Case study on snow avalanches - Davos Frauentobel, Switzerland

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Outline

1. From a local problem of safety services to risk assessment.

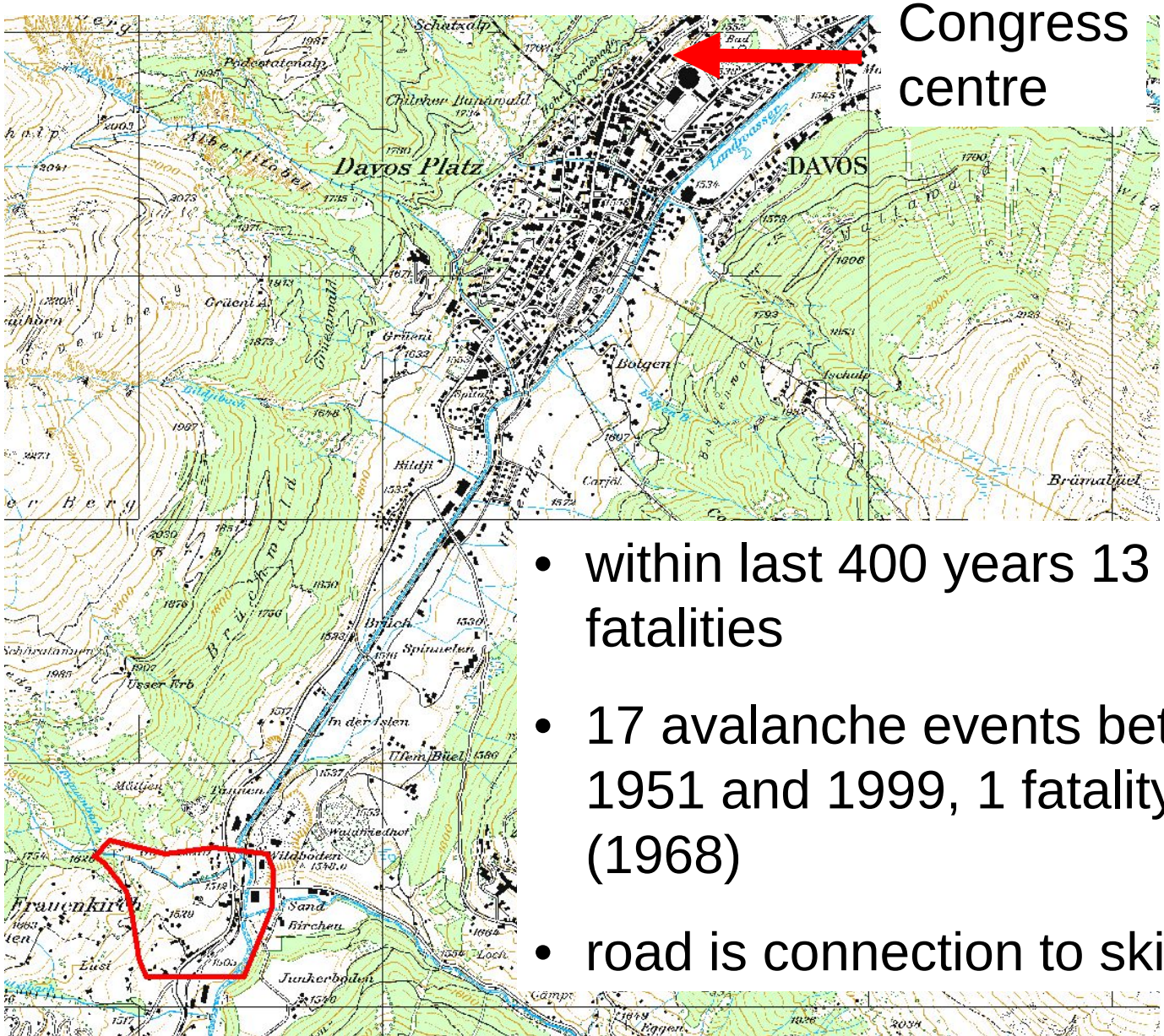
2. From risk assessment to planning and optimisation of countermeasures.

3. Realisation of the safety concept in practice.

4. Conclusions.

From a local problem
of safety services
to risk assessment.

Investigation area Davos Frauentobel

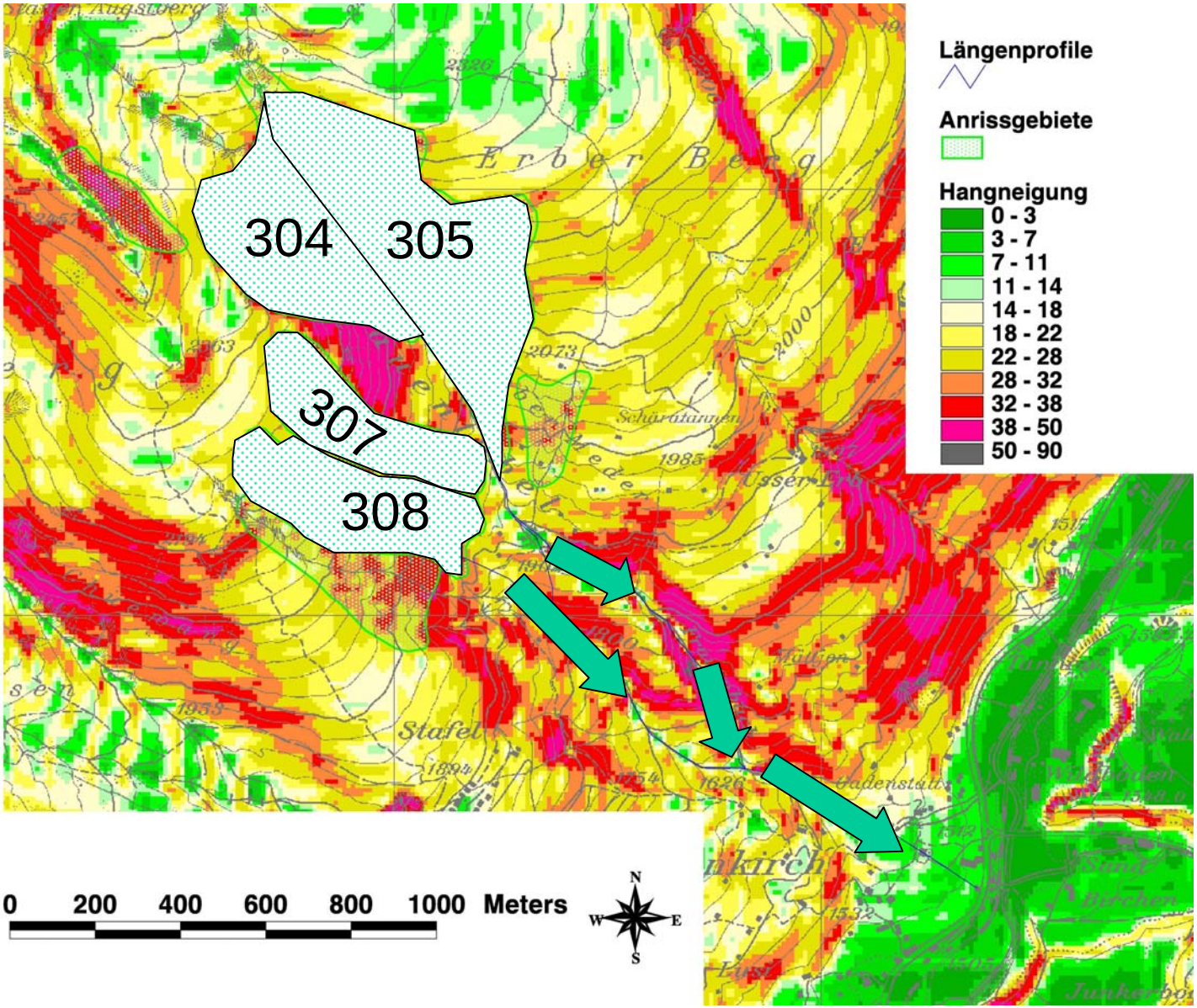


- within last 400 years 13 fatalities
- 17 avalanche events between 1951 and 1999, 1 fatality (1968)
- road is connection to ski resort.

Davos Frauentobel

From risk assessment to planning and optimisation of countermeasures.

Release areas and slope angle

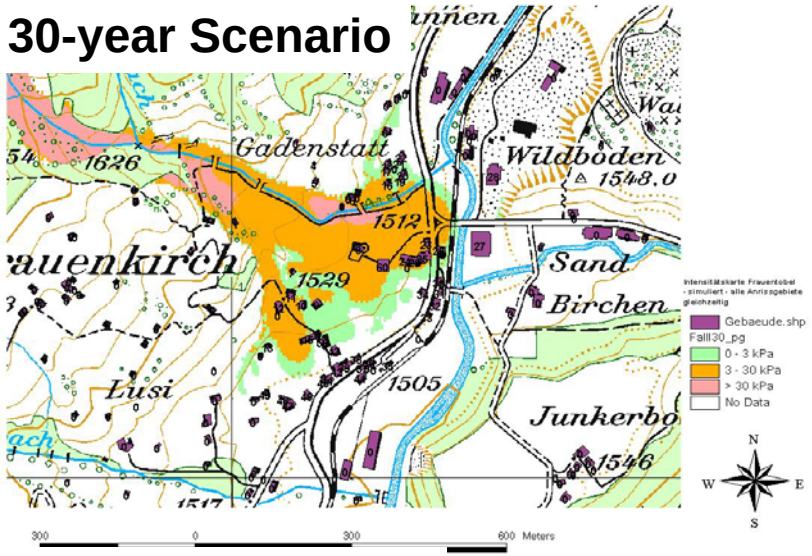


Hazard analysis – intensity maps without measures

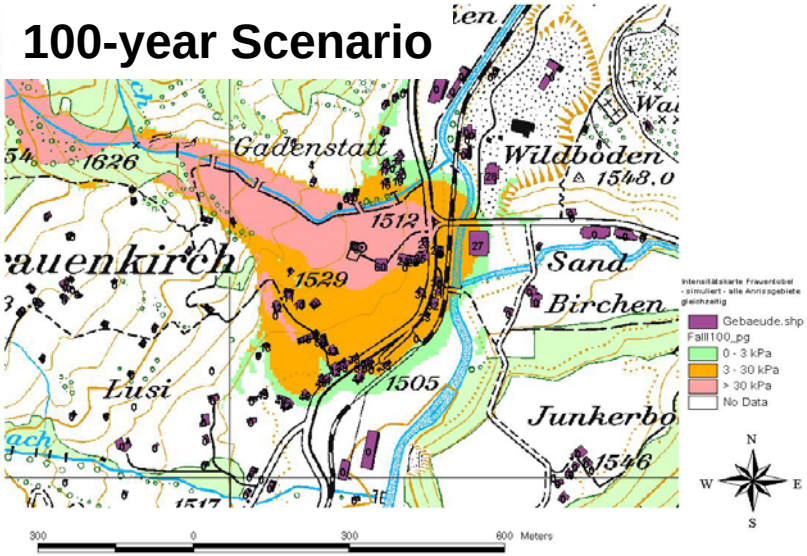
Identification of realistic scenarios, estimation of impact.

Two components:
- event analysis
- impact analysis

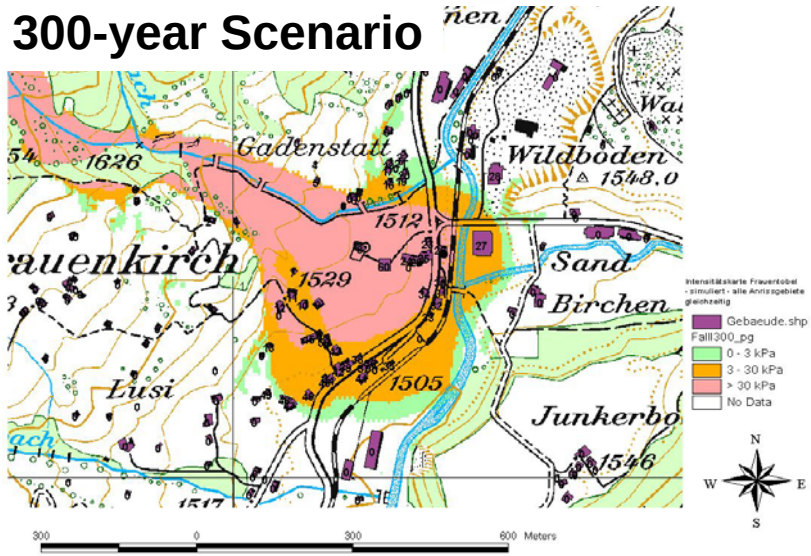
30-year Scenario



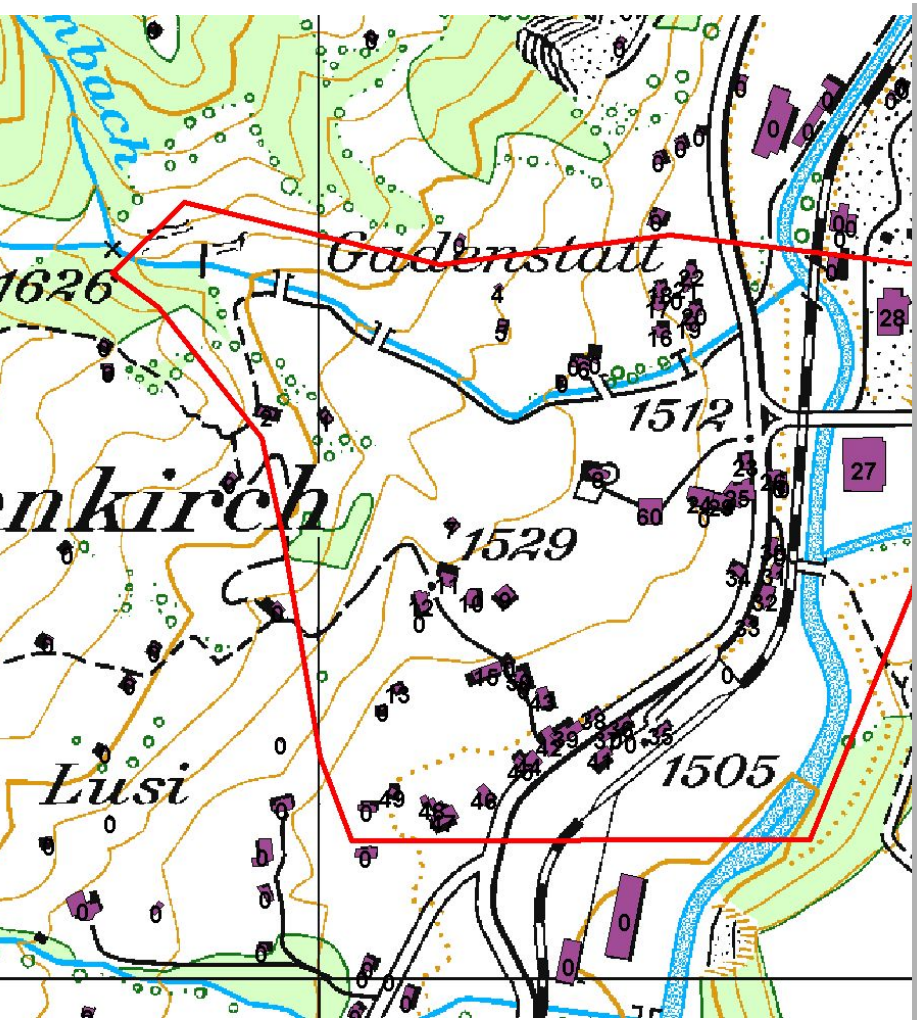
100-year Scenario



300-year Scenario



Exposure analysis: exposed objects



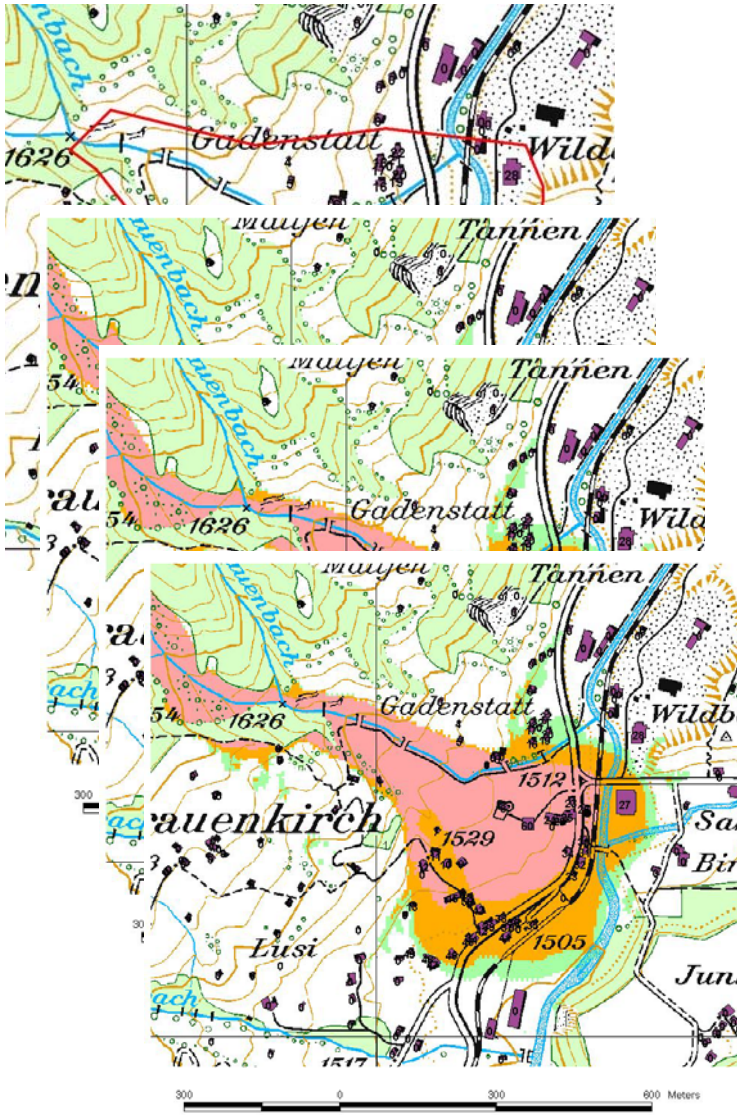
24	residential houses
1	church
1	school
2	hotels
1	railway station
2	public buildings
15	stables with livestock
3	garages
	road
	railway

Number persons: 185

Damage potential: 51 million CHF

33 million Euro

Consequence analysis

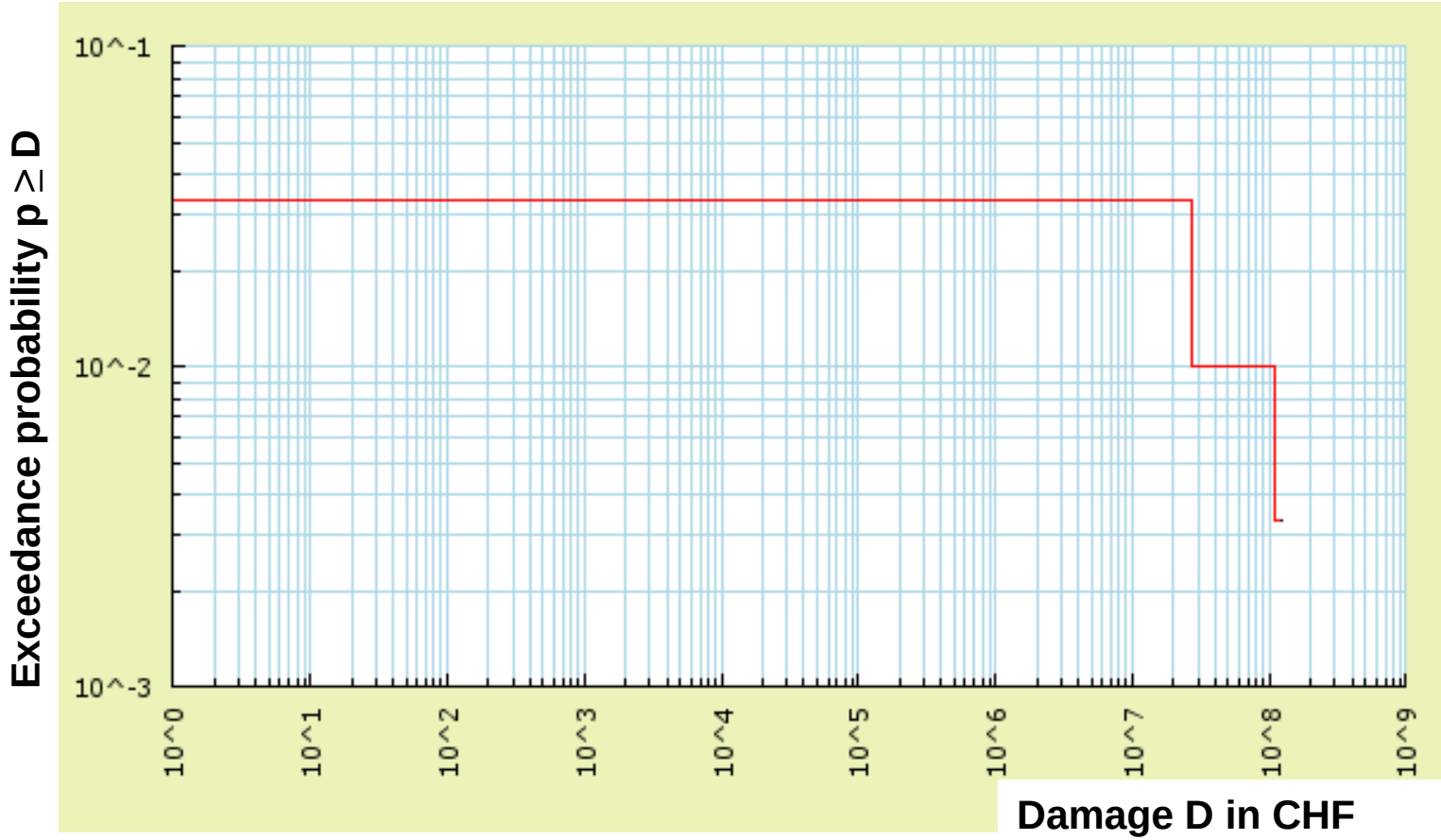


Calculation of loss
(e.g. persons in buildings):

$$L(ep)_{i,j} = p_{Sp} \cdot (1 - r(op)) \cdot Np \cdot V_{bui} \cdot \lambda$$

p_{Sp} = spatial variability
r(op) = object protection buildings
N_p = number of persons
V_{bui} = vulnerability of buildings
l = mortality of persons

Presentation initial risk in FN-Diagramme

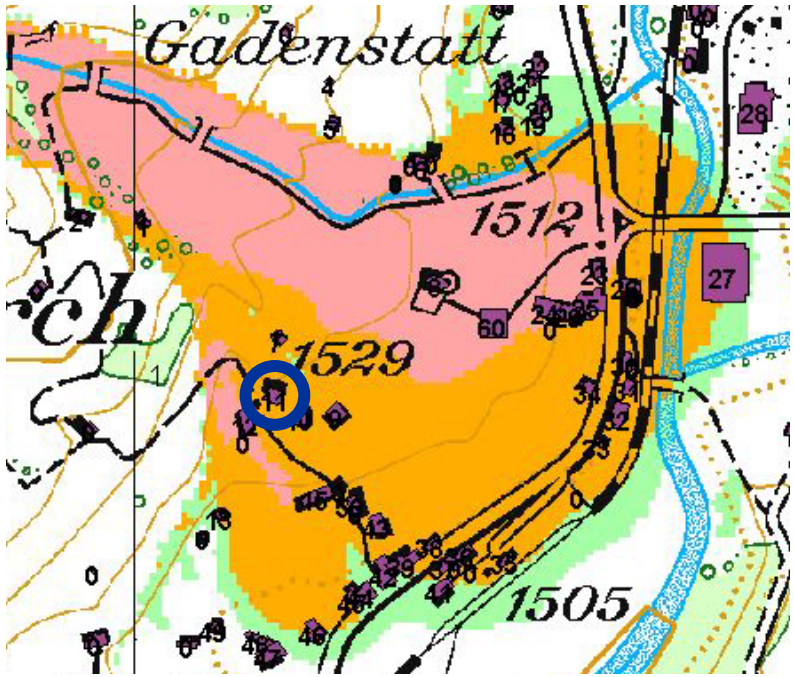


Calculation of individual risk

Identification of certain persons, which are especially endangered.

r_i (b11) = 1.94 x 10^{-3}

p(pr) = 0.8, i.e. in 80% of the time the person is present in the house.



➔ protection goal
$r_i(max) \leq 1 \times 10^{-5}$ is violated.

Protection goals, example Switzerland

Category	Individual risk (CH)	Societal risk (VSL, CH) x 10^6 CHF	Example
high degree of self control (category 1-2, PLANAT-Strategy)	$10^{-2} \leq r_i \leq 1x\ 10^{-5}$	1 - 5	alpine climbing, working risks car driving on mountain roads
low degree of self control (category 3-4, PLANAT-Strategy)	$r_i \leq 1x\ 10^{-5}$	5 – 20	train riding, living in blue or red hazard zones.

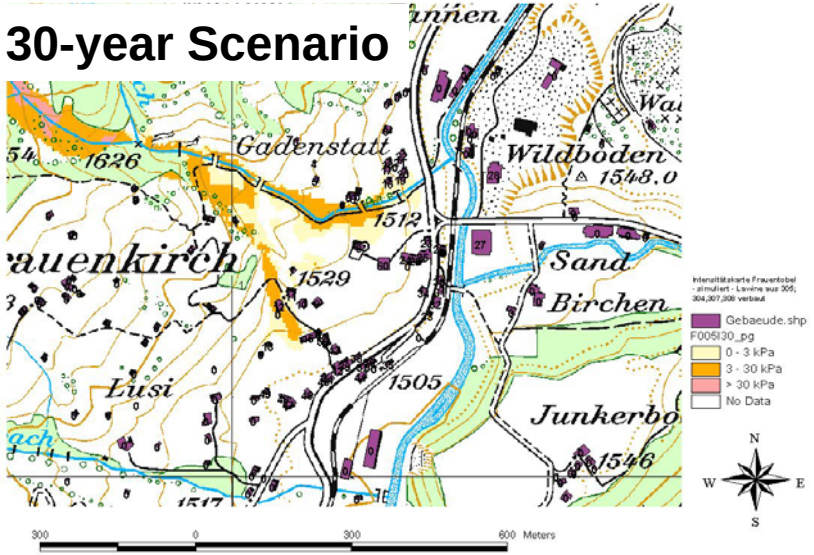
Considered measures

- improvement of organisational measures (evacuation and closure)
- artificial avalanche release
- defence structures of several release areas (here 304, 307, 308)
- combination of these measures

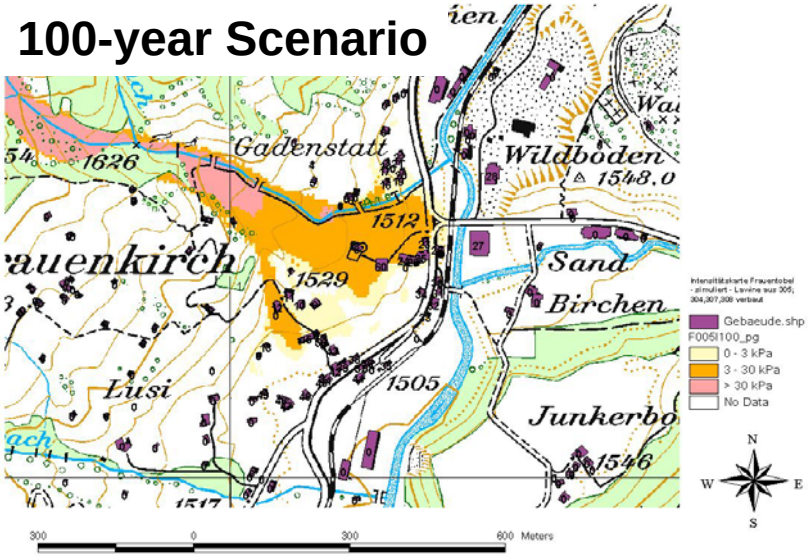
Hazard analysis – intensity maps after the realisation of measures

- Hazard analysis assuming realisation of measures.
- Calculation or estimation of intensity maps.
  e.g. defence structures in the release zone.

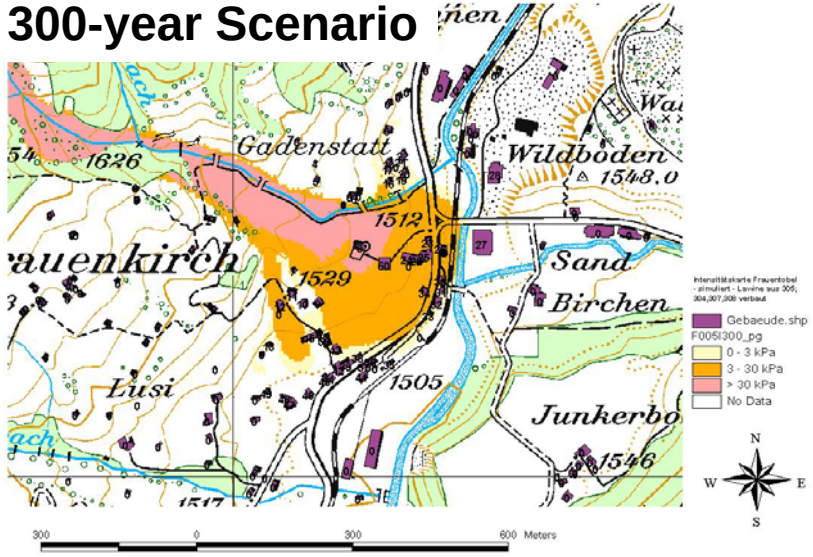
30-year Scenario



100-year Scenario

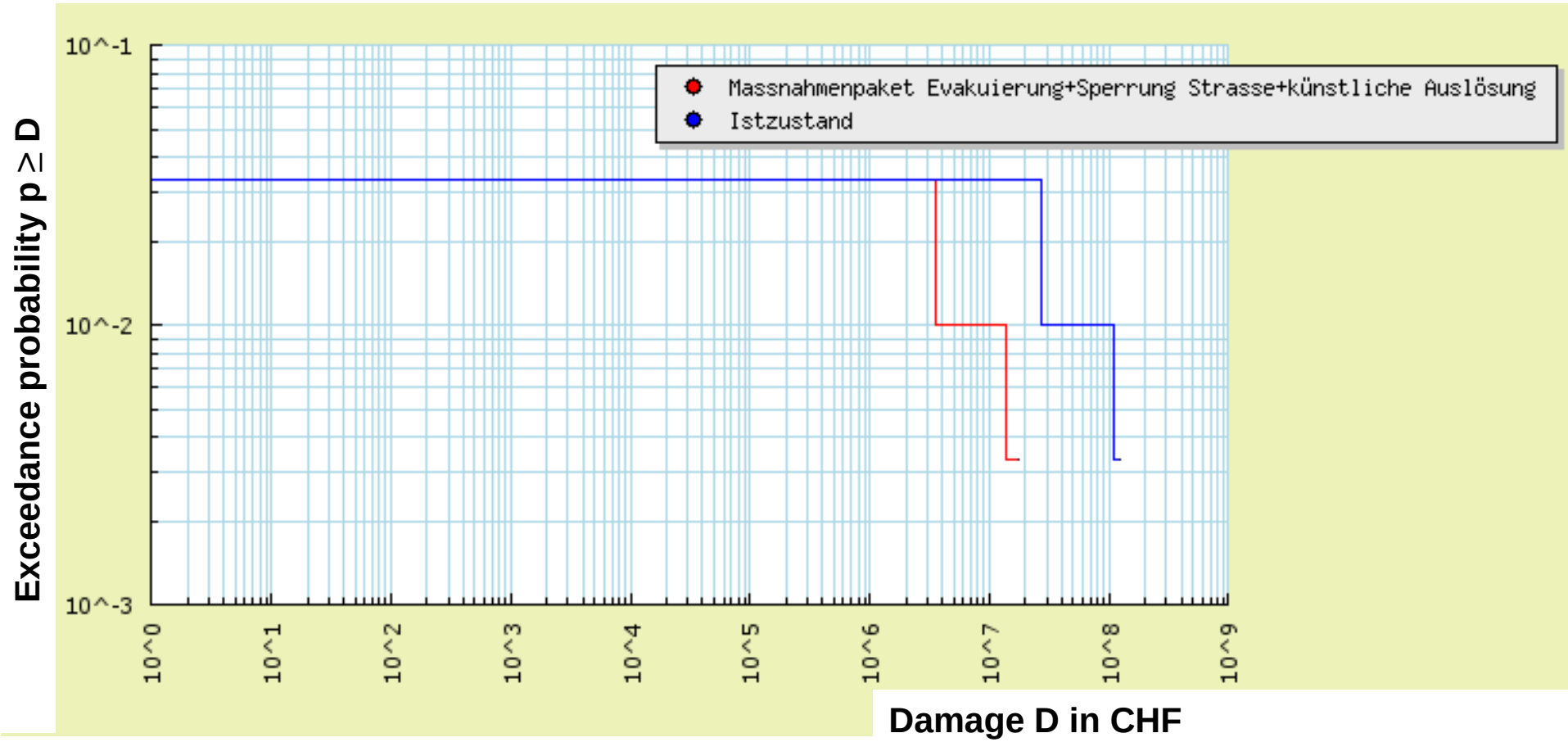


300-year Scenario



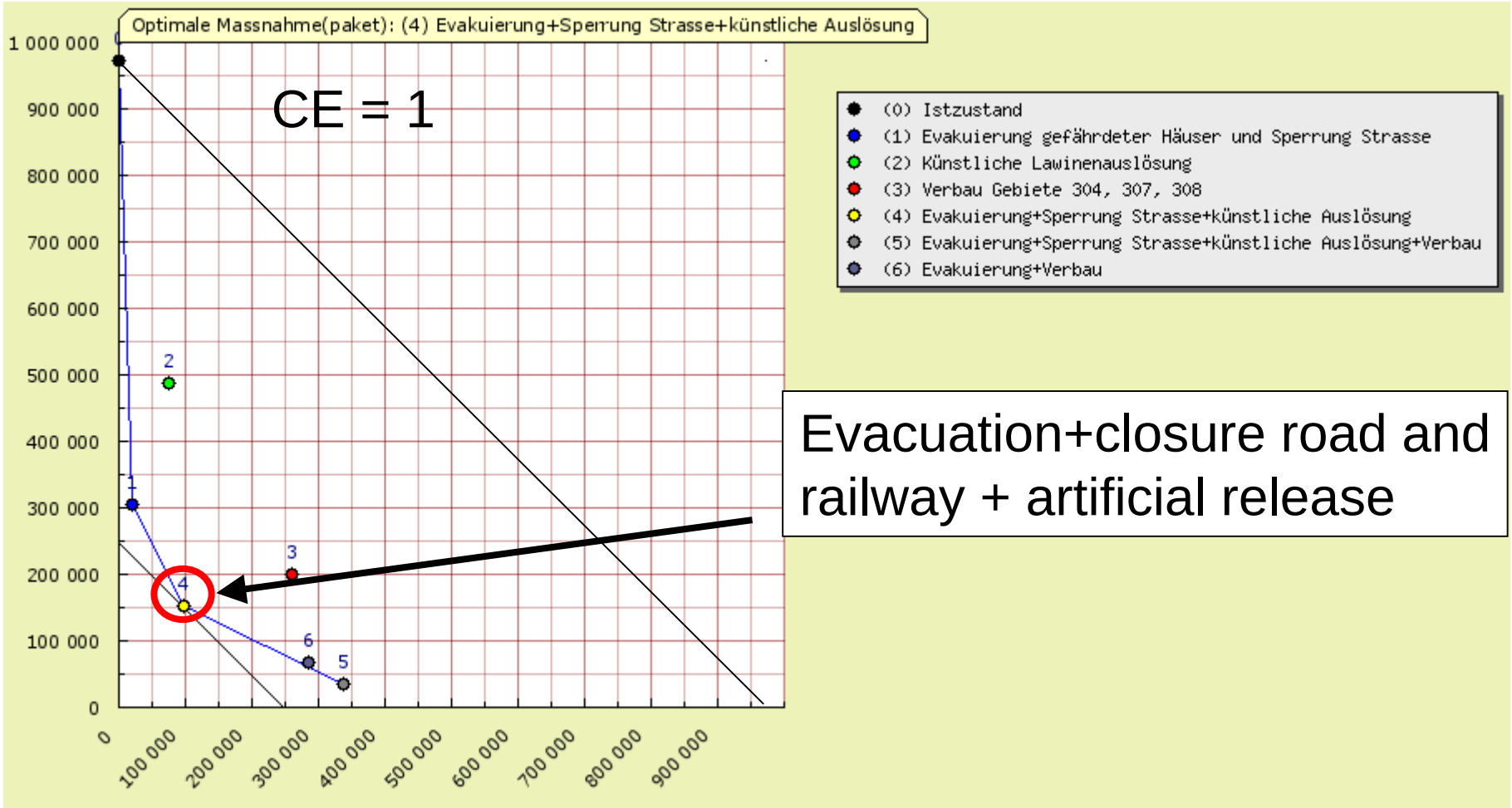
Presentation of societal risk after countermeasures

Evacuation+closure+artifical release



Risk-Cost Curve Davos Frauentobel

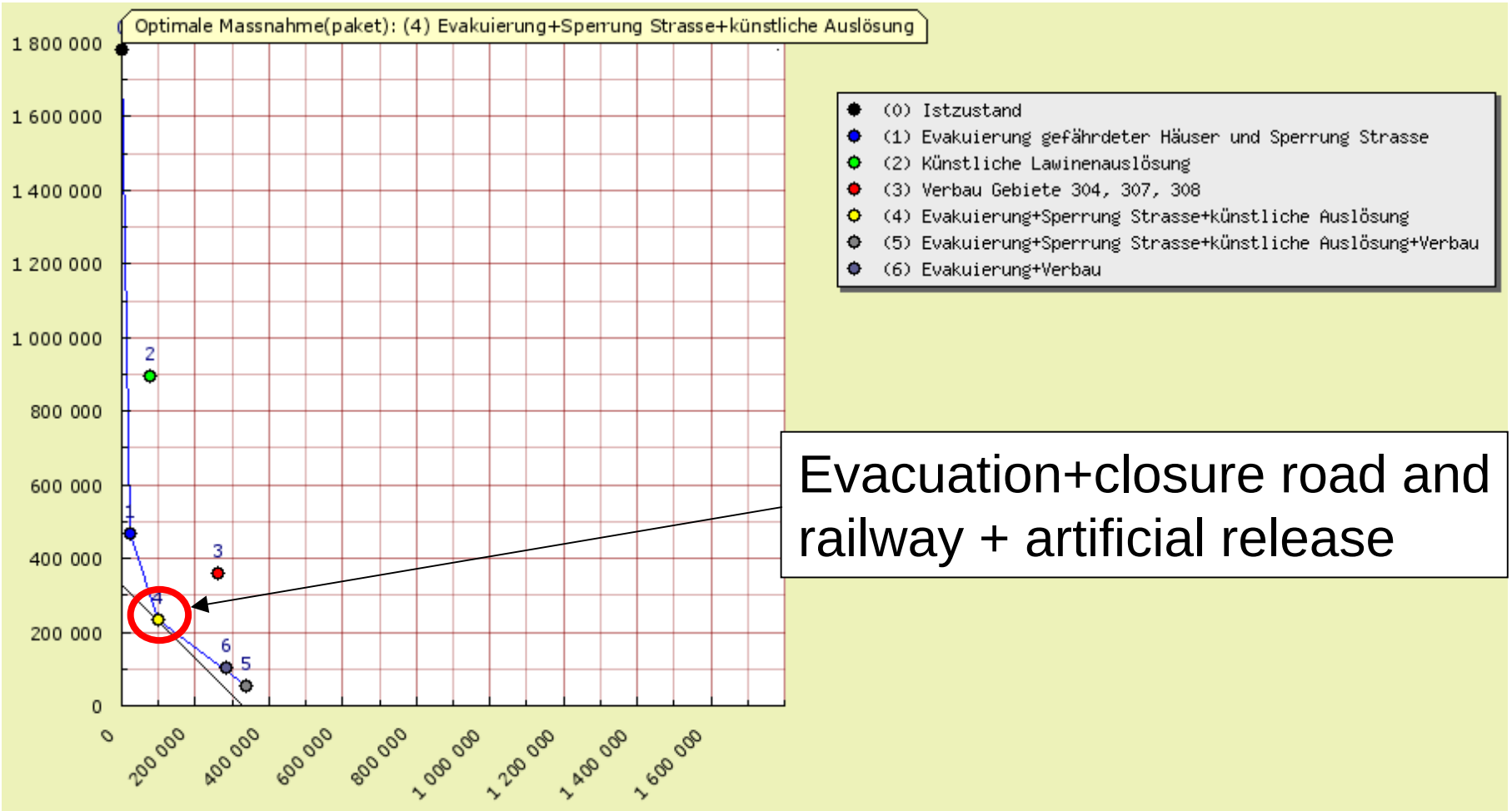
without weighting of damage (risk aversion)
5 mio CHF/averted fatality



Evacuation+closure road and railway + artificial release

Risk-Cost Curve Davos Frauentobel

without weighting of damage (risk aversion)
10 mio CHF/averted fatality



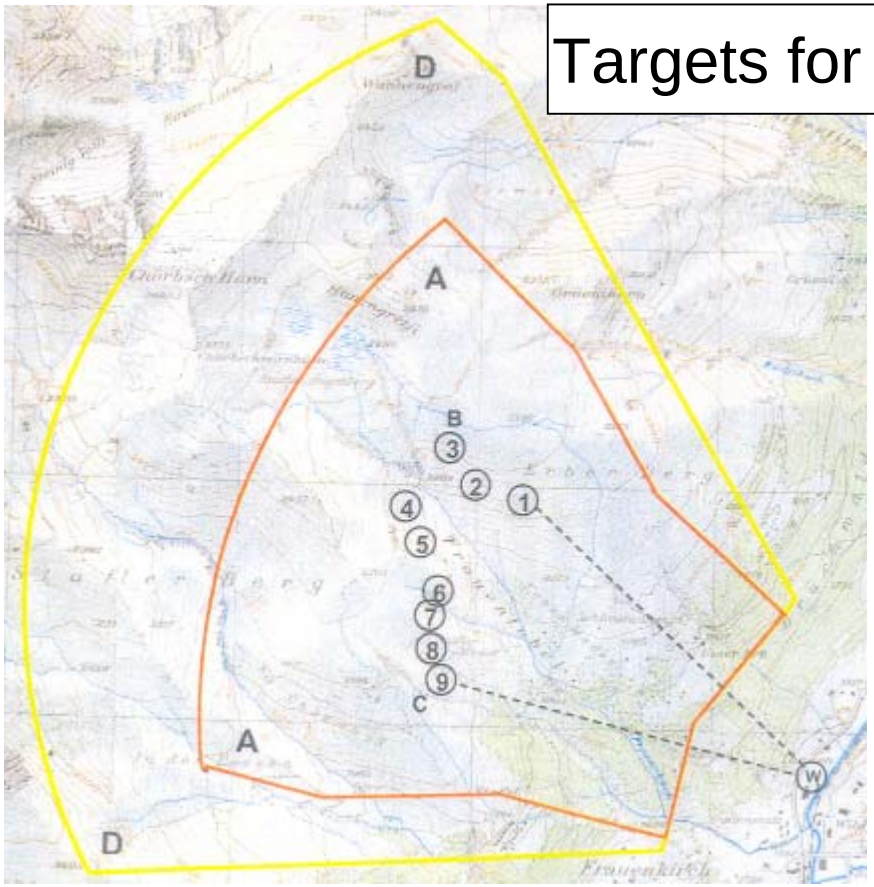
Evacuation+closure road and railway + artificial release

Communication to the affected population

- Results were presented and discussed with the local safety services
- Presentation of the results to the affected, discussion about problems, constraints, etc.
- Information in the local newspaper.

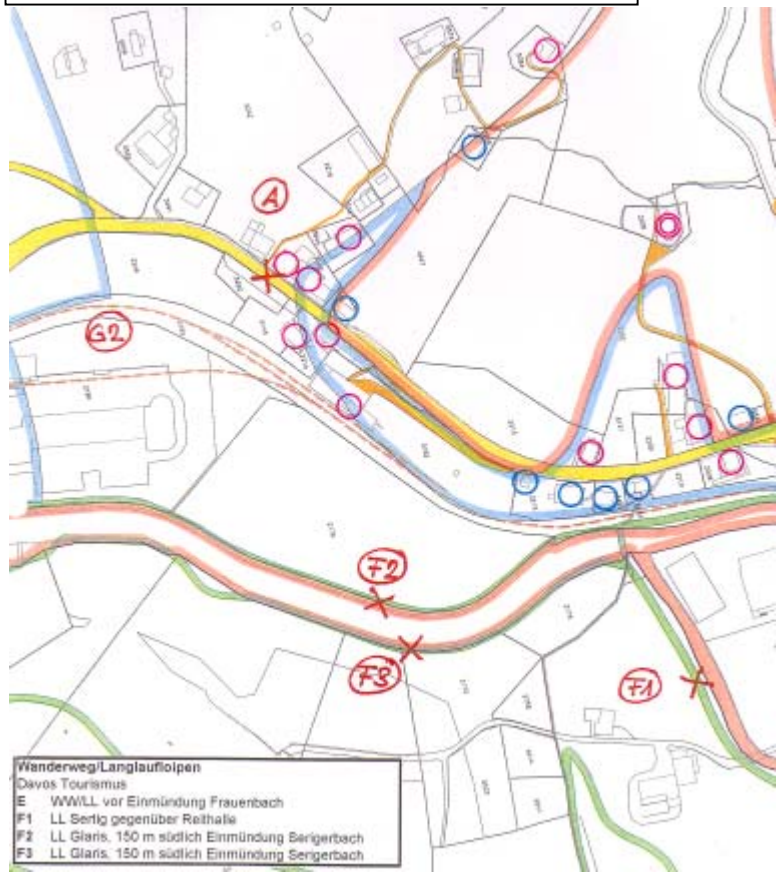
Realisation of the safety concept in practice.

Realisation of safety concept



Targets for army weapons (mortar)

Closure plan



Artificial release 7 February 2003

Schedule:

1. preparation safety service
2. information residents
3. coordination
4. decision
5. closure
6. safety action
7. check of success
8. road clearing
9. road opening
10. information residents

Conclusions

- Risk based planning of countermeasures becomes more and more the state-of-the-art in many alpine countries.
- Although there are uncertainties the result of risk analyses provide valuable basis for decisions.
- Information and communication with the affected population is a critical factor for success.
- This case study can be regarded as “best-practice example” of a collaboration between science and practice.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