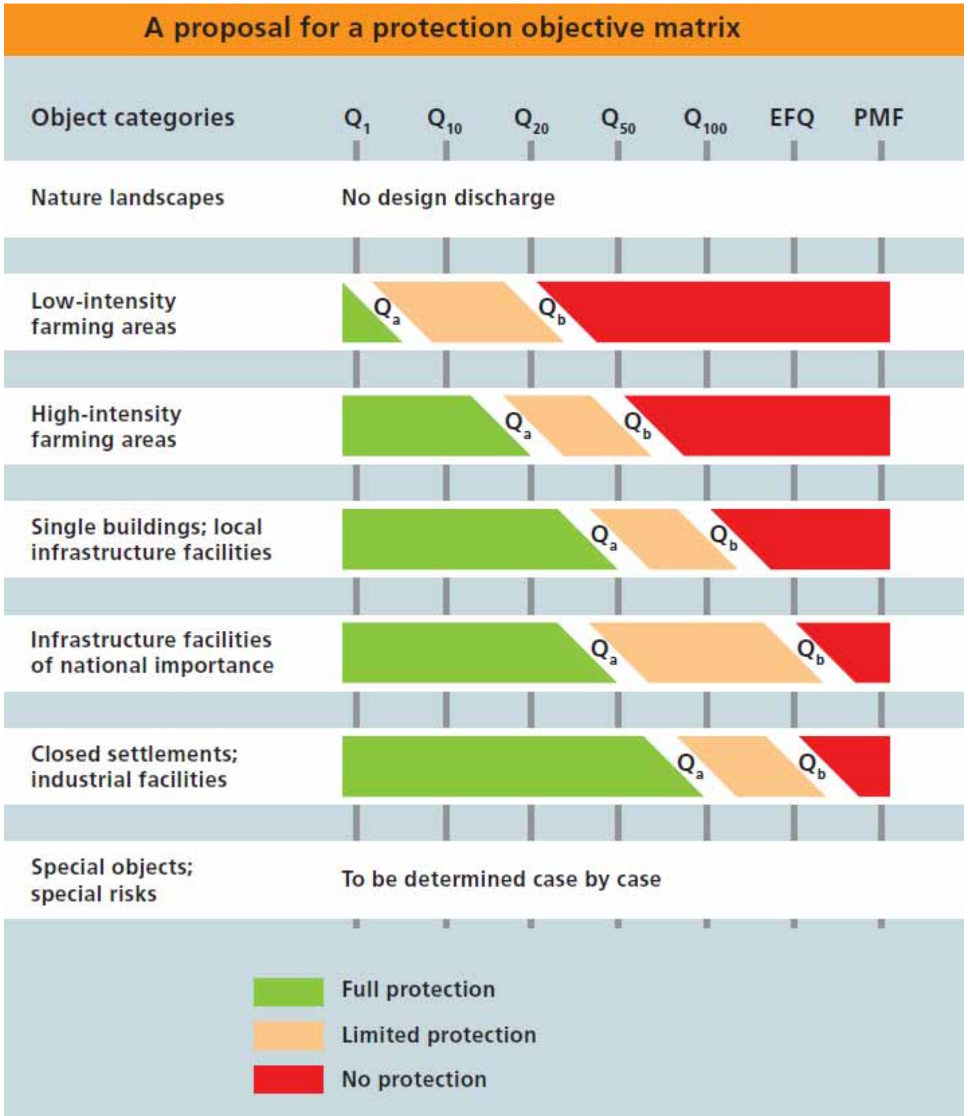
CURRENT TRENDS

Main limitation of danger maps

- By itself, don't give enough information on the danger type (intensity and frequency) → intensity map are now mandatory
- Suitable for unconstructed areas, but what to do if a building is in a red zone?
- Is it suitable to build an hospital in a yellow zone?
- Is it an appropriate method for roads, hiking trails,…?

→ Hazard assessment is a necessary step, but further elements are needed for risk management

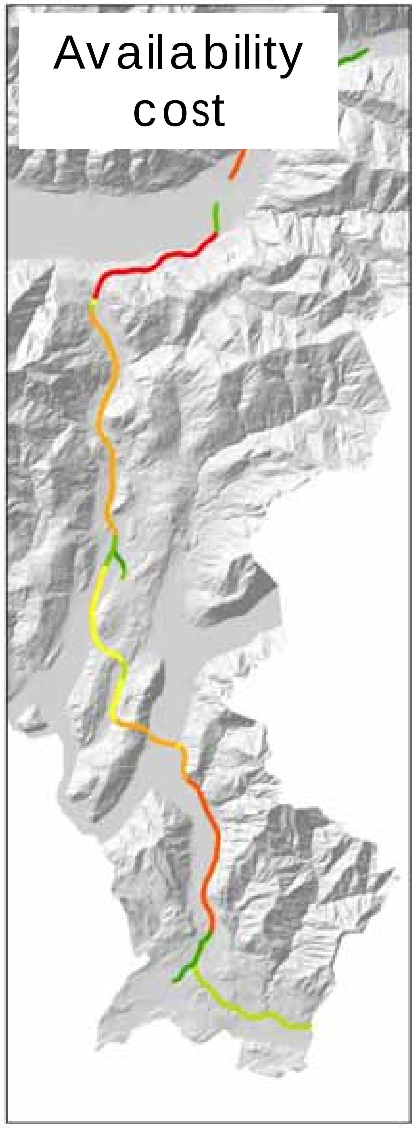
Protection objective



→ Different rules depending on the affectation (e.g. farming area or industrial facility)

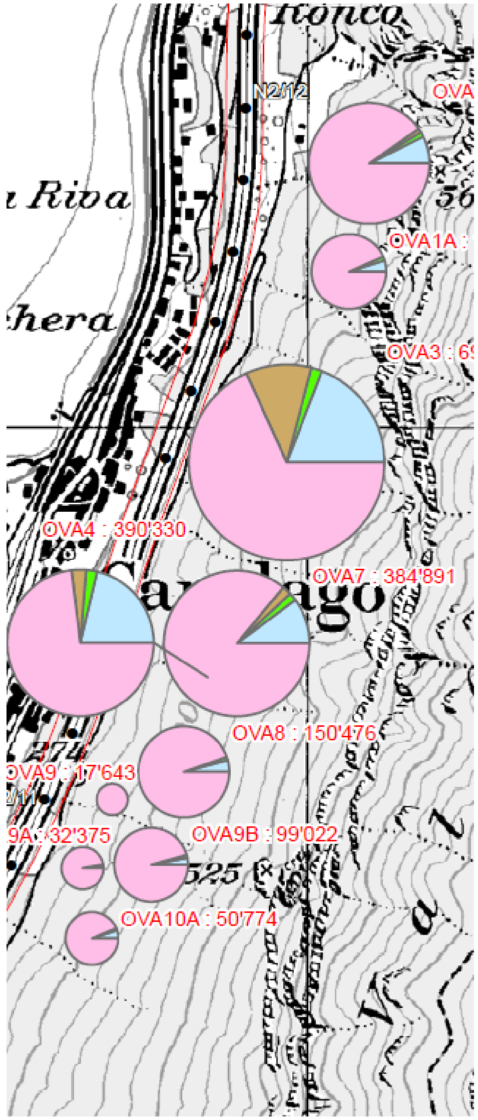
FOWG (2001)

Risk analysis for Highways



Risk analysis including different kind of damage, in particular the availability cost, to account for the consequences of a closure

It also focuses more on low intensity-low probability events.



Risk analysis for protection measures

- Funding of protection measure by the Confederation is based on a cost-benefit analysis

Management strategy for the next 30 years: The Third Rhone Correction

Rhone and current land use management principle: the centennial flood is mitigate by widening the channel and the management of extreme flooding by the creation of back levees

1860 -1890: The first correction

1930 -1960: The second correction

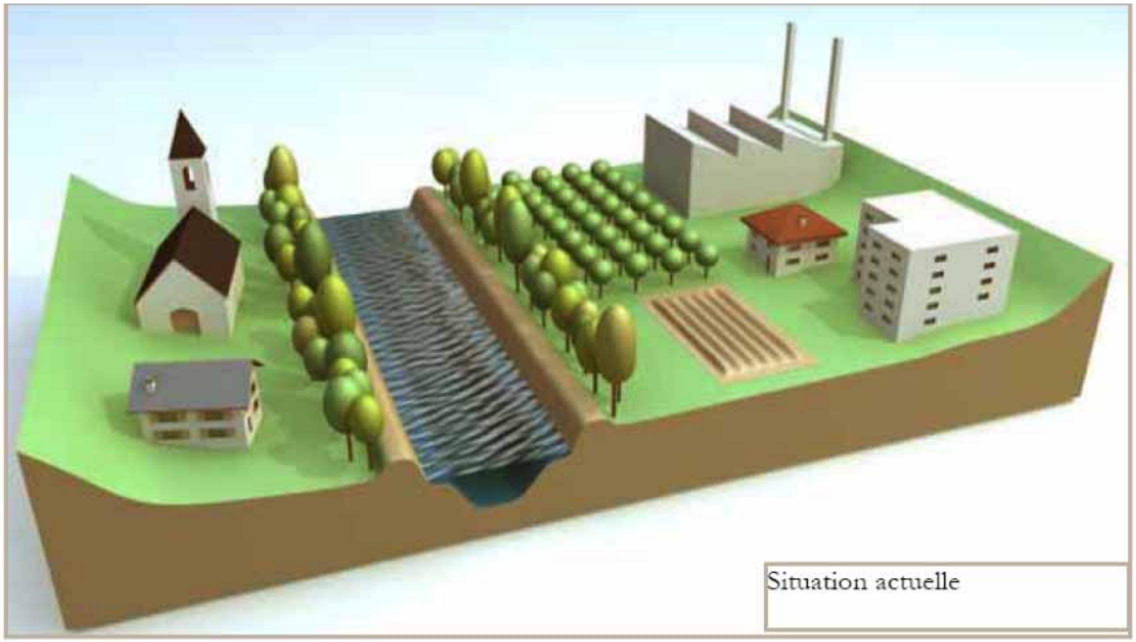
Cost: ~ 1 billion CHF

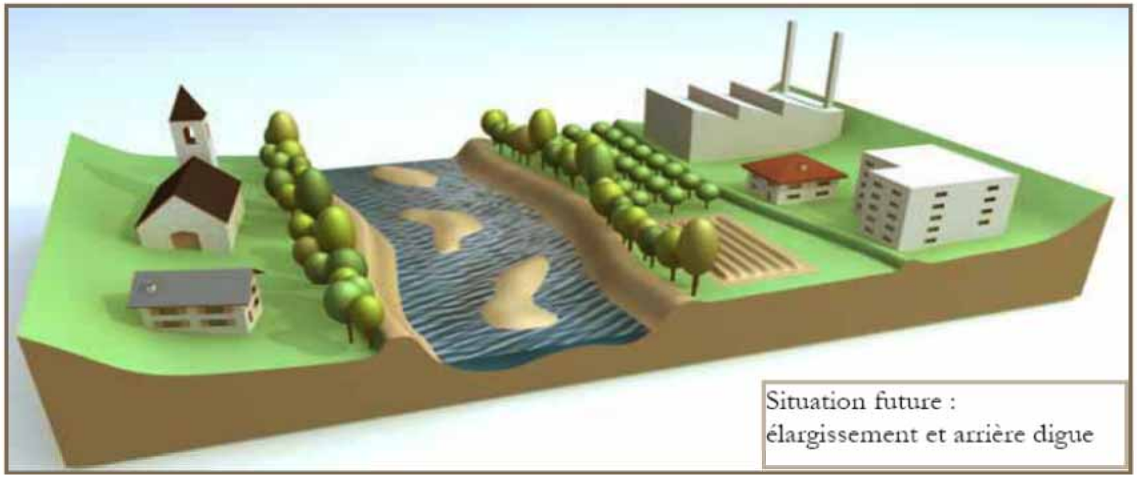
Duration → 2030

Early work:

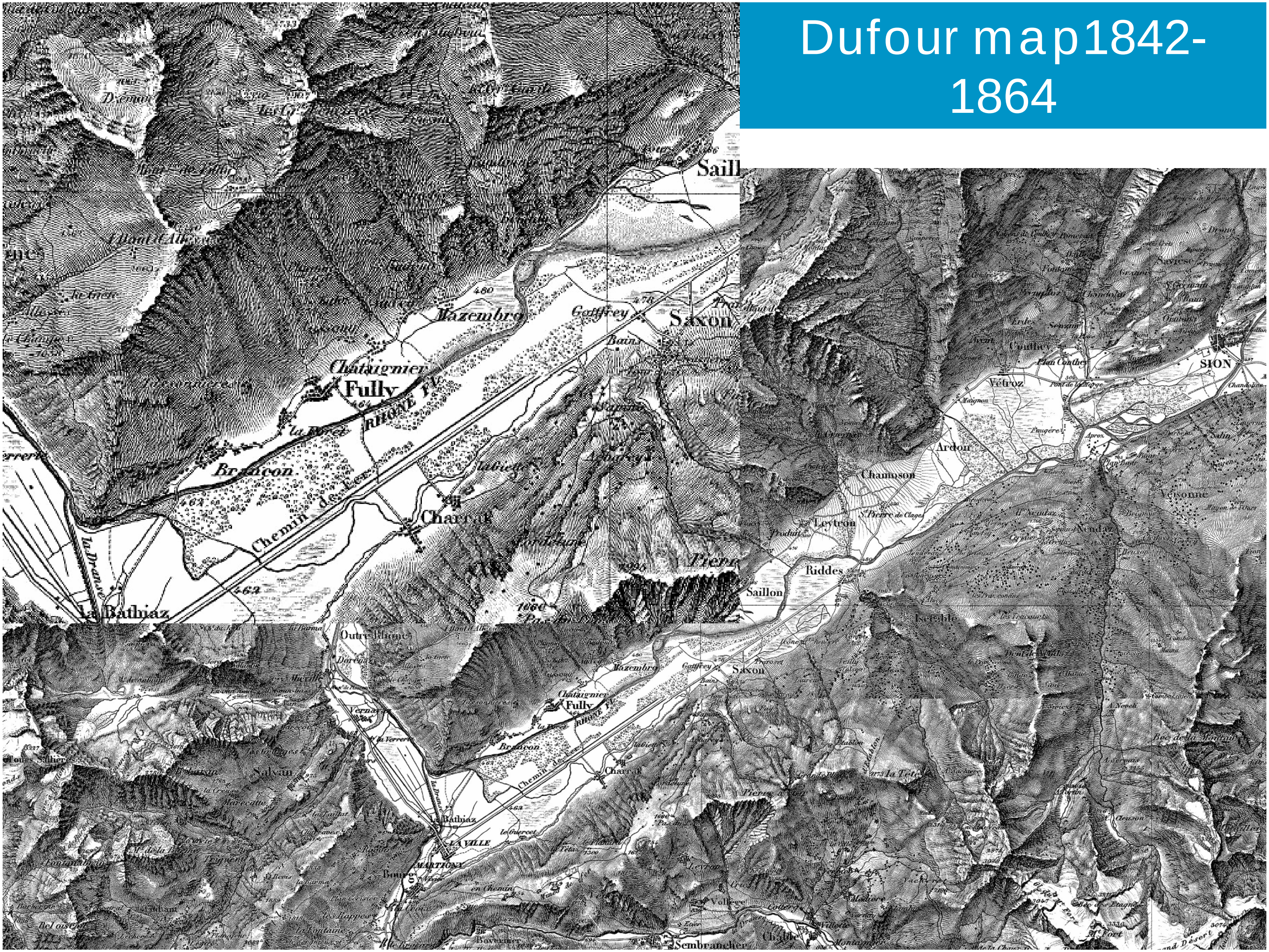
Visp Chippis, Fully (200 Mio. CHF)

(**from:** Plan sectoriel 3ème correction du Rhône Version pour consultation; Etat du Valais, MAI 2005)





Dufour map1842-1864



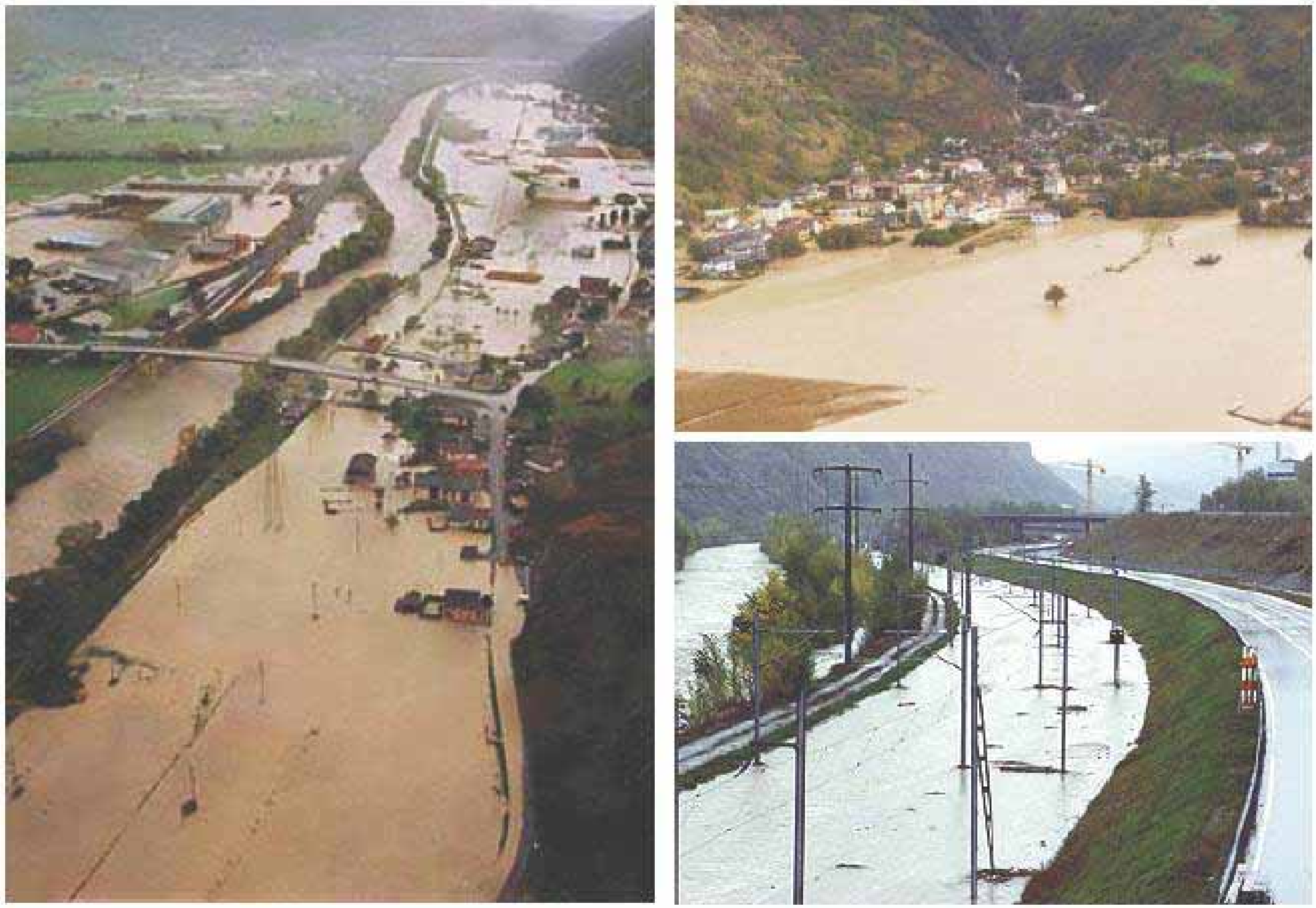
Significant changes in land use

- Google Earth 2006

Break of embankment the Rhône river 2000

- *Rupture of the dike of the Rhone at Chamoson (from Wuilloud, 2004)*

Floods 2000

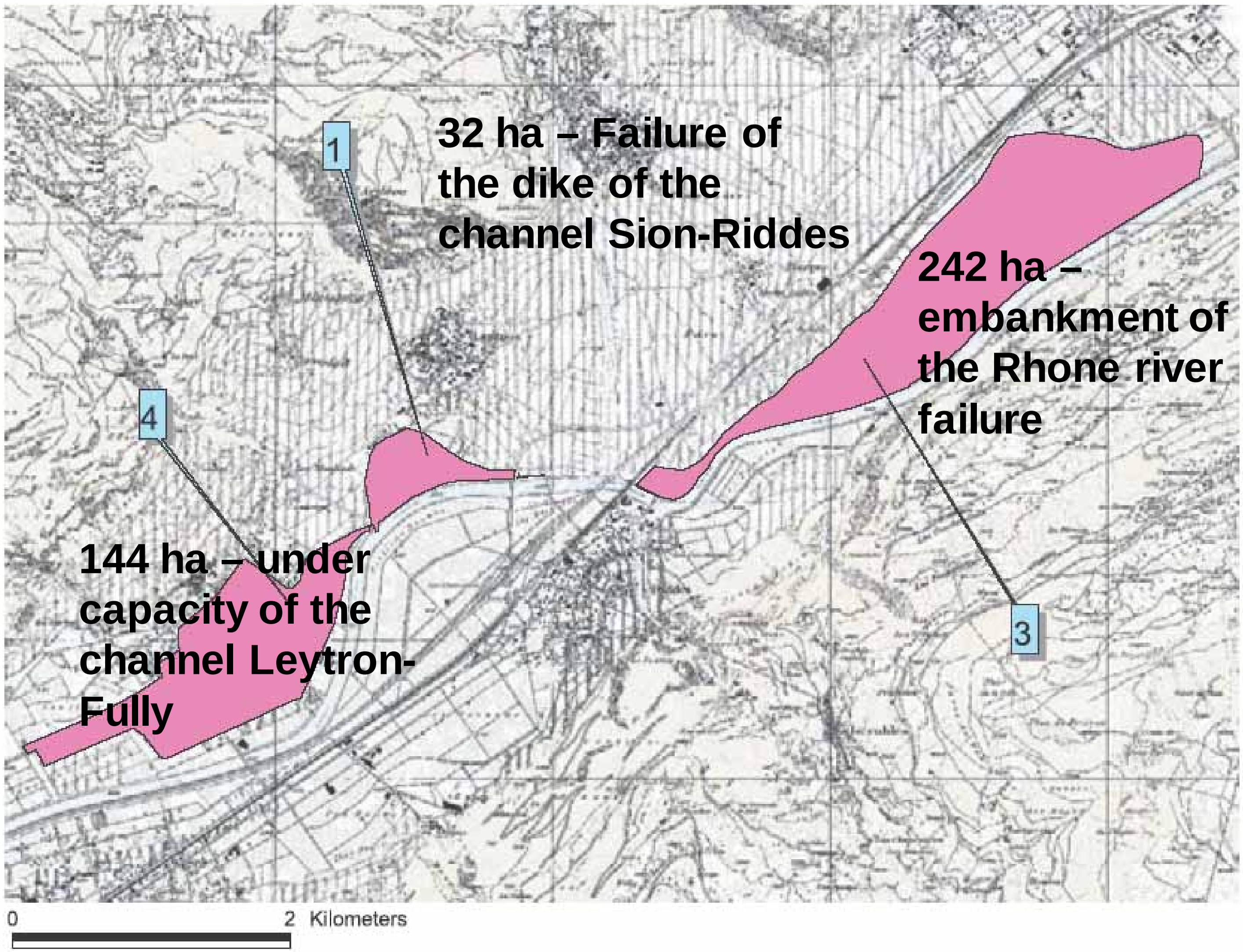


- *(from Bourban, 2001 et photod www.edicom.ch)*

Rhône valley

- *Floods in 1920 and 1935 in Sion area Conthey (From Bourban, B., 2001 photos From Torrenté 1962)*

Flood in Saillon (OFEG, 2002)



Lavey-Bex (photos Sesa)