Conférence Coulomb
Paris
CFMS, 10 juin 2011

Evaluation et gestion du risque associé aux géo-hasards

Suzanne Lacasse
Directer général
INSTITUT DE GEOTECHNIQUE NORVEGIEN
NGI

NGI
ICG
International Centre for Geohazards

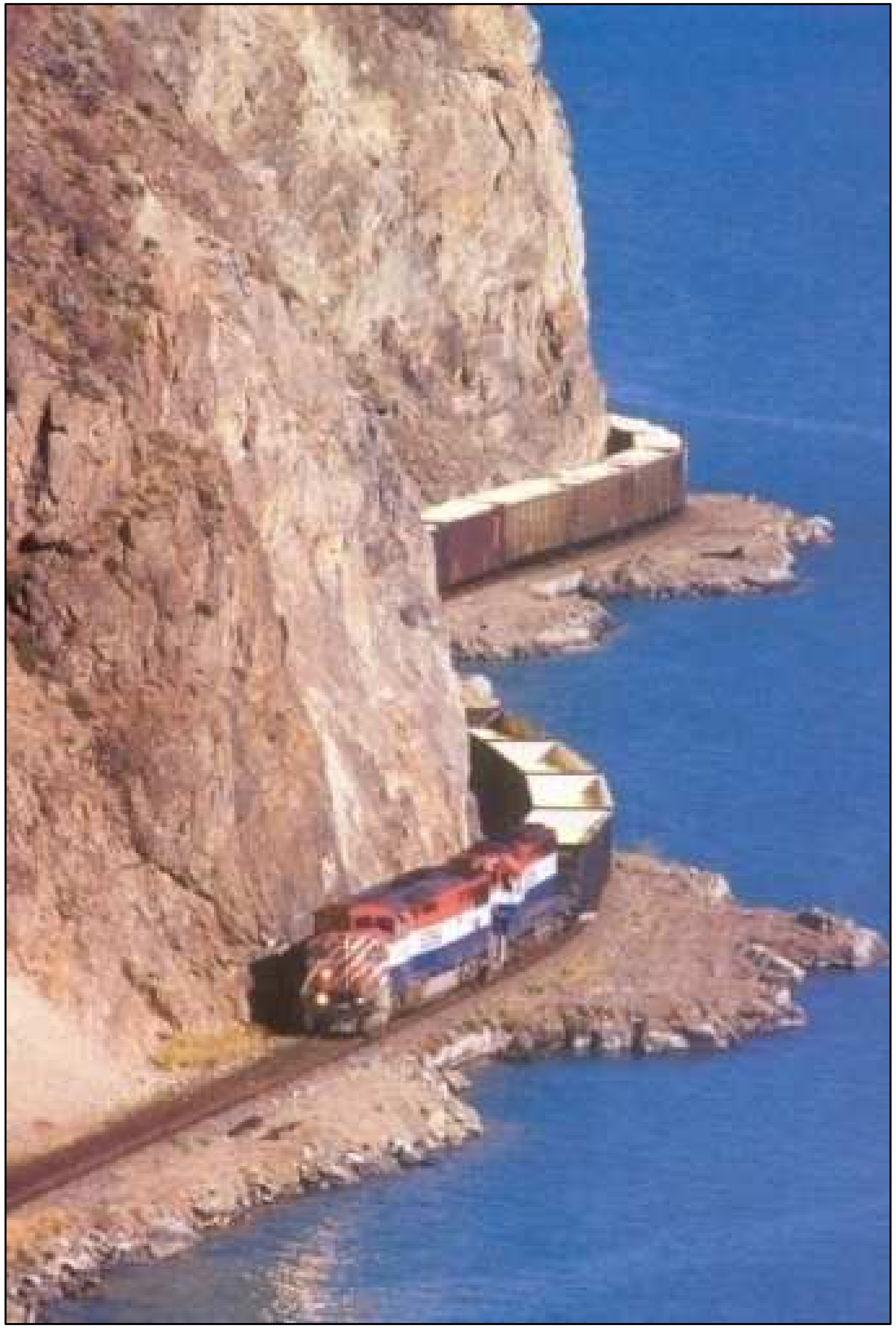
Natural hazards
Socio-economic impact in Europe (statistics 1900-2000)



	Hazard		Loss of life	Costs
European	45	floods	10,000	105 B€
statistics	1700	landslides	16,000	200 B€
1900-2000	32	earthquakes	239,000	325 B€

Frequency of landslides in Europe is the highest among natural hazards, compared to floods, earthquakes, cyclones: **20/yr**


©2002 Steven J Brown



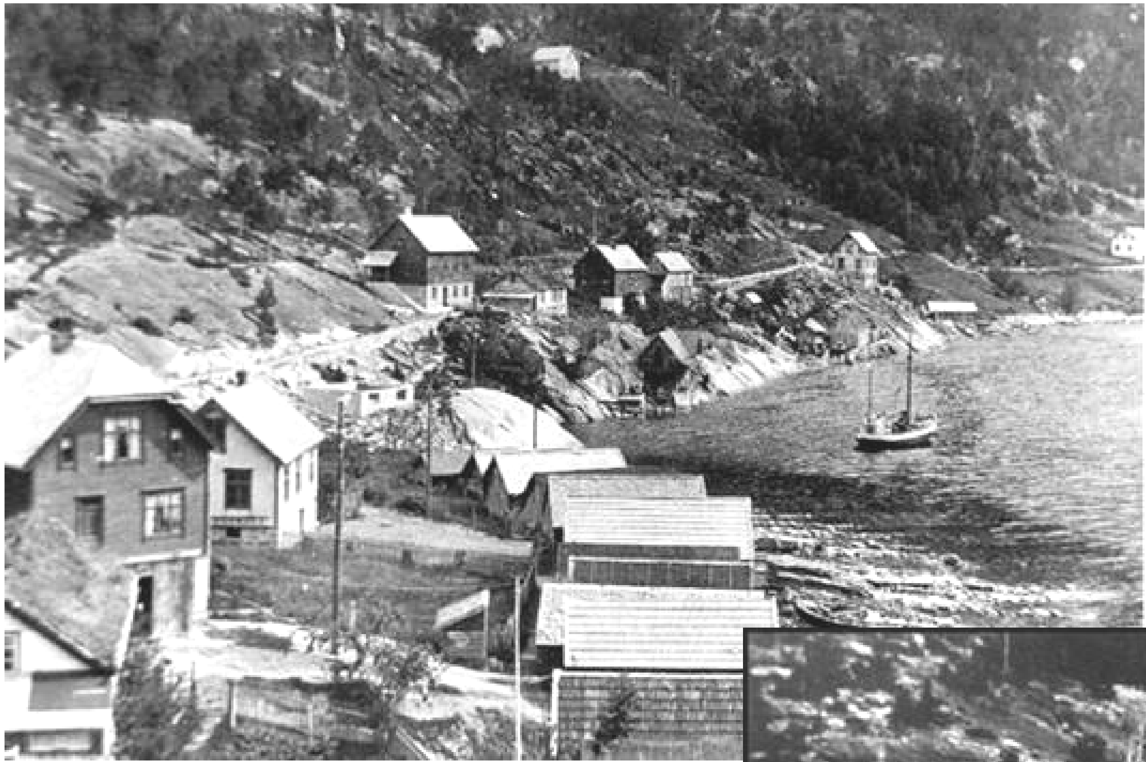
Triggering of slides by rainfall

Venezuela, Dec. 1999

ICG
International Centre for Geohazards

Slide triggered by heavy rainfall in Bhutan

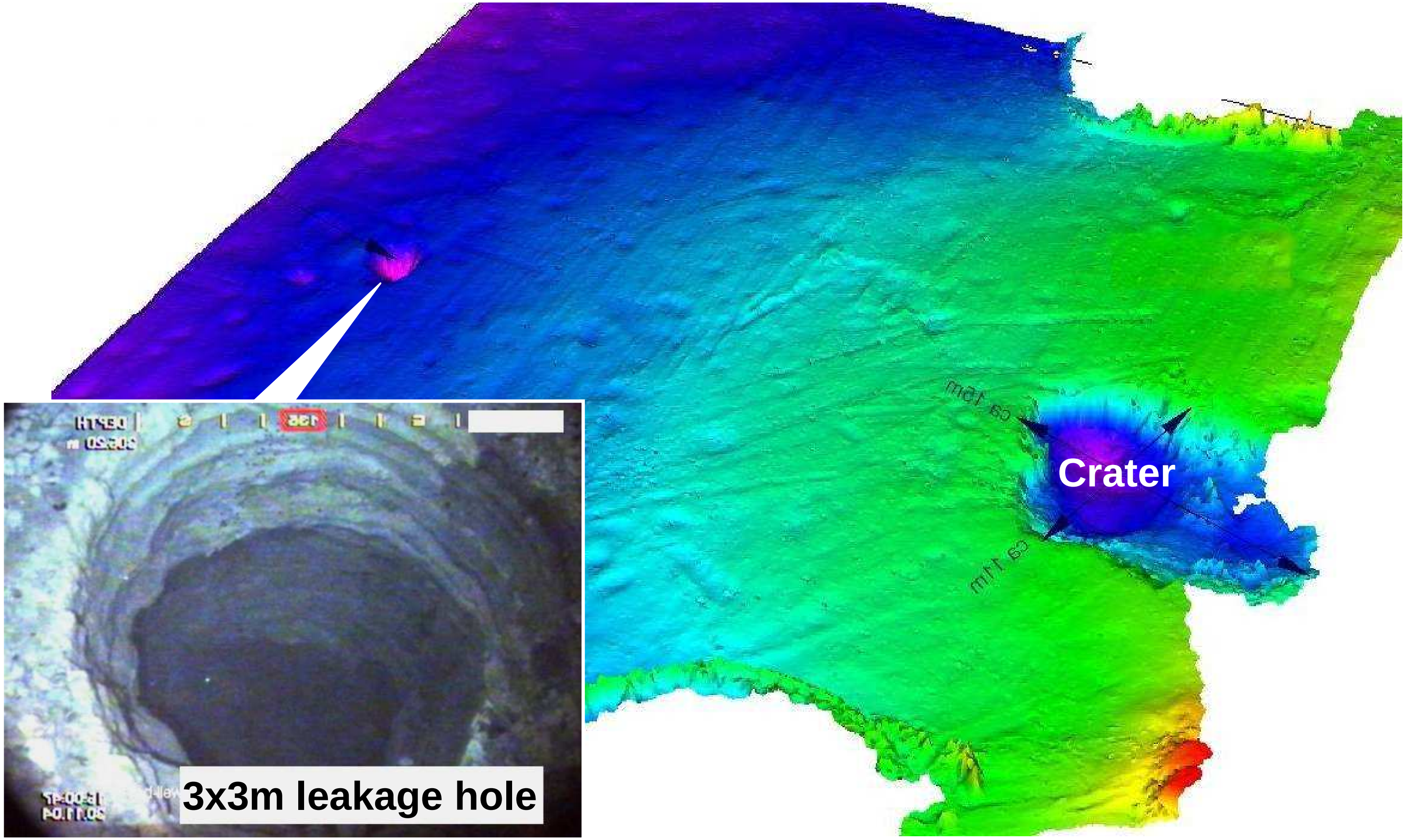
Tsunamigenic
rock slide
Tafjord 1934



Before the slide

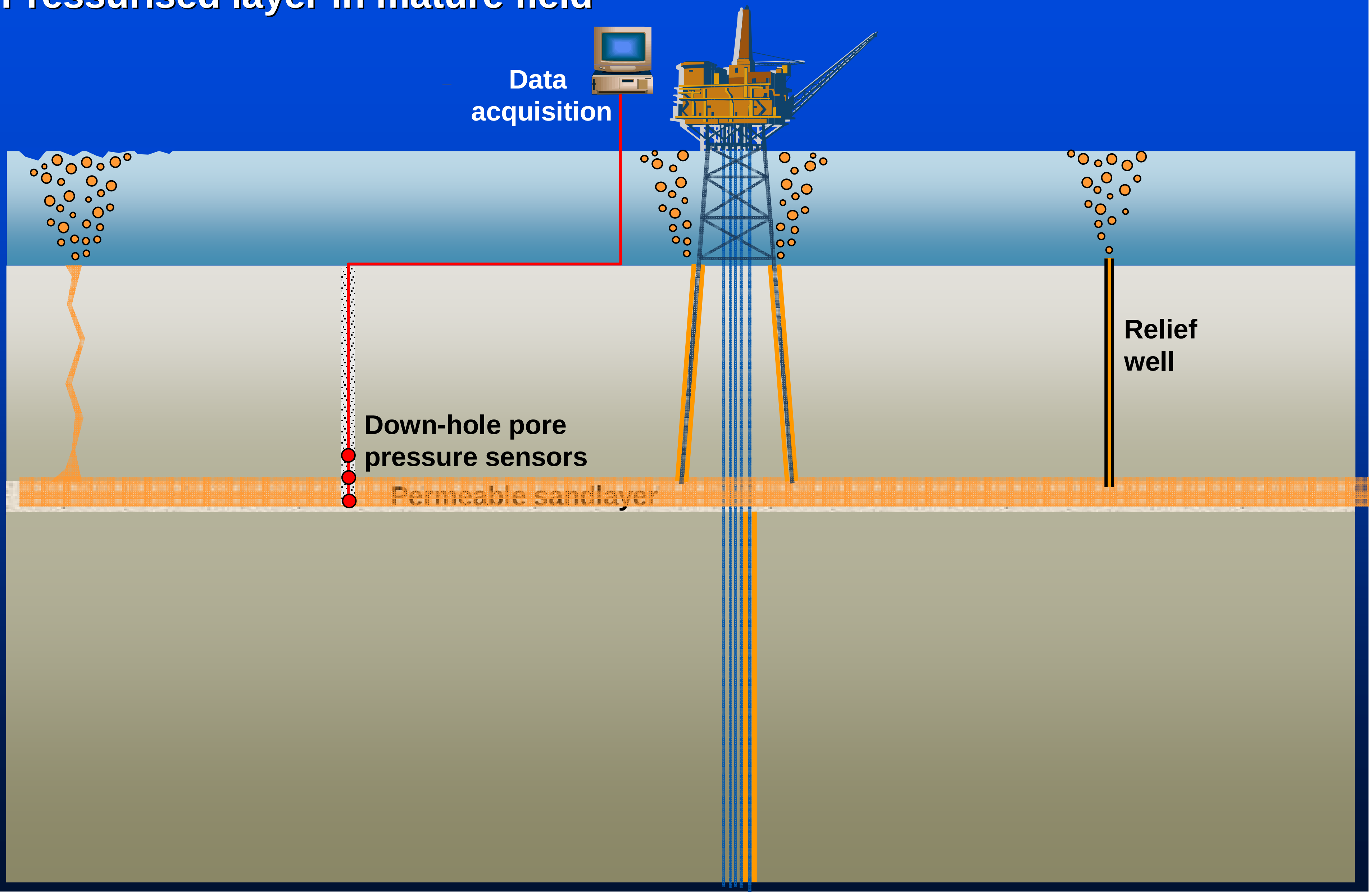
After the slide

Effects of rapid gas leakage



Gas leakage

Pressurised layer in mature field

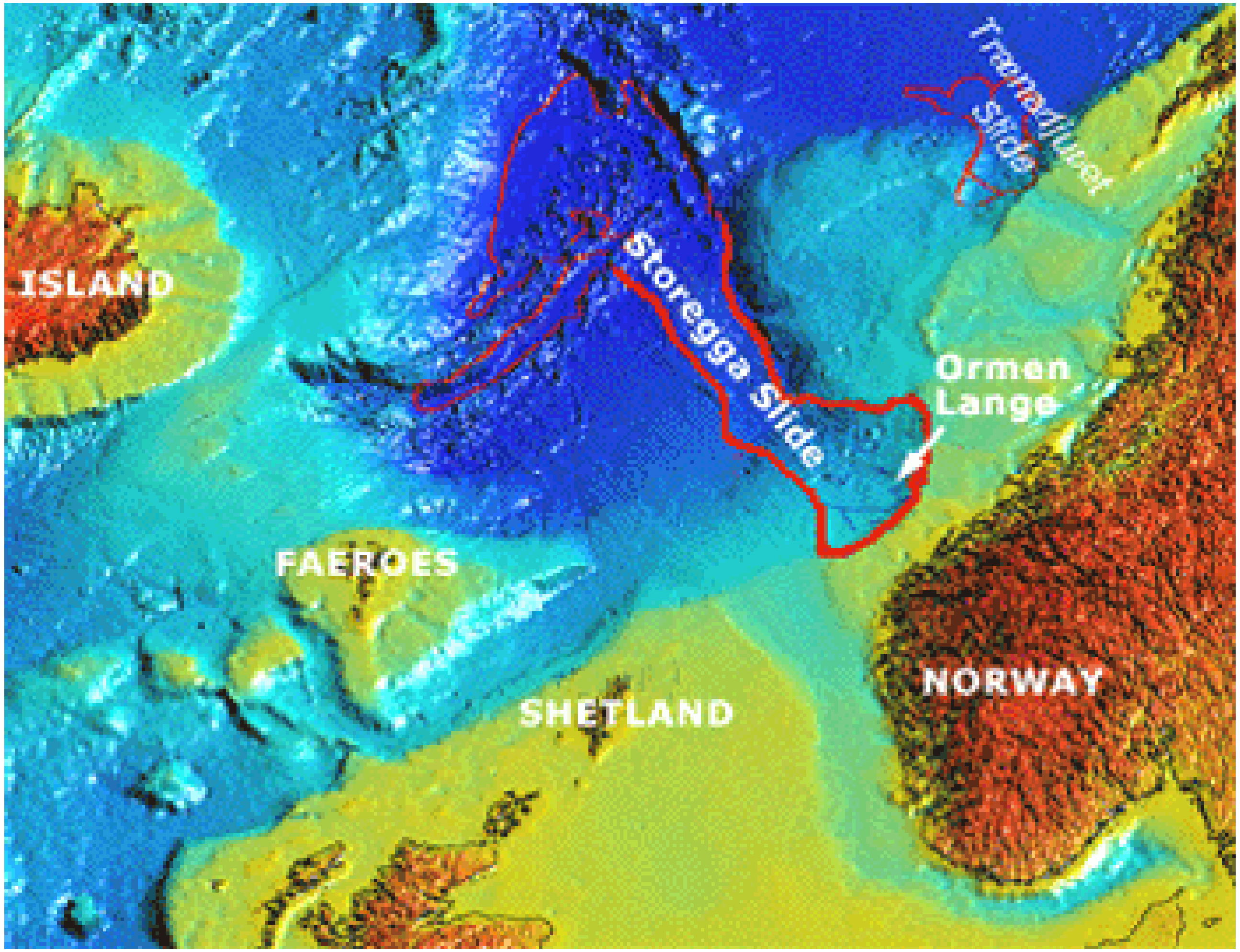


Triggering of slides by human activity

Triggering of Landslides by Earthquakes

El Salvador, January 2001

Probably triggered by earthquake
Underwater slide



Plan de la conférence

- **Management du risque**
- **Hazard[1], vulnerabilité et appréciation du risque**
- **Traitement du risque**
- **Conclusions**

Exemples

[1] Phénomène dangereux

NGI ICG International Centre for Geohazards

Risk Management

(1) What can cause harm?	⟶	**Danger** identification
(2) How often or how likely can danger happen?	⟶	Estimation of frequency of occurrence (**hazard**)
(3) What can go wrong?	⟶	Evaluation of **loss** from vulnerability of **elements at risk** (consequence)
(4) How bad are the consequences?	⟶	Assessment of severity of consequence and **risk**
(5) What should be done?	⟶	**Acceptability**/tolerability of risk, **decision-making and mitigation**

Communication within the risk team (pluri-disciplinary) and outside team (including outreach) is needed throughout process

Quantification of Risk

Risk = Hazard x Consequences

$$R = H \cdot E \cdot V$$

H = Hazard (probability of a threat within a period of time)

E = Value of element(s) at risk

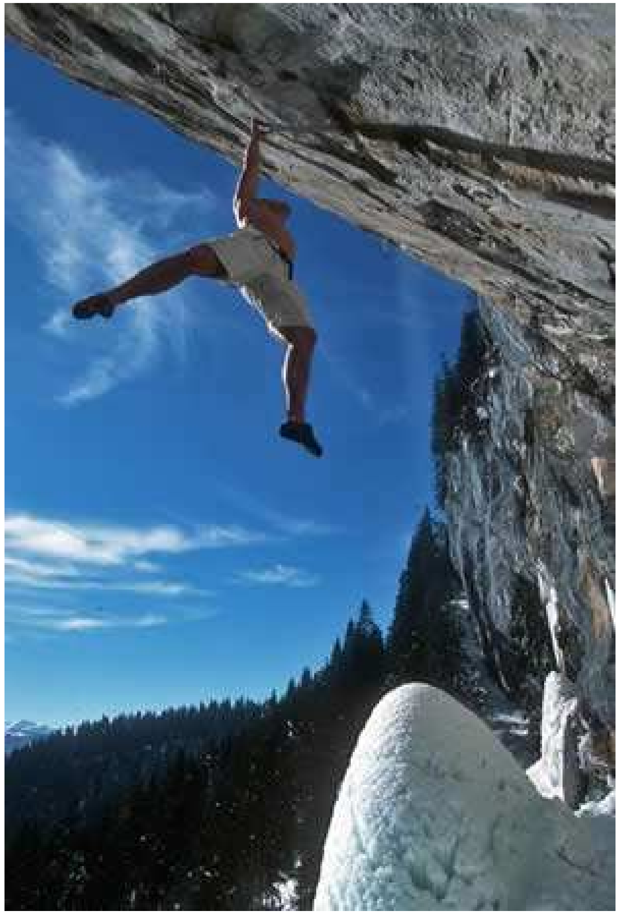
V = Vulnerability of element(s) at risk

Terminology: ISSMGE Glossary

UNISDR at http://unisdr.org/eng/terminology/terminology-2009-eng.html

How much risk are we willing to accept?

Depends on whether the situation is voluntary or imposed.



Terminology

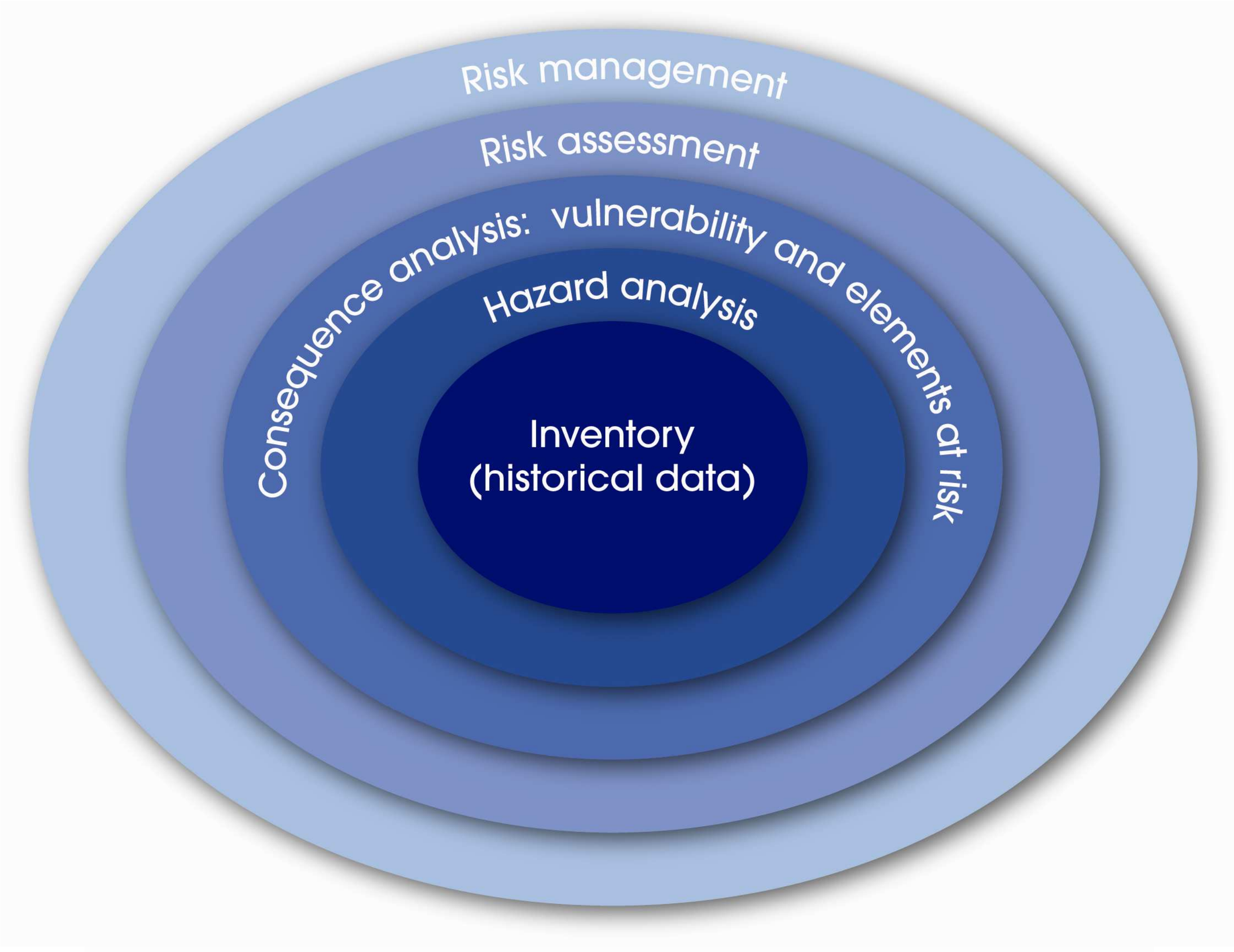
Danger (Threat): Phenomenon that could lead to damage; can be an existing or potential threat, but it involves no forecasting.

Hazard: Probability that a particular danger (threat) occurs within a given period of time.

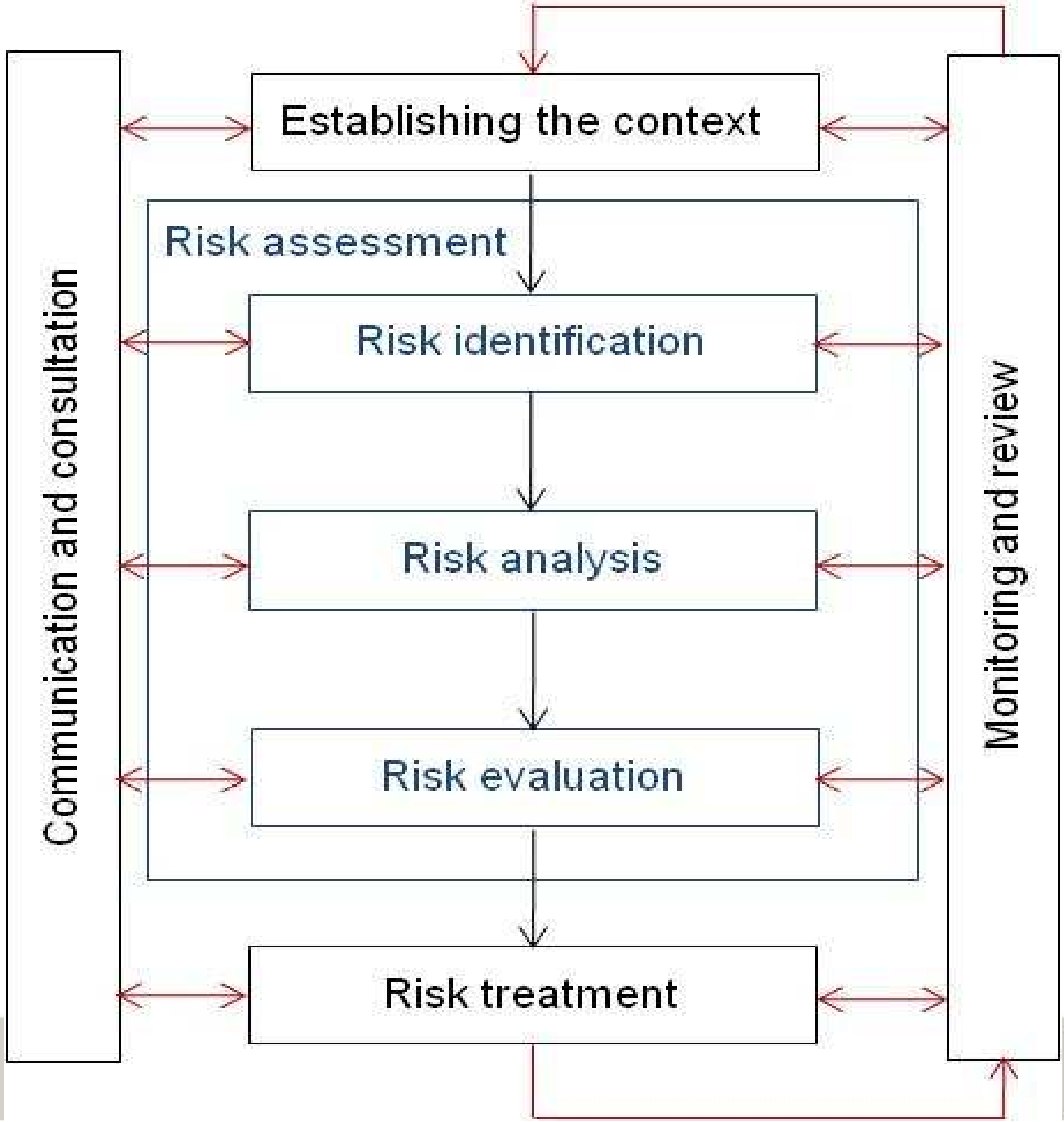
Risk: Measure of the probability and severity of an adverse effect to life, health, property, or the environment.

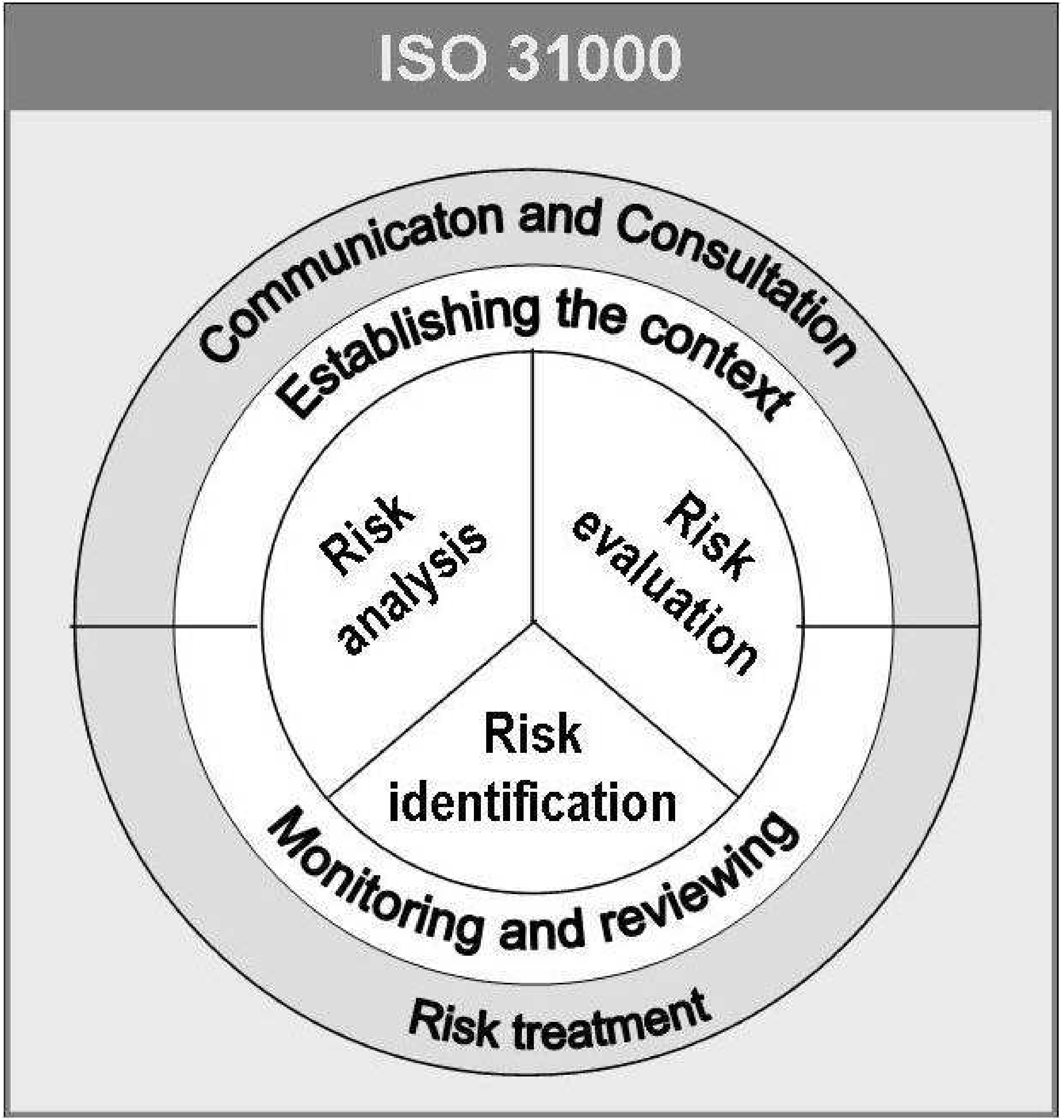
Also: UNISDR secretariat at
http://unisdr.org/eng/terminology/terminology-2009-eng.html

Management du risque – un processus intégré



ISO 31000 (2009)




ISO 31000
Communicaton and Consultation
Establishing the context
Risk analysis
Risk evaluation
Risk identification
Monitoring and reviewing
Risk treatment

Risk Assessment
changing trend

“Hazardous events only become disasters when people’s lives and livelihoods are swept away”

-Kofi Annan (2003)

Assessment of vulnerability

Model example
(UNEP, GRID-Geneva)

Indicator of vulnerability

Economical

(GDP, poverty index, unemployment, .)

Activities

(% arable land, age labour force…)

Quality of environment

(forests, irrigation …)

Demography

Education

Health

(calory/capita, sanitation, safe water, # doctors, mortality rate …)

Governance

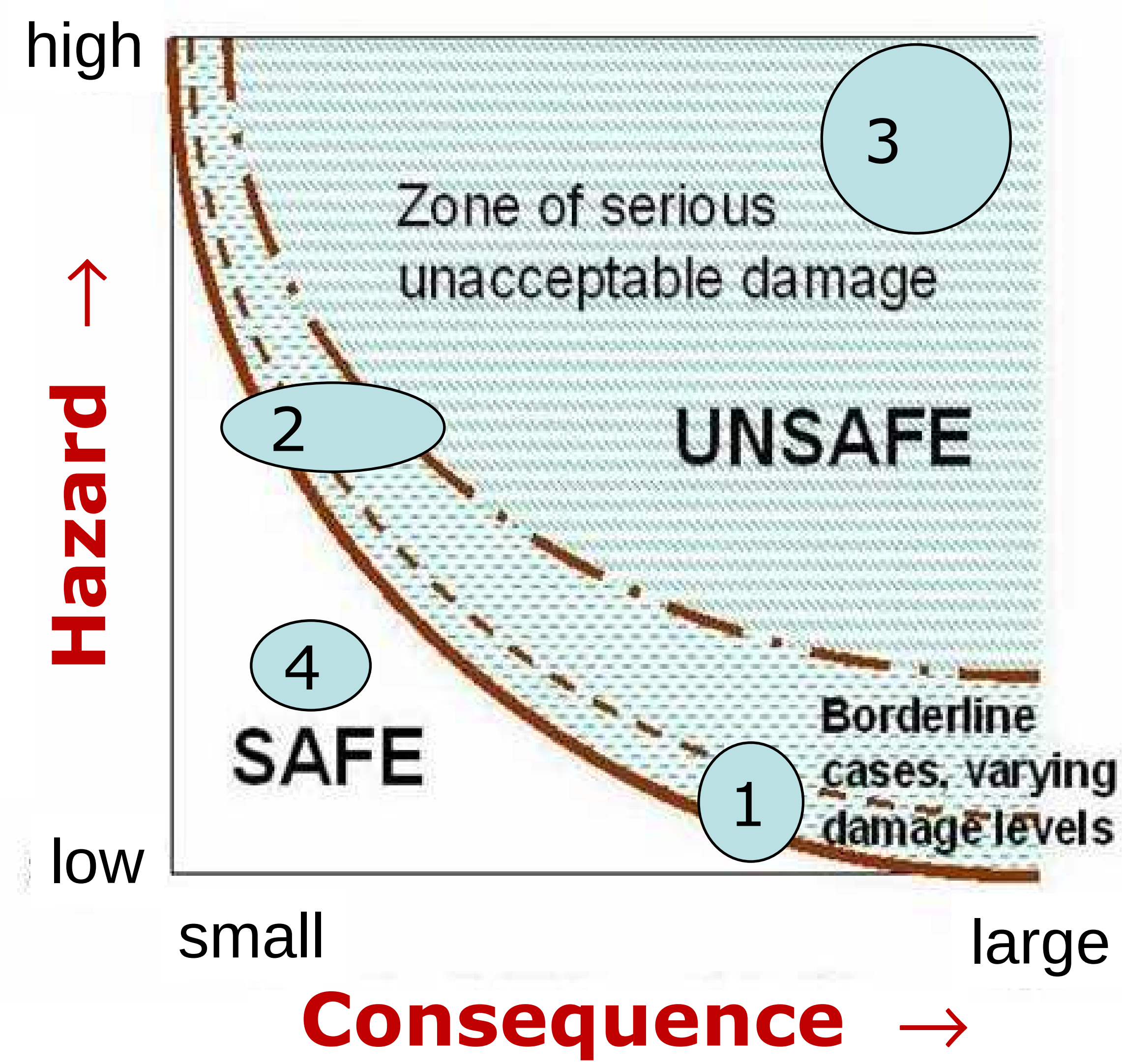
Warning and coping capacity

Human development

Social and physical vulnerability

- Social vulnerability: the capacity of society to cope with hazardous events
- Physical vulnerability: the degree of expected loss in a system under a specific threat (0 (no loss) to 1 (total loss))

Hazard-consequence plane ➡ Risk diagram



Acceptable / Tolerable Risk and F-N curves

Acceptable Societal Risk is generally based on **expected number of fatalities** and use of **F - N Curves. F** is the annual occurrence probability of an event capable of causing **N** or more fatalities.

Typical equation for F-N curve defining acceptable risk:

$$\mathbf{F \cdot N^{\alpha} = k}$$

In general, a single event with many fatalities is less acceptable to the society than several accidents with few fatalities.

Acceptable / Tolerable Risk

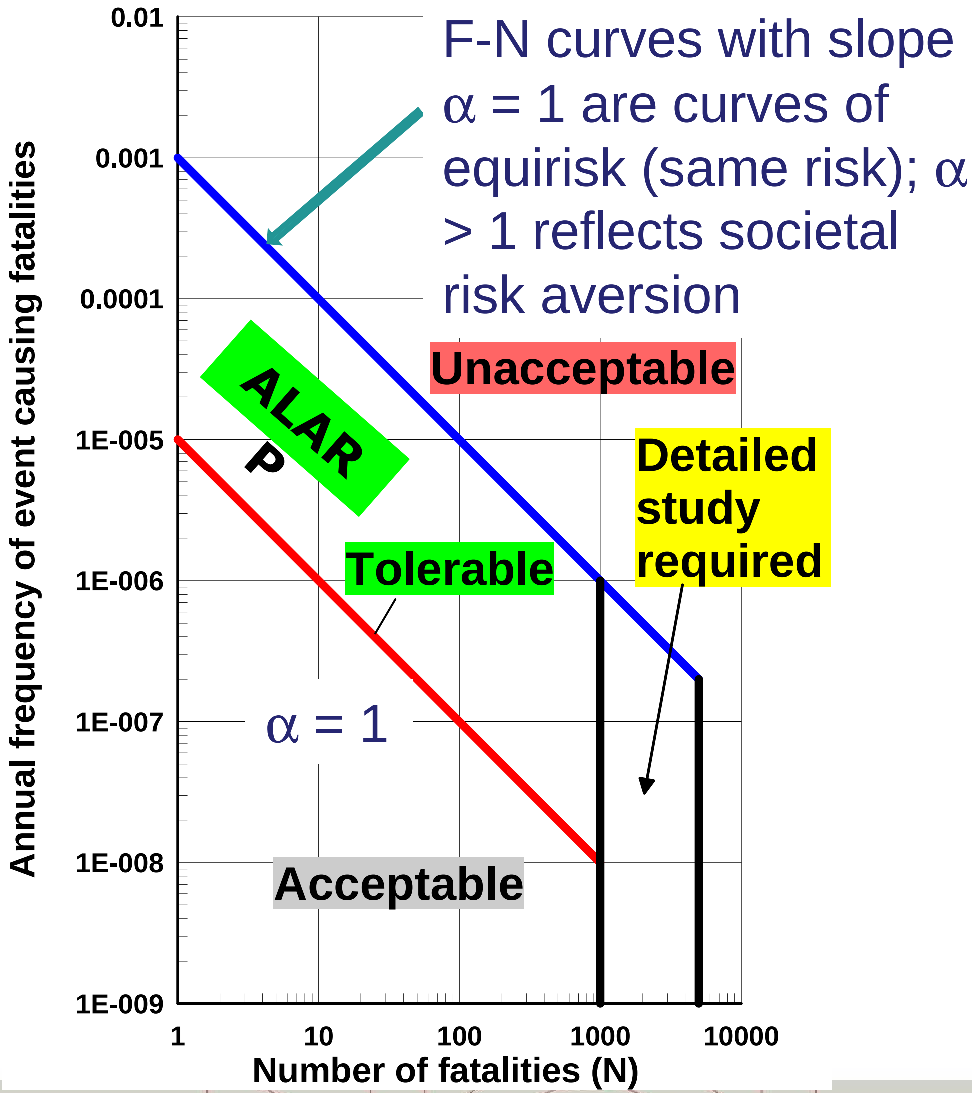
Example of Acceptable Societal Risk for slopes from Hong Kong:

Use of **F - N** Charts & **ALARP** principle

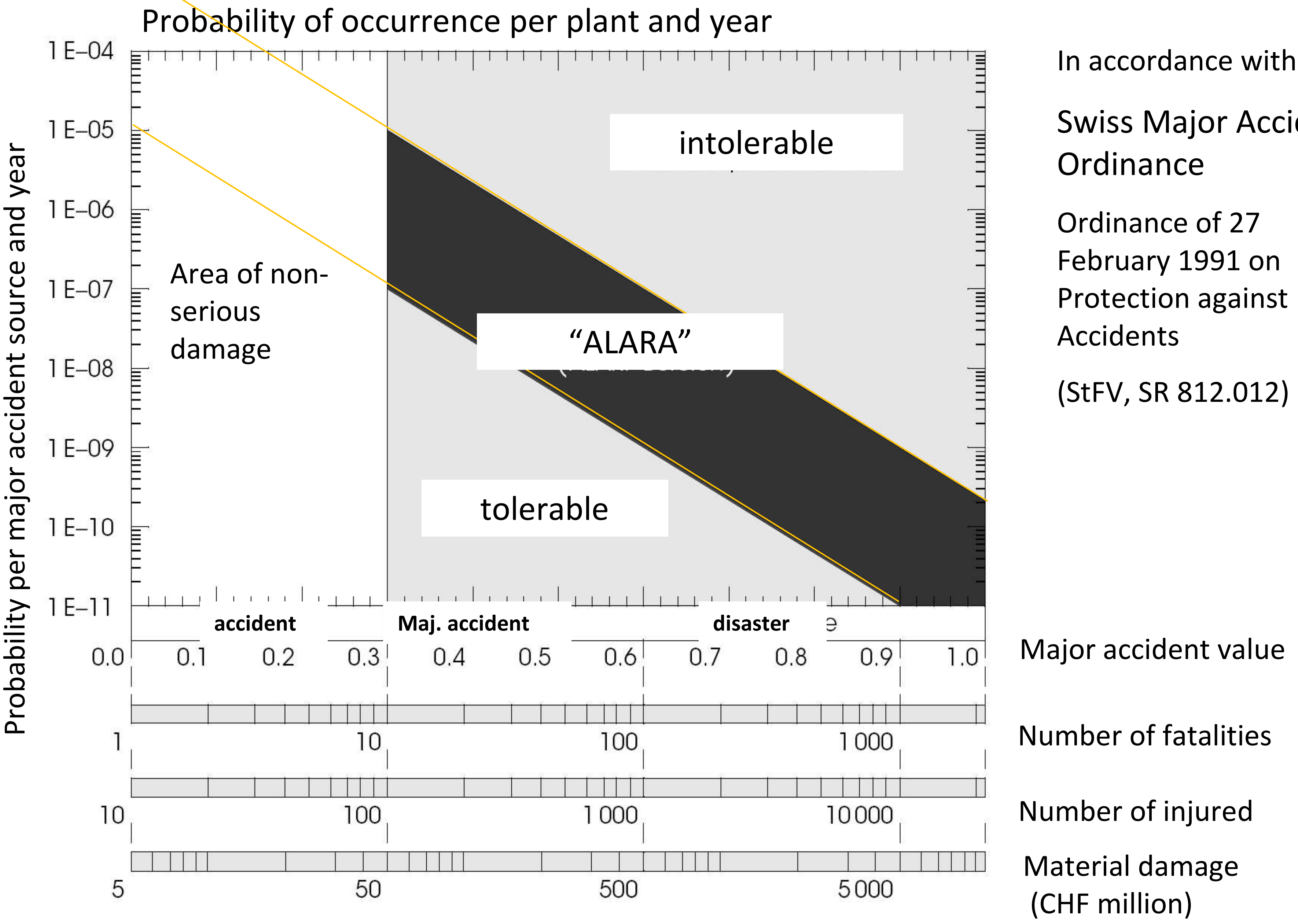
$$\mathbf{F \cdot N^{\alpha} = k}$$

k = 0.001, α = 1 (blue curve)

ALARP = As Low As Reasonably Practicable



RISK EVALUATION – Protection Ojectives in Practice



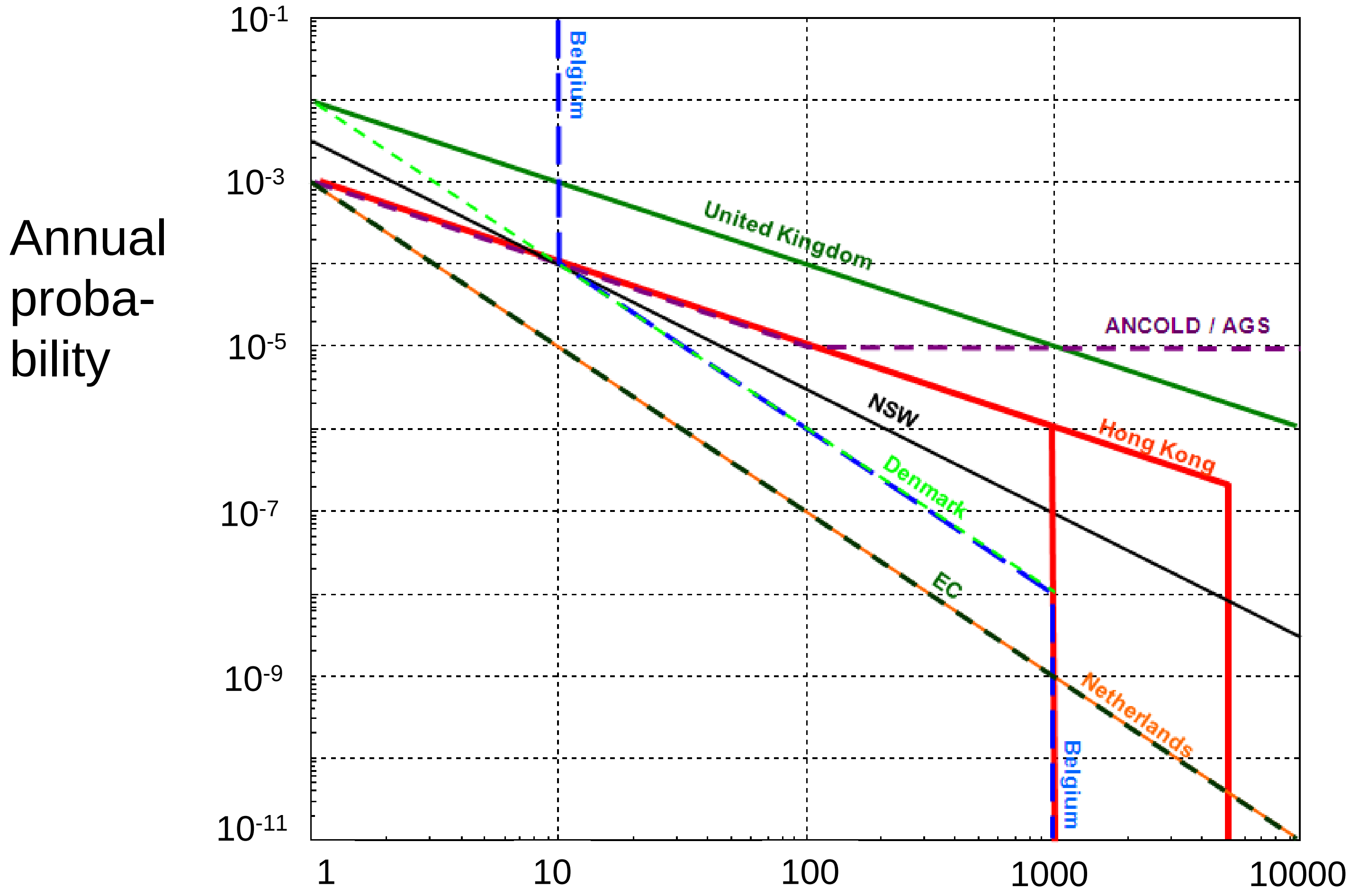
In accordance with:

Swiss Major Accidents Ordinance

Ordinance of 27 February 1991 on Protection against Major Accidents

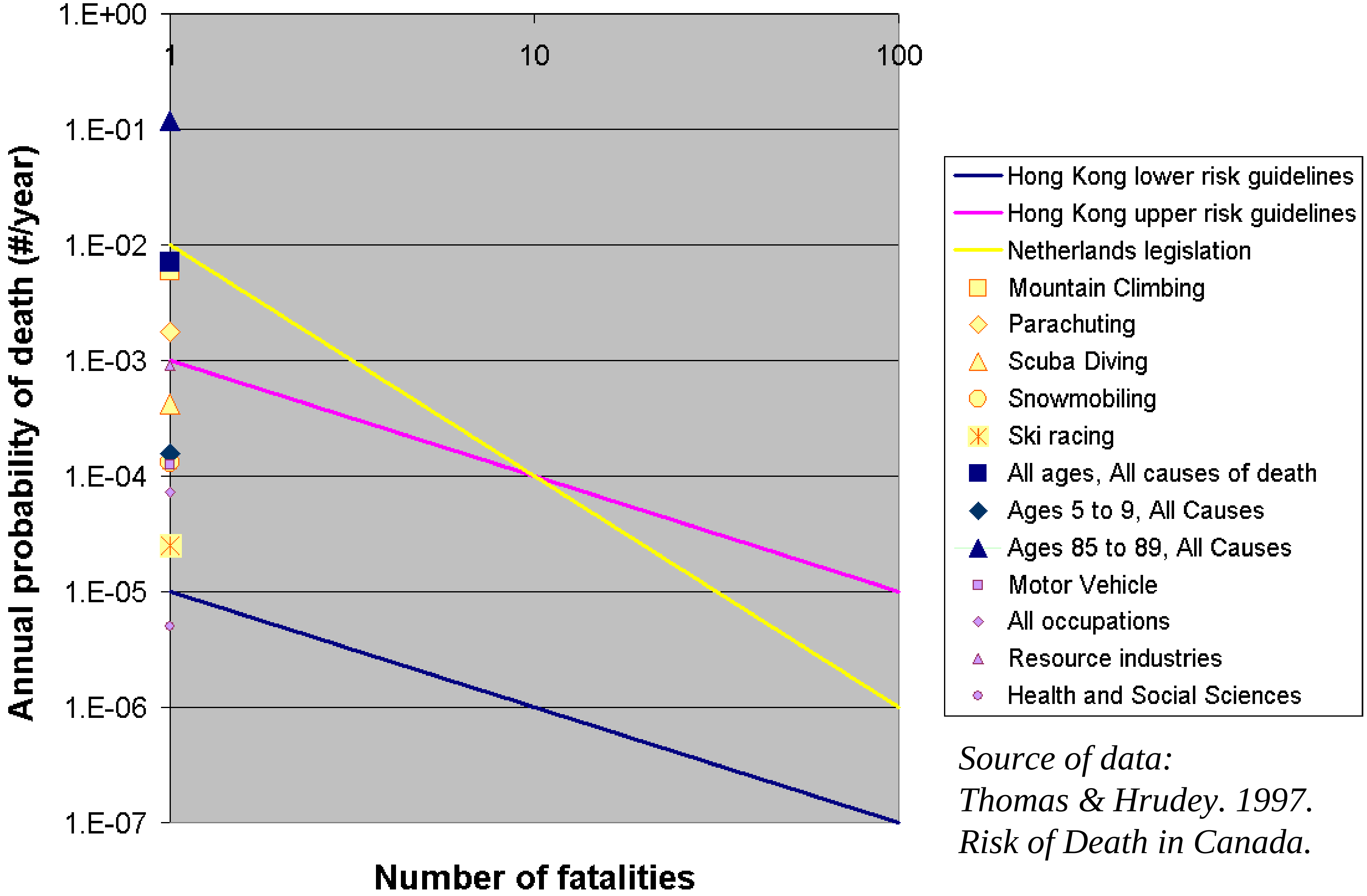
(StFV, SR 812.012)

Comparison of Acceptable Societal Risk criteria in different countries



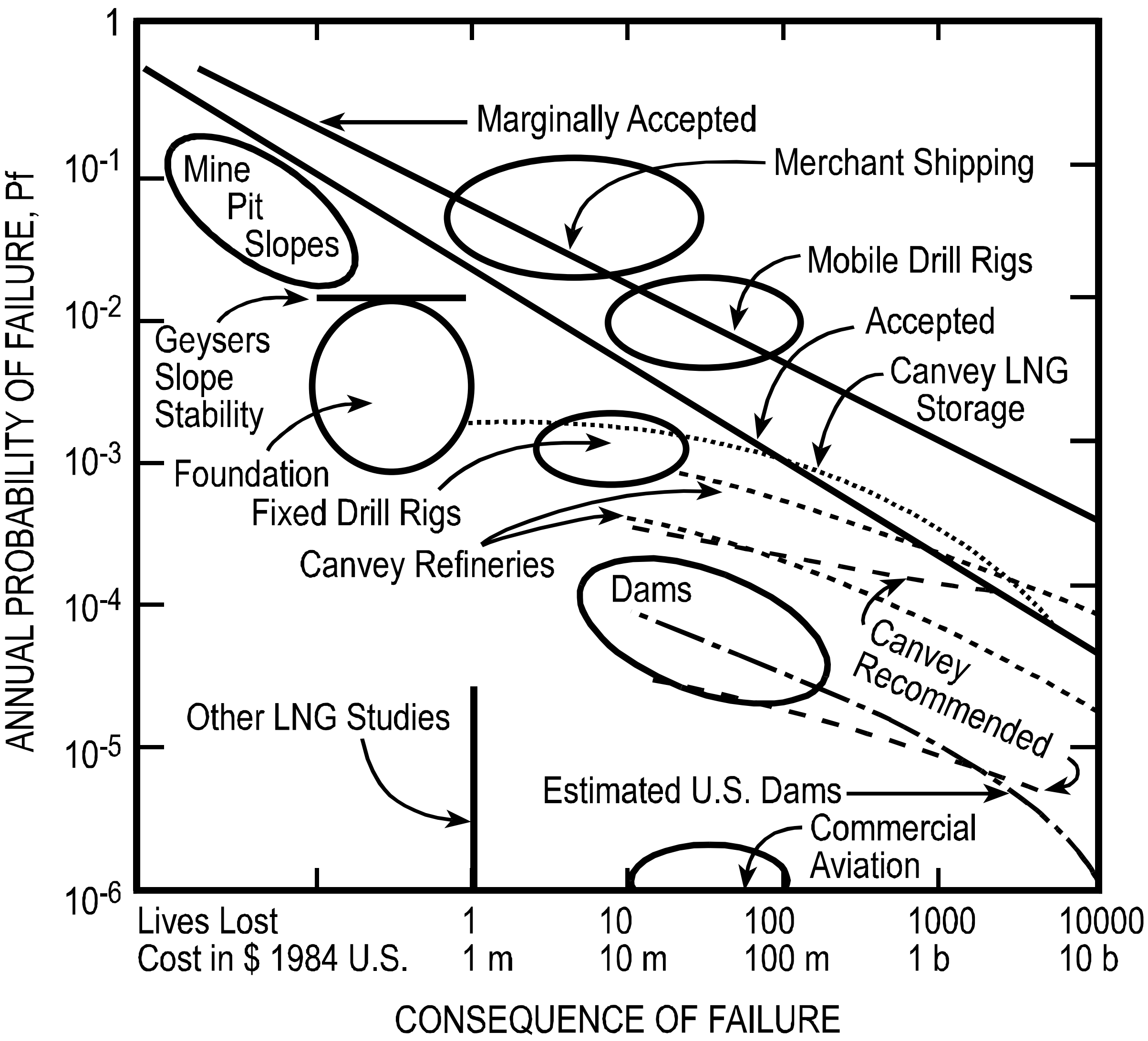
(Ken Ho 2009; Government of Hong Kong SAR, CEDD, Geotechnical Engineering Office, Personal Communication)

Risques 'acceptés'

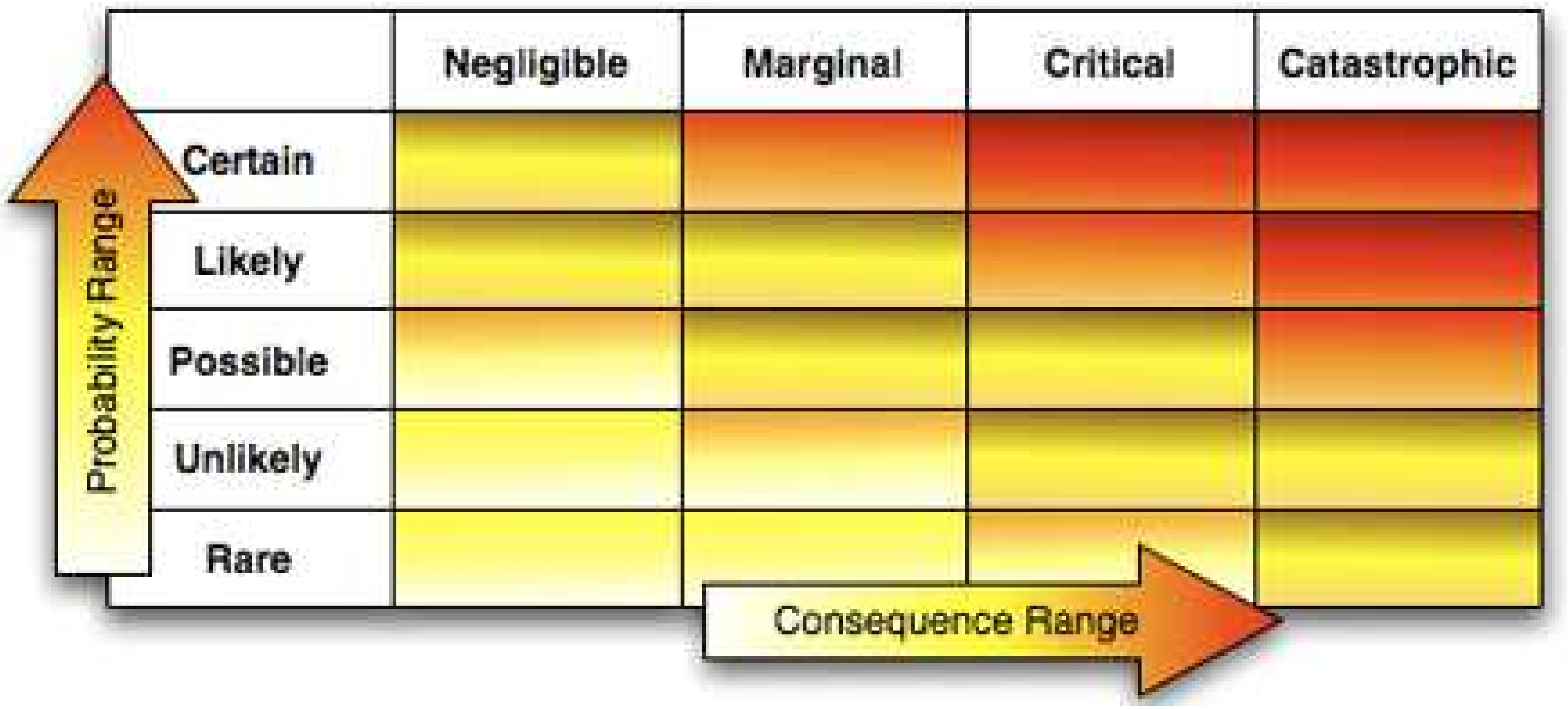


Source of data:
Thomas & Hrudey. 1997.
Risk of Death in Canada.

Examples of F-N curves (Whitman, 1984)



Qualitative Risk Assessment



http://images.tmcnet.com/tmc/misc/article-images/Image/exec%20brief.jpg

Analyse et management du risque

2 questions émergentes:

1) Comment évaluer le risque pour les hazards en cascade (cascading hazards) et les multi-risques?
    1) Chine: tremblement de terre → glissements de terrain → rupture de barrage
    2) Japon: tremblement de terre → tsunami → accident nucléaire
    3) France (1999, 2002): inondations → désastre environmental

L'analyse des multi-risques relève de plusieurs champs d'expertise, est fragmentée et n'a pas de traitement théorique fiable aujourd'hui.

Analyse et management du risque

2 questions émergentes:

2) Dans plusieurs contextes, l'expert seul ne peut sélectionner les mesures de traiteetn du risque les plus appropriées. Une approche multi-disciplinaire est nécessaire, et fortement appuyée par l' ONU.

Un facteur décisif dans un événement devenant un désastre ou non, est la vulnerabilité de la population, i.e. sa capacité à se préparer, répondre et de retourner à la normale après un événement extrême ("coping capacity")..

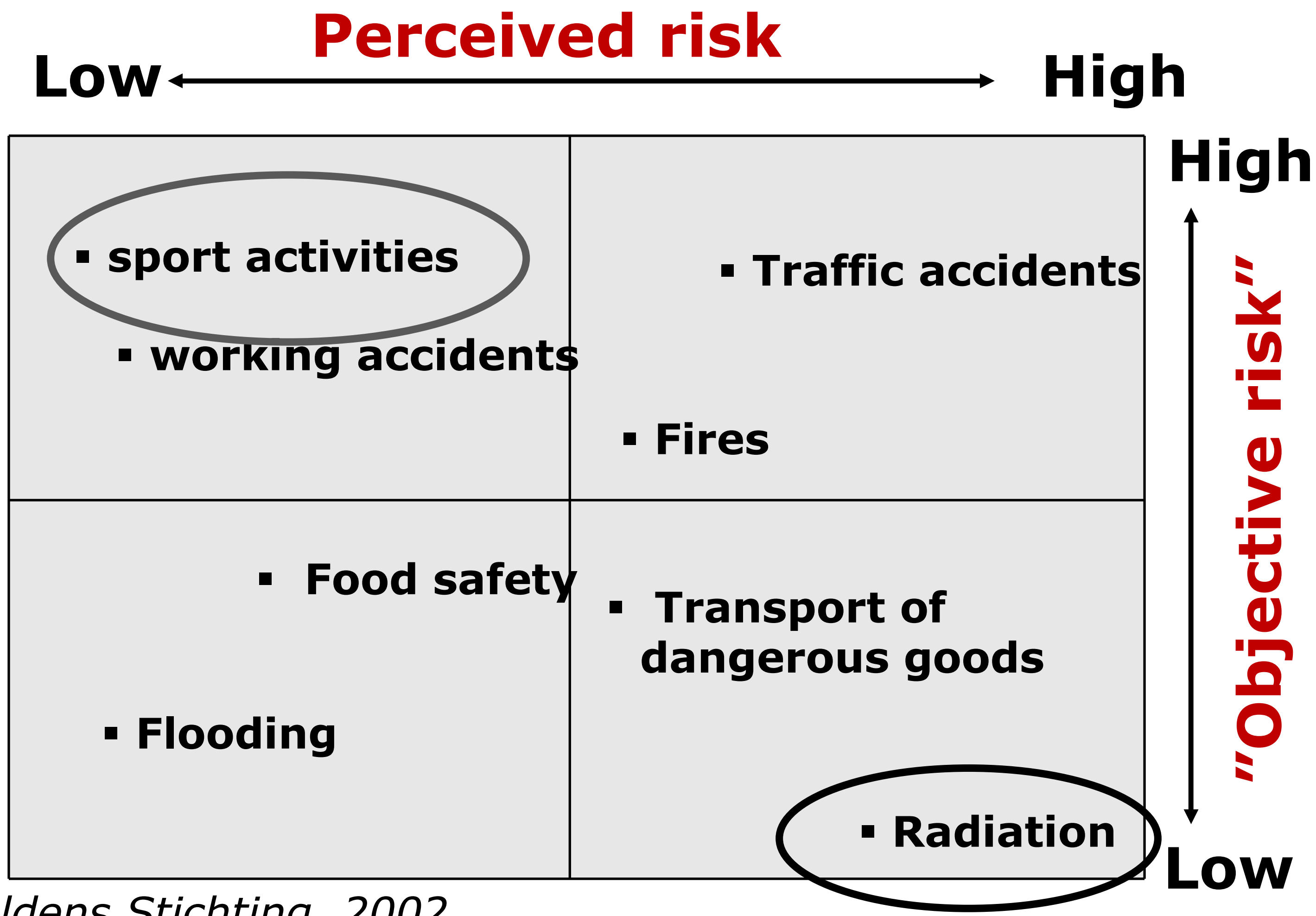
Les multi-risques

Interaction et amplification des risque (cascading hazards, effets en cascades): *i.e. le multi-risque est plus que l'aggrégation de chaque risque séparement.*

Vulnerabilité dynamique aux multi-risques: *i.e. comment la vulnerabilité change avec le temps with time avec différents événements, et comment la vulnerabilité change quand différents dangers se produisent presque en même temps.*

Application des mesures des multi-risques: *i.e. en pratique, comment limiter les fatalités et dommages de manière effective.*

Perception du risque



Max Geldens Stichting, 2002

Plan de la conférence

- Management du risque
- Hazard[1], vulnerabilité et appréciation du risque
- Traitement du risque
- Conclusions

Exemples

[1] Phénomène dangereux

Risk Assessment

Likelihood of occurrence of **hazardous event**

"Value" (loss of life, moneys involved, environment damage, ...) of **vulnerable assets**

Expected level of adverse consequences as result of hazardous event occurring

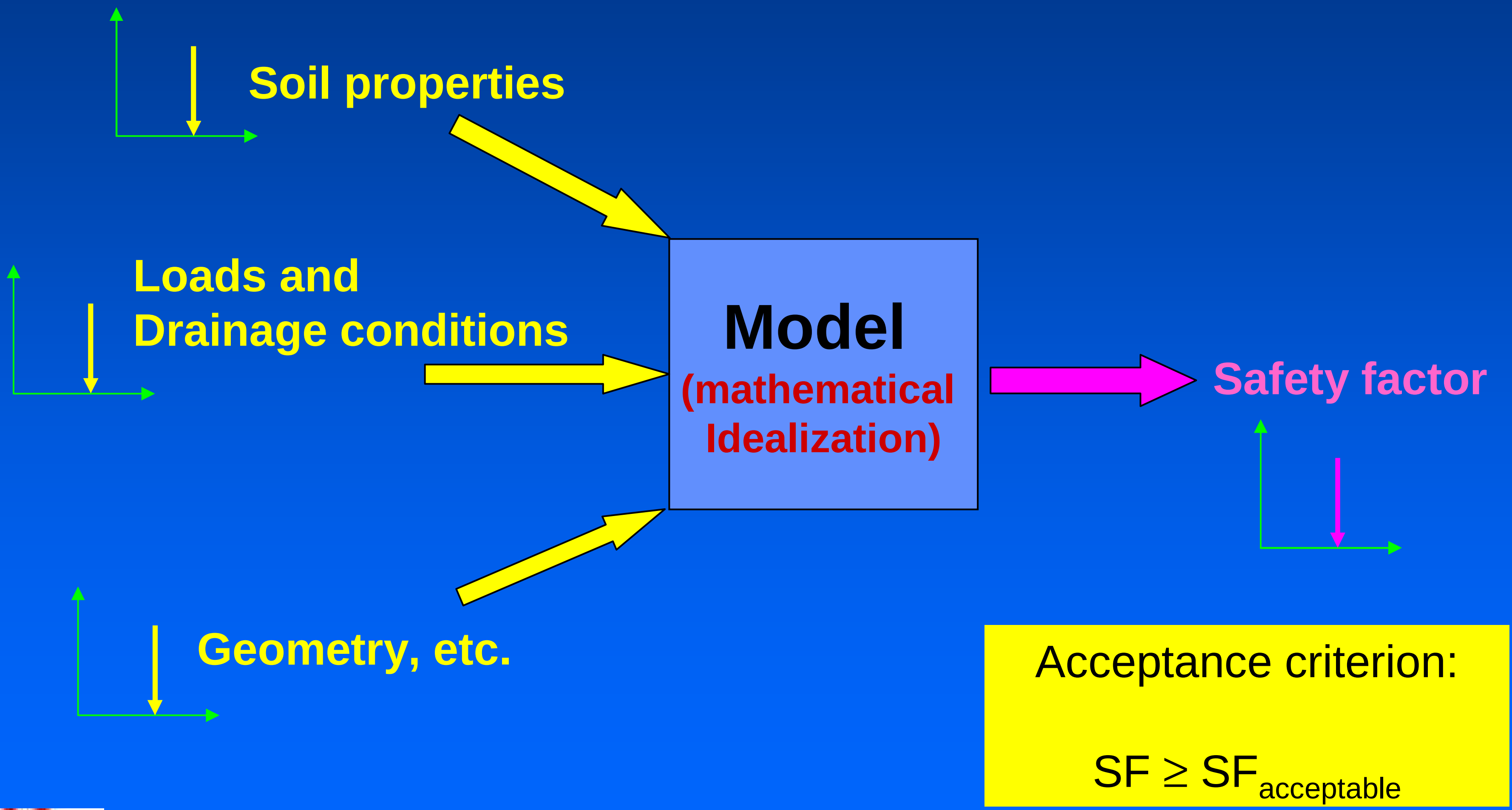
$$R = f\,(H, V, E)$$

Propensity of the human, social, physical, economic, environmental, cultural, institutional and political assets to suffer damage from hazardous event

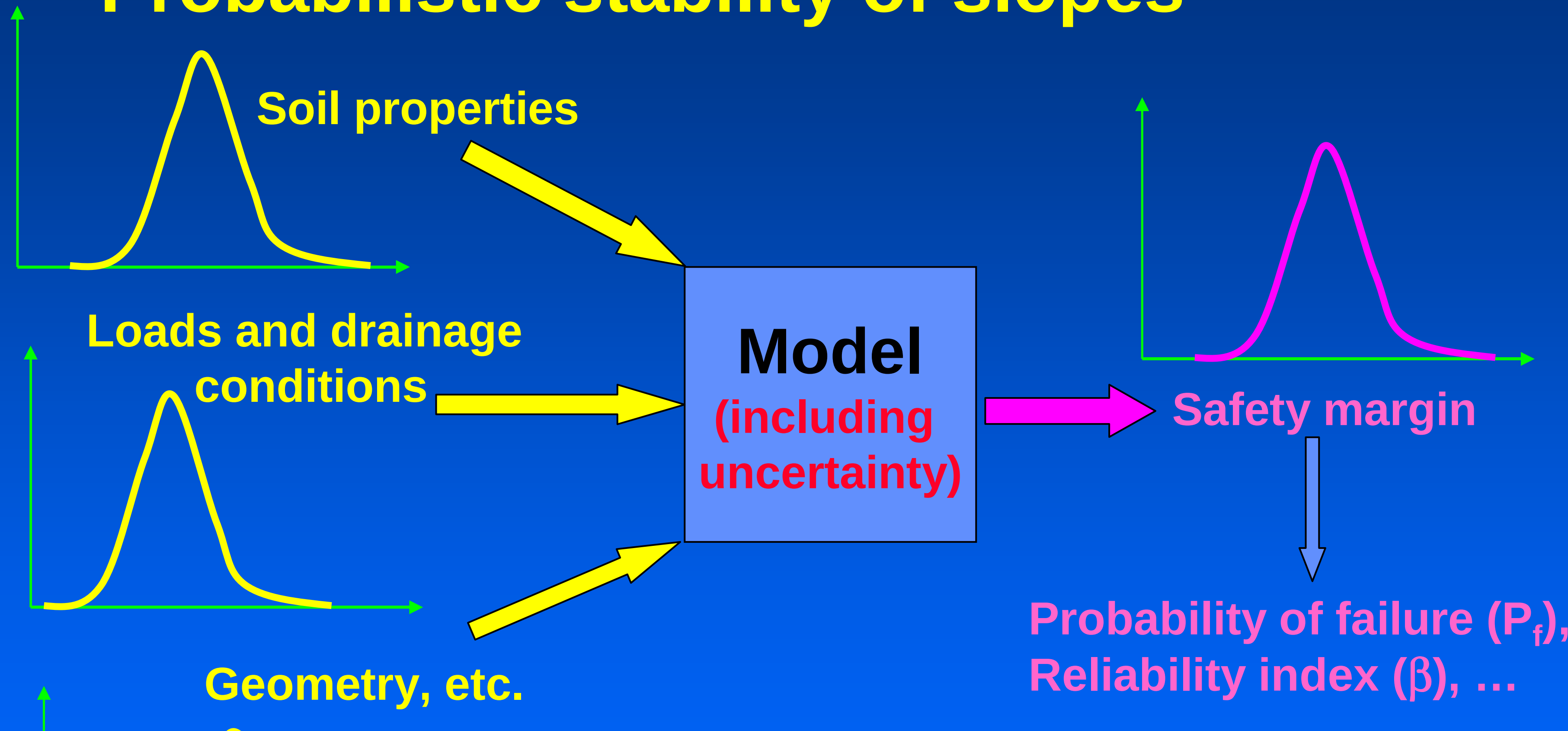
Scenario-based hazard and risk assessment for landslides (based on Nadim and Glade, 2006)

- Define scenarios for landslide triggering and associated occurrence probability
- Compute run-out distance, volume and extent of landslide for each scenario
- Estimate losses for each scenario
- Estimate risk and compare it with tolerable or acceptable risk levels

Hazard
Deterministic stability of slopes



Hazard
Probabilistic stability of slopes

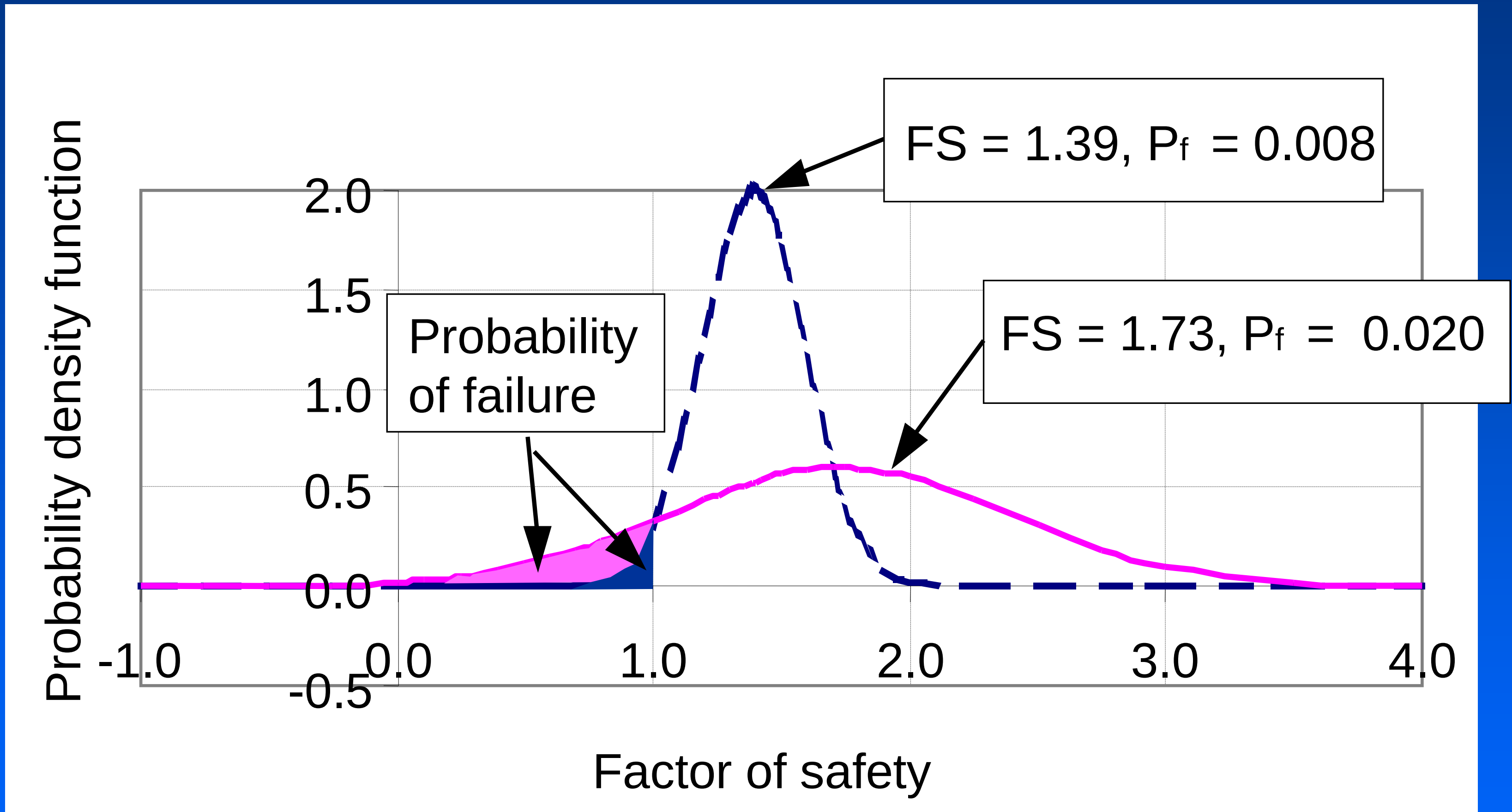


Acceptance criterion:

$P_f \leq P_{f,acceptable}$

or $\beta \geq \beta_{acceptable}$

ICG International Centre for Geohazards



FS = 1.39, Pf = 0.008
FS = 1.73, Pf = 0.020
Probability of failure
Probability density function
Factor of safety
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0.0
1.0
2.0
3.0
4.0

Factor of Safety **is not a sufficient indicator of safety margin because the <u>uncertainties</u> in the analysis parameters affect <u>probability of failure and safety</u>**

It is better to be

probably *right…*

… than to be

exactly *wrong*

International Centre for Geohazards

Some landslide-vulnerable categories…

Estimating vulnerability

$$V = I \cdot S$$

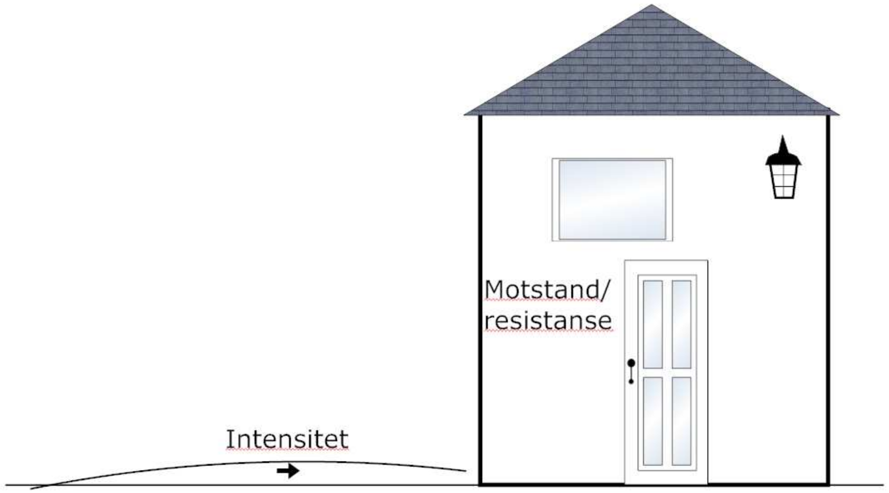
Vulnerability

=

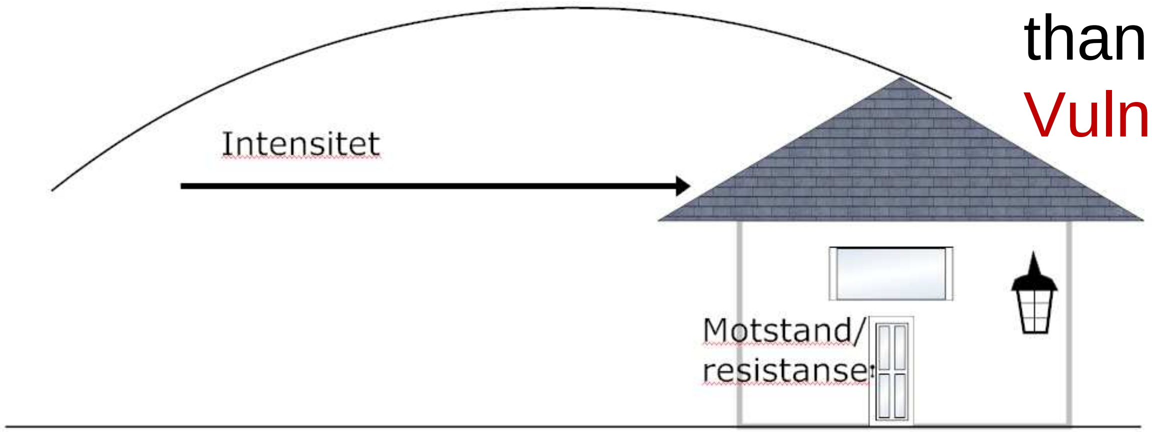
Landslide intensity

x

Susceptibility of vulnerable elements



Intensity much smaller than resistance:
Vulnerability is almost 0



Intensity much greater than resistance:
Vulnerability is almost 1

Landslide intensity (V= I x S)

Model

$$I = k_S \cdot \left[r_D \cdot I_D + r_G \cdot I_G \right]$$

Symbol	Description
k_S	Spatial impact ratio
r_D	Dynamic relevance factor
r_G	Geometric relevance factor
I_D	Dynamic intensity component
I_G	Geometric intensity component

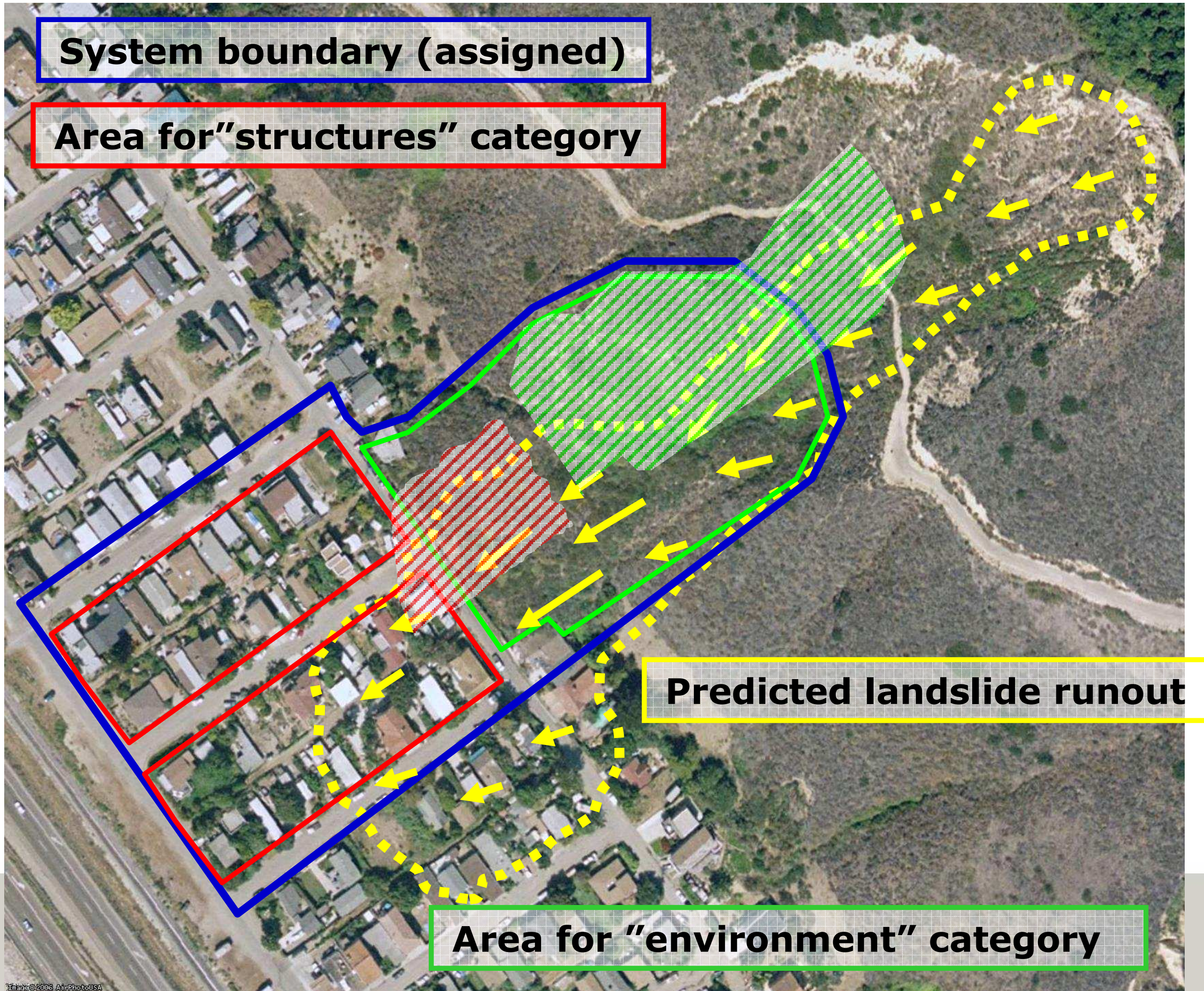
Spatial impact ratio

Expresses how much the category is affected spatially by a landslide

Defined in the range [0,1]

Spatial impact ratio

$$\boxed{k_S = A_i / A_t}$$



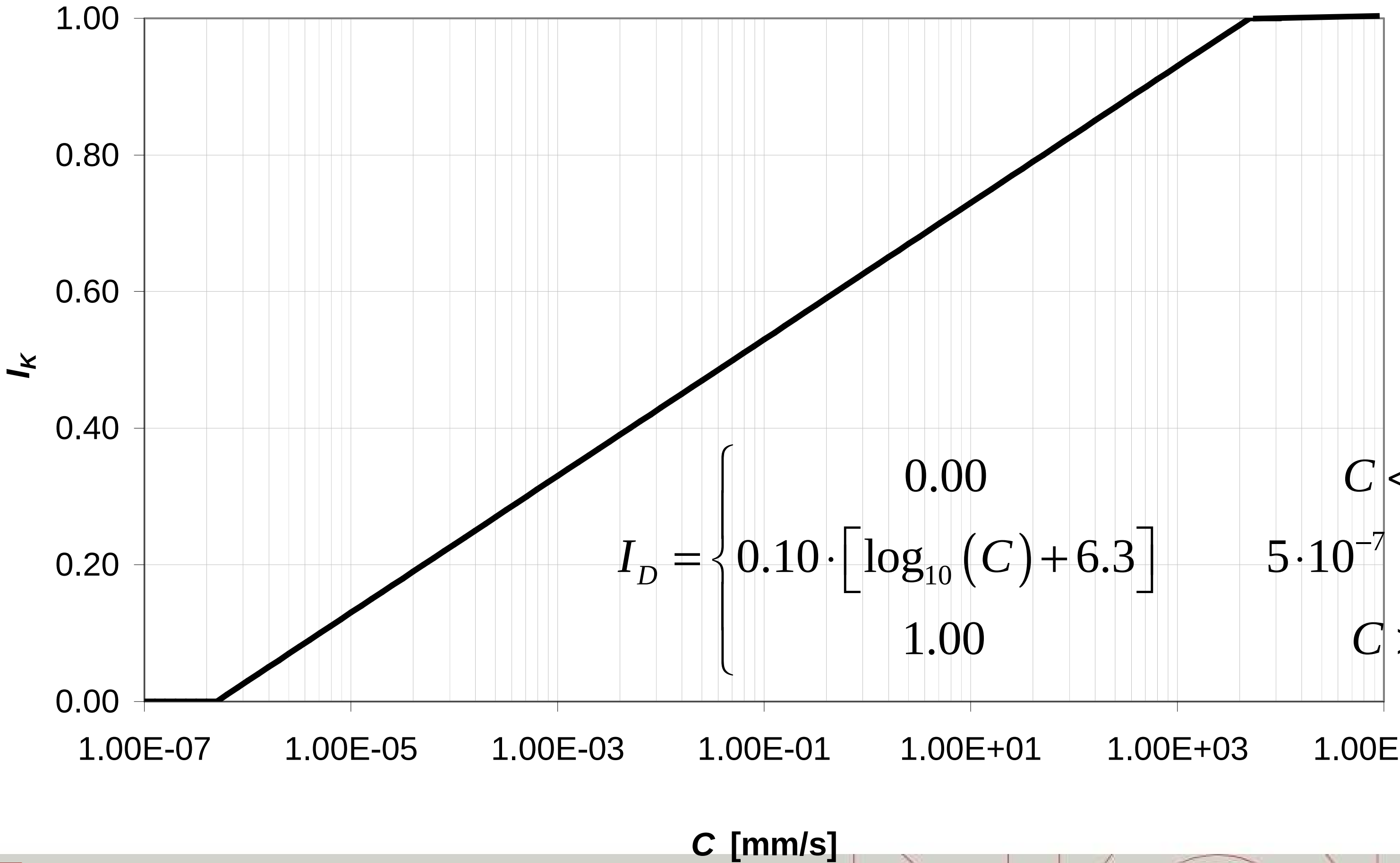
Geometric intensity

Accounts for dimensional properties of sliding masses (e.g. depth, volume, displacement, area,…)

Only constraint: defined in range [0,1]

Dynamic intensity

e.g. proposed model for structures (after Cruden & Varnes,'96)

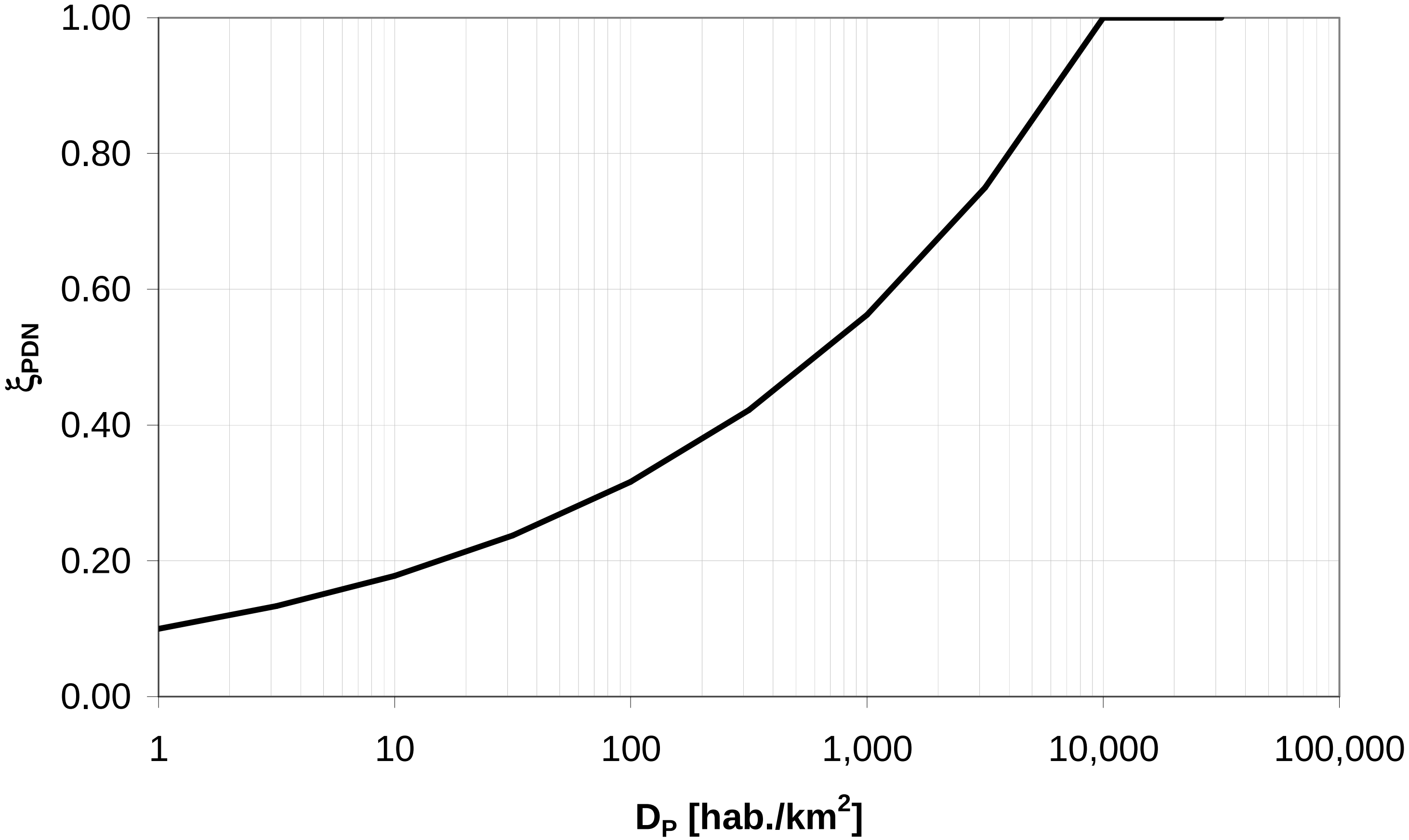


$$I_D = \begin{cases} 0.00 & C < 5\cdot10^{-7} \\ 0.10\cdot\left[\log_{10}(C)+6.3\right] & 5\cdot10^{-7} \le C \le 5\cdot10^{3} \\ 1.00 & C > 5\cdot10^{3} \end{cases}$$

Susceptibility factor for population density

Proposed model

$$\xi_{PDN} = \begin{cases} 0.1 \cdot D_P^{\ 0.25} & D_P \leq 10{,}000 \\ 1.00 & D_P > 10{,}000 \end{cases}$$



VIS approach

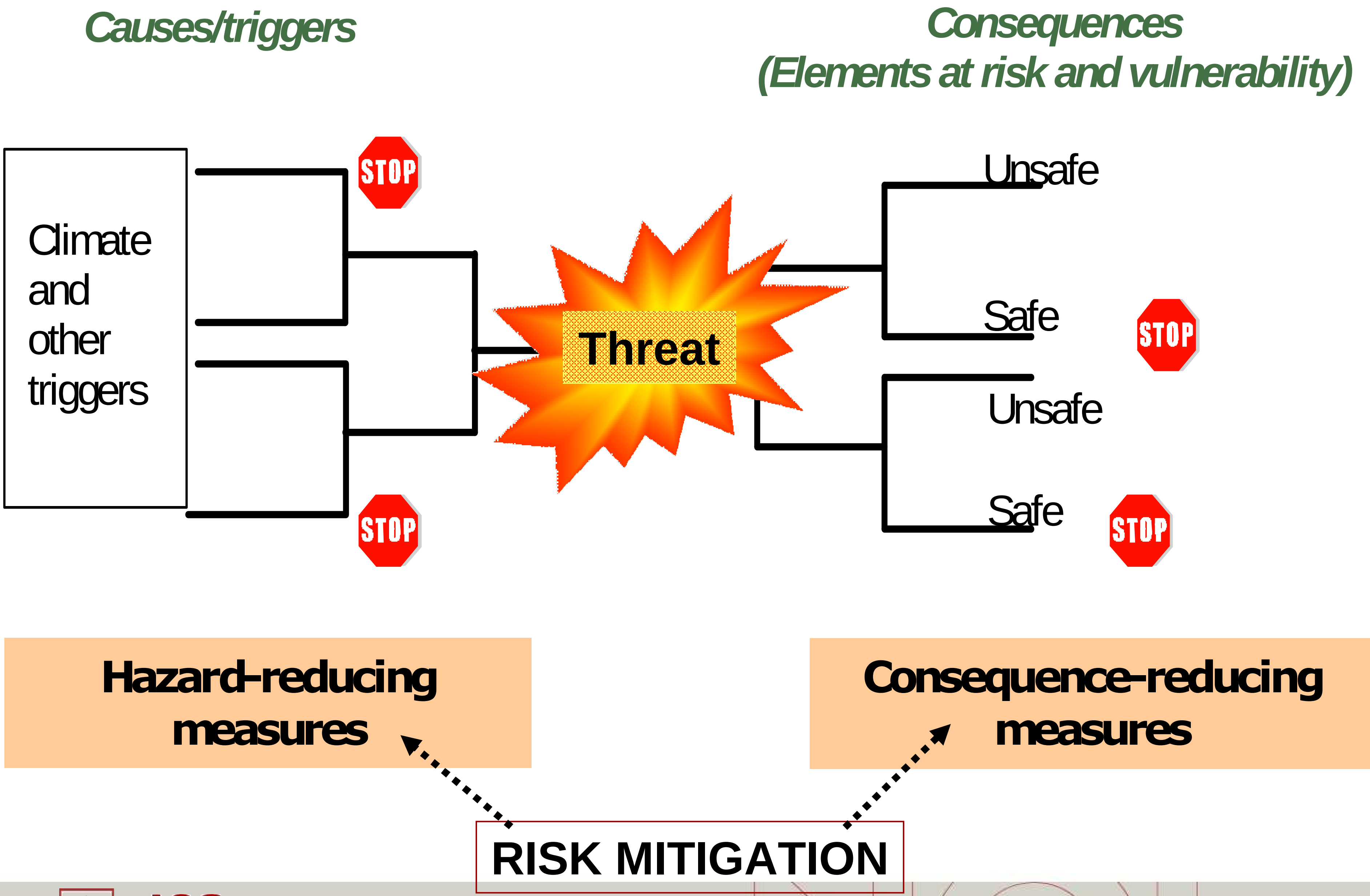
- Allows quantitative vulnerability estimation
- Operates at category-level (user-defined)
- Applicable to any landslide type
- Allows user-defined input models
- Numerical results must be assessed with care!

Plan de la conférence

- Management du risque
- Hazard[1], vulnerabilité et appréciation du risque
- Traitement du risque
- Conclusions

} Exemples

1 Phénomène dangereux


Causes/triggers
Consequences
(Elements at risk and vulnerability)
Climate and other triggers
STOP
STOP
Threat
Unsafe
Safe
STOP
Unsafe
Safe
STOP
Hazard-reducing measures
Consequence-reducing measures
RISK MITIGATION

Mitigation measures (landslides)

Physical (structural) measures

Slope stabilisation, drainage, erosion protection, channelling, vegetation, ground improvement, barriers, elevated land, anchoring and retaining structures etc

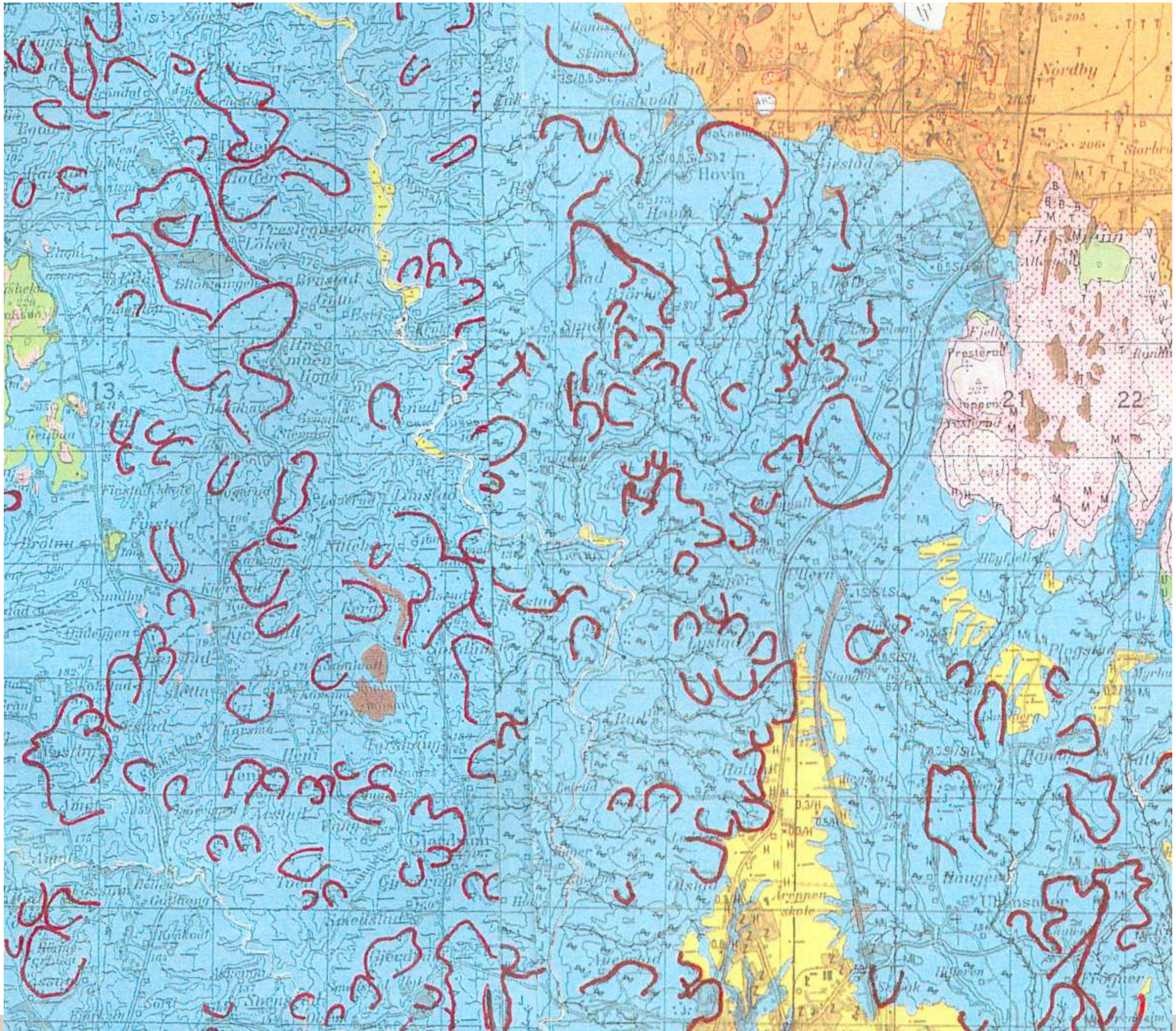
Non-structural measures

Early warning systems, land-use planning, public awareness, emergency preparedness, enforcement of building codes and good construction practice, measures to pool and transfer the risks etc

Bhutan: surface water system for road stabilization in an unstable slope

High capacity drainage channels for protecting villages in Sikkim

Slide scars close to Oslo



Assigning scores to hazards and consequences and estimating "risk classes"

Hazard classes	Consequence classes
Low	Low
Medium	Medium
High	High

Weighting significance of hazards and consequences

Hazard indicators

Topography
- Earlier sliding
- Height of slope
- Inclination of slope

Geo characteristics
- OCR
- Pore pressure
- Thickness of clay
- Sensitivity

Conditions
- Erosion
- Human activity

Consequence indicators

Human life and health
- Number of dwellings
- Humans in industrial buildings

Infrastructure
- Roads (traffic density)
- Railways
- Power lines

Private property
- Buildings
- Effect of floods

Determination of risk indicator

Risk indicator : $H_i \bullet C_i$

Hazard indicator, H_i

$$\sum (H_{Score} \bullet H_{Weight})$$

Consequence indicator, C_i

$$\sum (C_{Score} \bullet C_{Weight})$$

Hazard Indicator

Hazard indicator	Weight	Score value 3	2	1	0
Earlier landslides	1	Frequent	Some	Few	None
Height of slope	2	>30 m	20 – 30 m	15 – 20 m	<15 m
Overcons'tion ratio (OCR)	2	1.0-1.2	1.2-1.5	1.5-2.0	>2.0
Pore pressure: **- In excess (kPa)** **- Underpressure (kPa)**	3 -3	> + 30 > - 50	10 – 30 -(20 – 50)	0 – 10 -(0 – 20)	Hydrostatic Hydrostatic
Thickness clay layer	2	>H/2	H/2-H/4	<H/4	Thin layer
Sensitivity, S_t	1	>100	30-100	20-30	<20
Erosion	3	Active/slide	Some	Little	None
Human activity: **- Worsening effect** **- Improving effect**	3 -3	Import't Import't	Some Some	Little Little	None None
Max. weighted score		51	34	16	0
% of max. Weighted score		100 %	67 %	33 %	0 %

Consequence Indicator

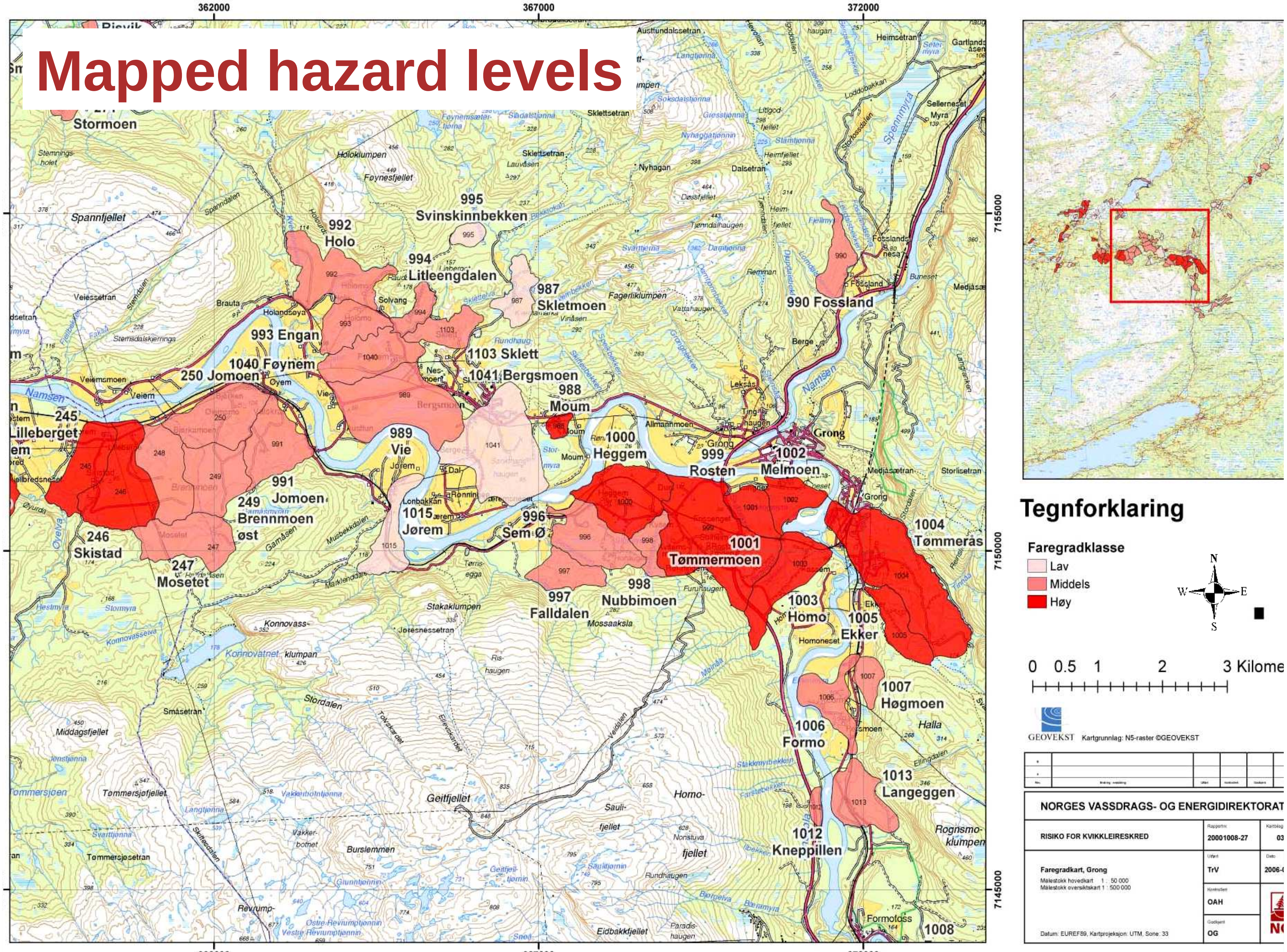
Element at risk	Weight	Score for consequence			
		3	2	1	0
No. of housing units	4	> 5 Closely spaced	> 5 Widely spaced	< 5 Widely spaced	0
Persons in industrial buildings	3	> 50	10 – 50	< 10	0
Value of buildings	1	High	Significant	Limited	None
Roads (traffic density)	2	High	Medium	Low	None
Railways (importance)	2	Highl	Medium	Low	None
Power lines	1	Main	Regional	Distribution network	Local
Consequence of flooding	2	Critical	Medium	Small	None
Max. weighted score		45	30	15	0
% of max. Weighted score		100 %	67 %	33 %	0 %

Risk matrix and required actions

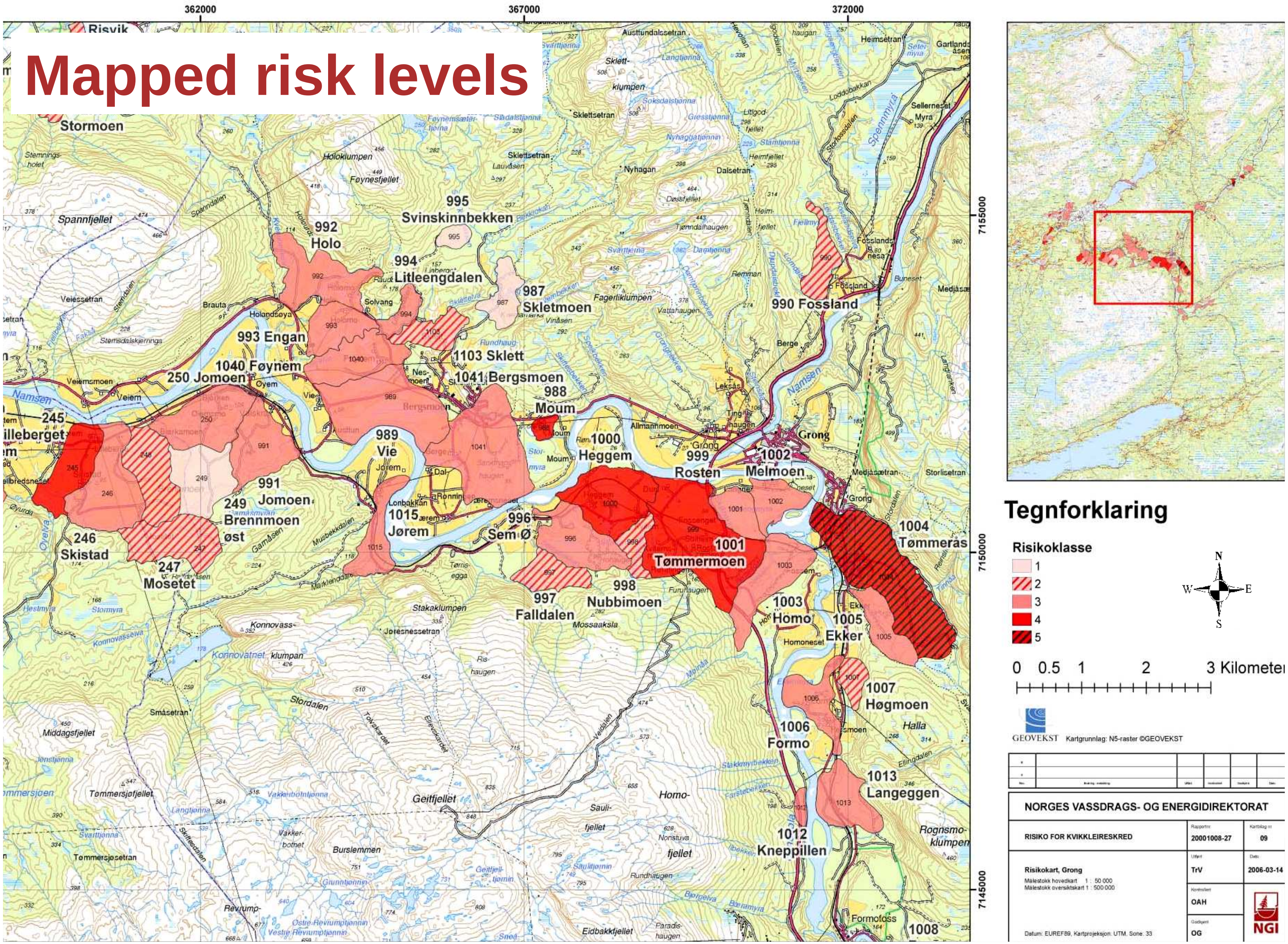
	Consequence Low	Consequence Medium	Consequence High
Low hazard (probability)	Low risk	Low risk	Medium risk
Medium hazard (probability)	Low risk	Medium risk	High risk
High hazard (probability)	Medium risk	High risk	High risk

Require new site investigations
Require stability calculations
Require mitigation measures

Mapped hazard levels



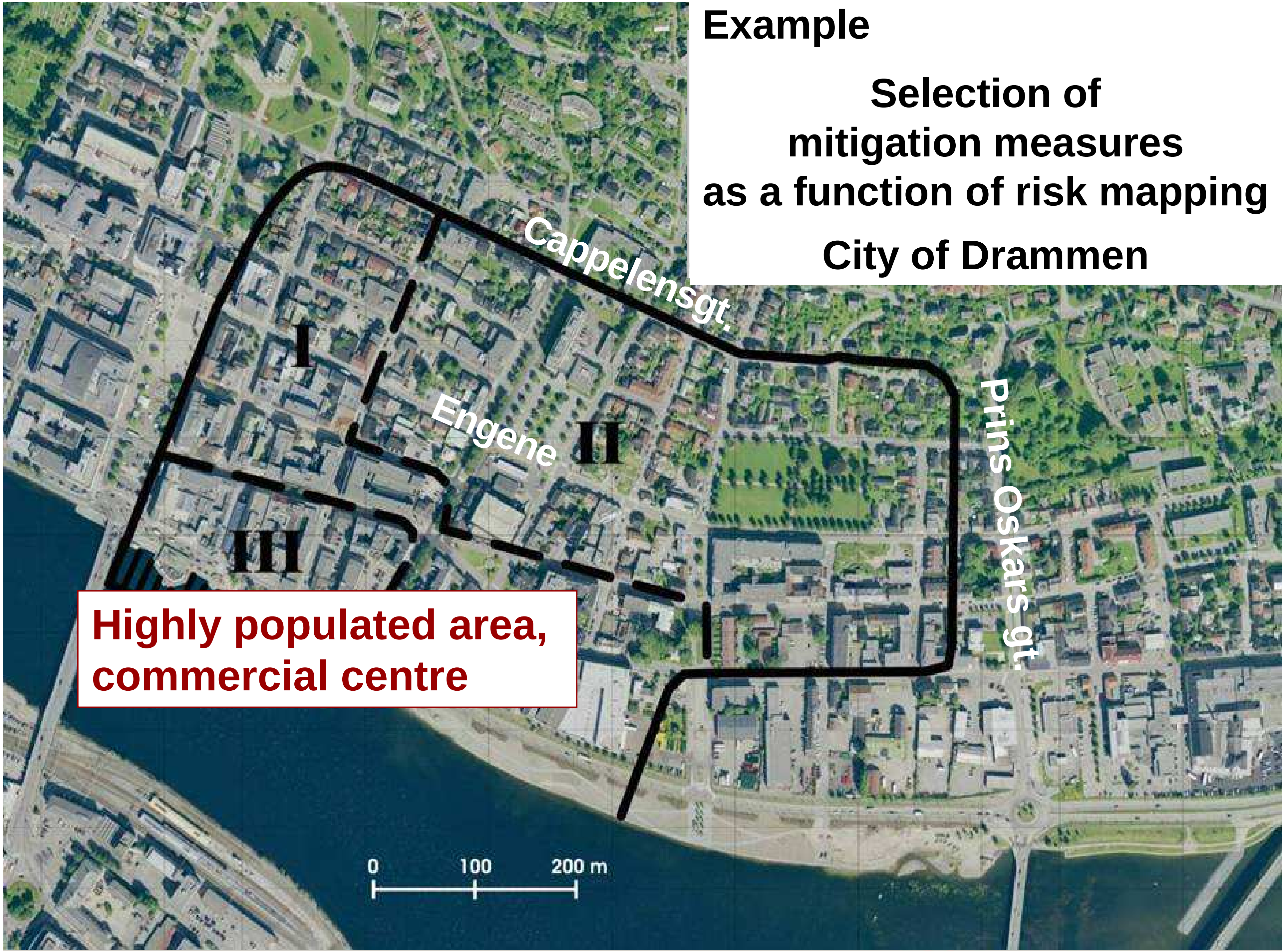
Mapped risk levels

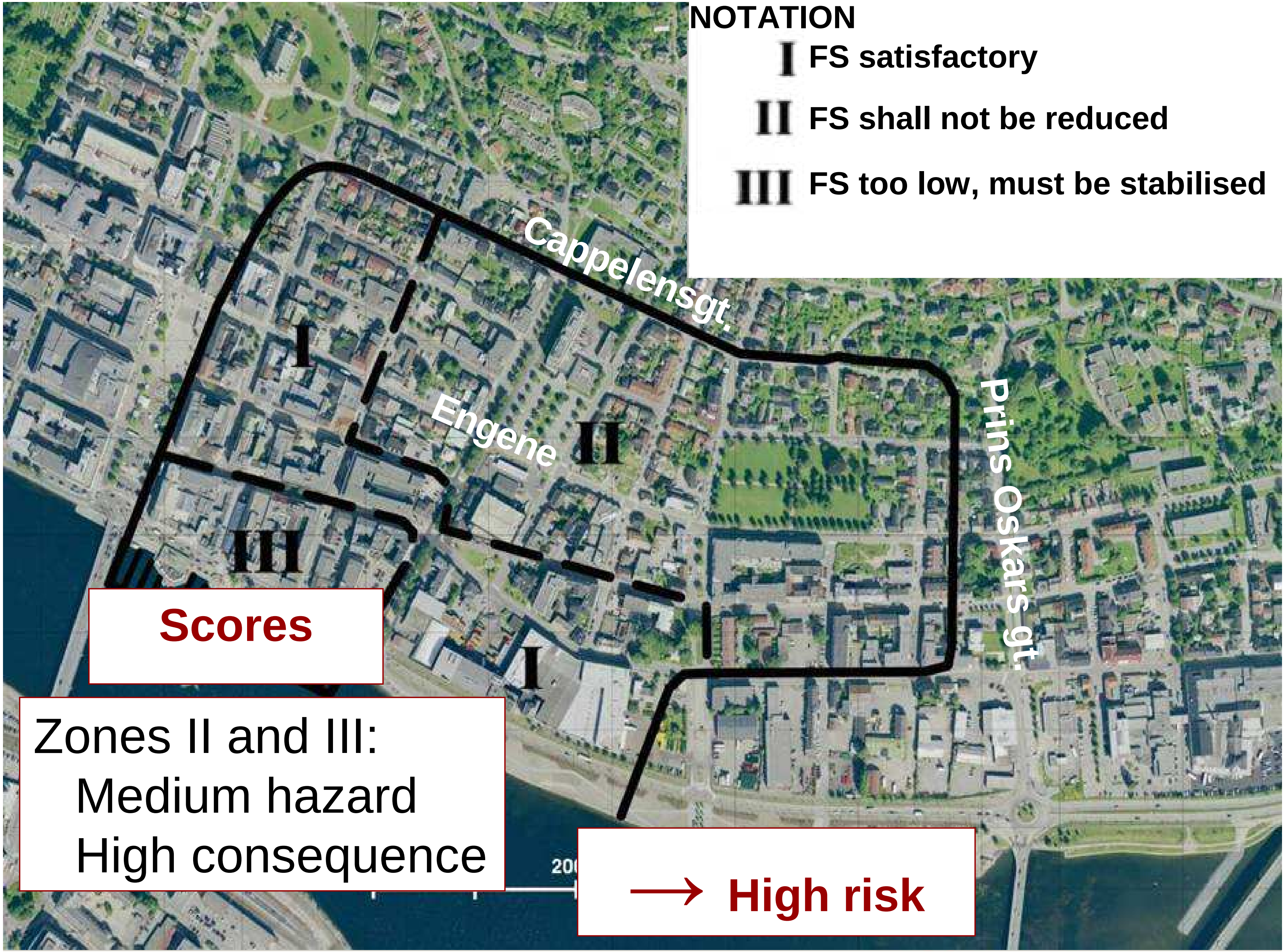


Example

Selection of mitigation measures as a function of risk mapping

City of Drammen



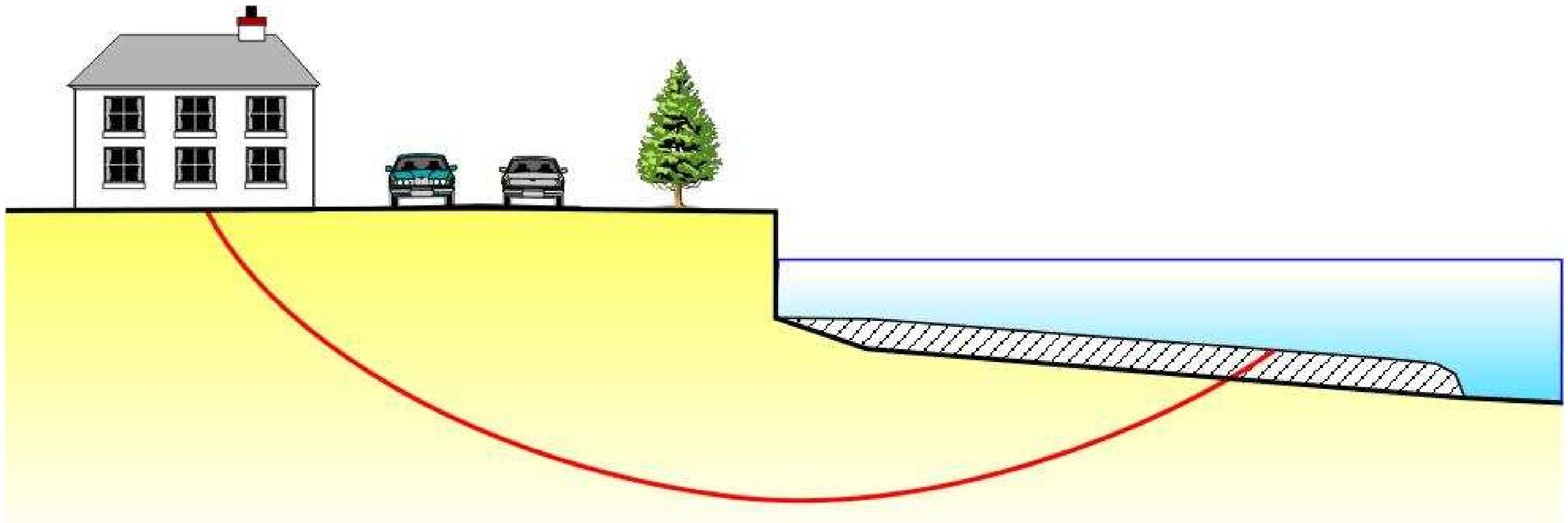


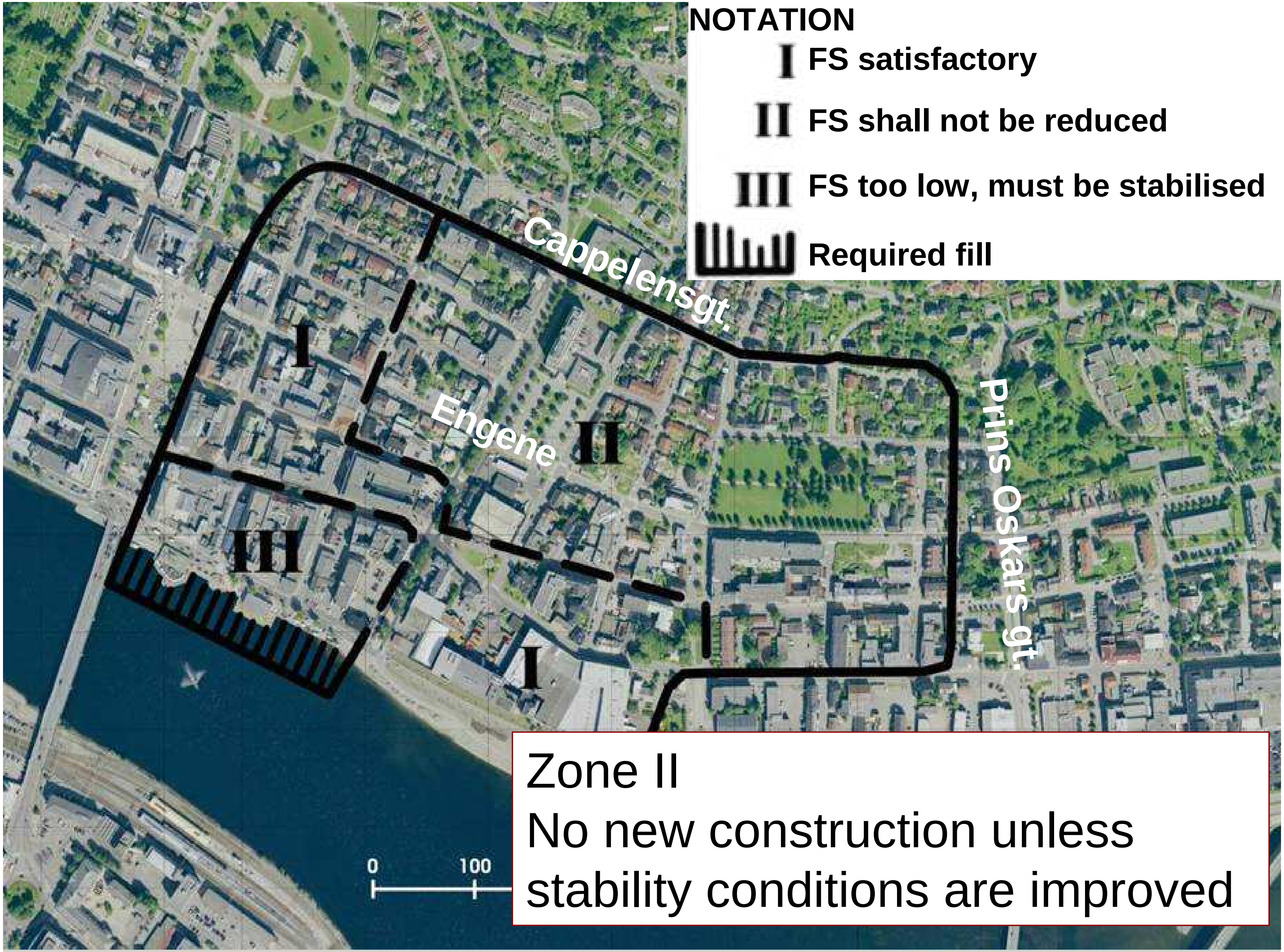
Scores

Zones II and III:
Medium hazard
High consequence

→ **High risk**

Risk zone III - Safety is too low – Mitigation with counter fill



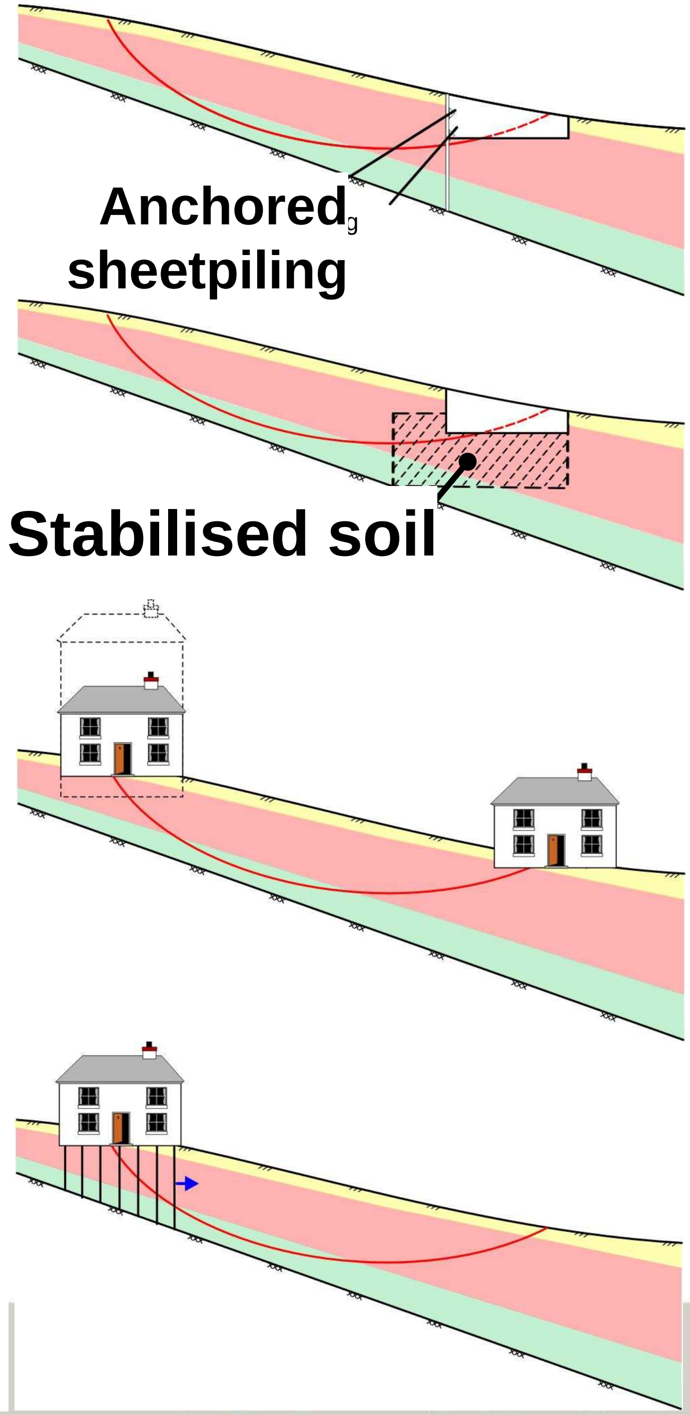


Zone II

No new construction unless stability conditions are improved

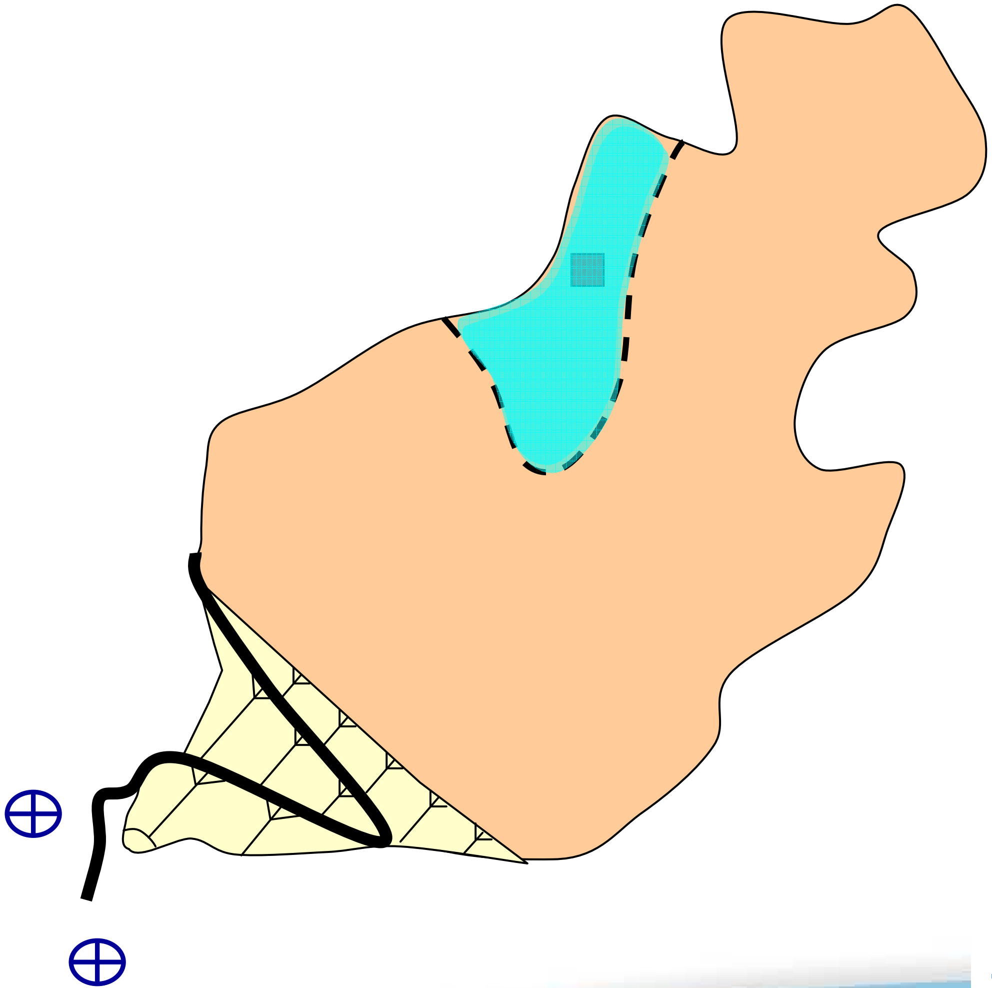
Drammen Countermeasures in Zones II

- No excavations
- Ground improvement
- Ban on new construction or new foundation work uphill



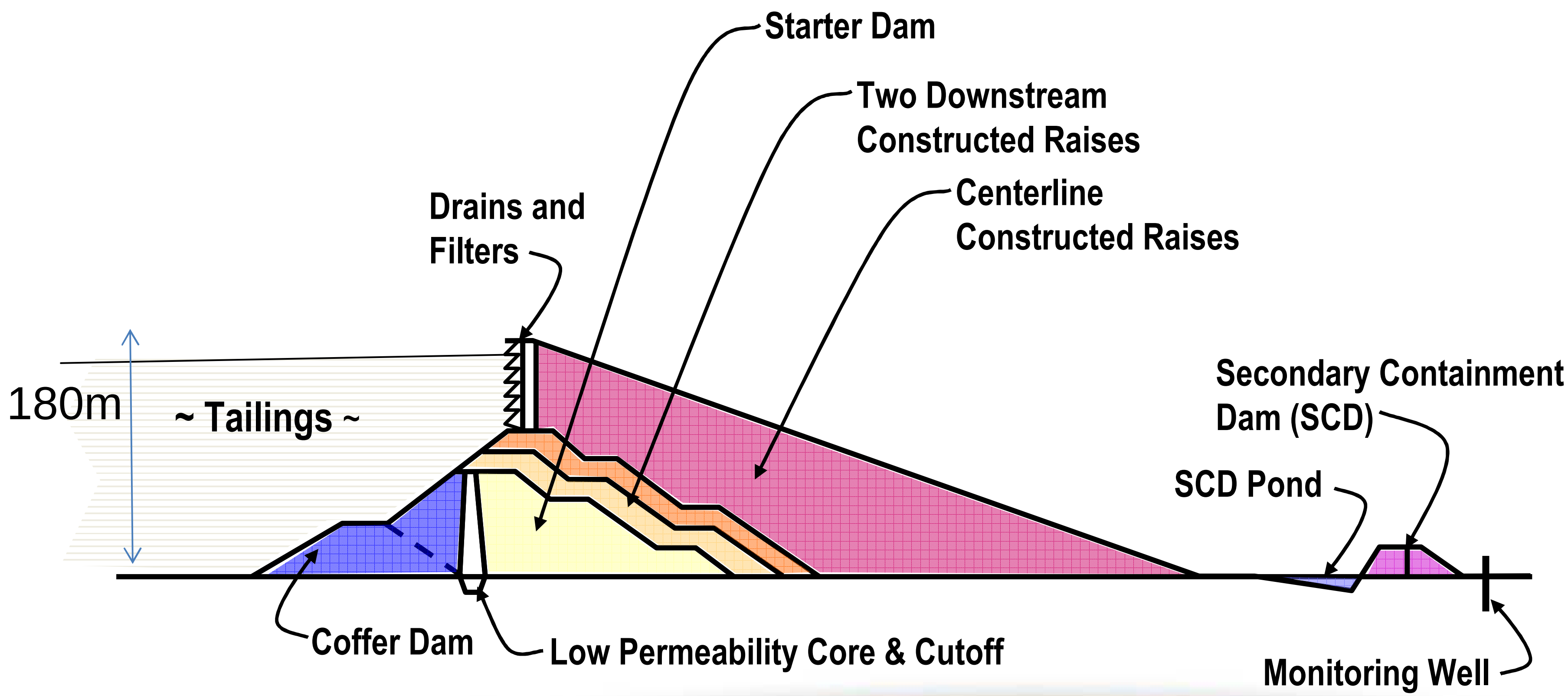
Tailings/Rockfill Dam Project - Risk analyses

Rosia Montana TMF - Design Criteria



- International Best Practice
- Meets or exceed:
  - Romanian Standards
  - International Tailings Dam standards
- International CN Management Code
- Earthquakes:
  - Richter M8 Earthquake,
- Floods:
  - Facility has reserve storage capacity for twice PMP rainfall (can occur once in 100 million yrs)
  - Spillway added as additional safety measure
- Construction of “tailings dam” with rockfill

TMF Dam - Components



What could happen to the TMF and to neighbouring environment?

- If an earthquake strikes
- If unusually intense rainfall occurs
- If a slide occurs on the hillside
- If the stockpile causes a foundation failure
- If dam crest settles
- If those triggers occur at the same time
- …

All plausible scenarios (triggers/events) were examined

Tailings Dam Construction Process

MWH
BUILDING A BETTER WORLD

Completed Starter Dam

MWH
BUILDING A BETTER WORLD

Hazard and Risk Assessment of Tailings Management Facility (TMF)

MWH
BUILDING A BETTER WORLD

<u>Hazard:</u>
Probability that a breach in the TMF occurs

<u>Risk associated with dam breach:</u>
Looks at probability of occurrence and consequence of breach

How did we do the evaluation?

MWH
BUILDING A BETTER WORLD

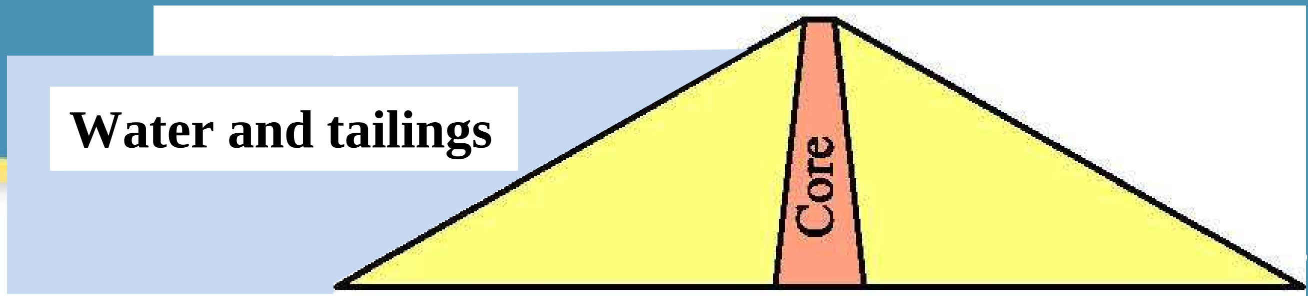
- Assembled dam and risk experts from USA, Norway, Canada and Romania, including past President of ICOLD (International Commission of Large Dams)
- Established all plausible scenarios where TMF could release tailings and water, during the entire life of the TMF
- Quantified <u>how often</u> these scenarios can happen
- Looked at the possible consequences

Critical mode screening

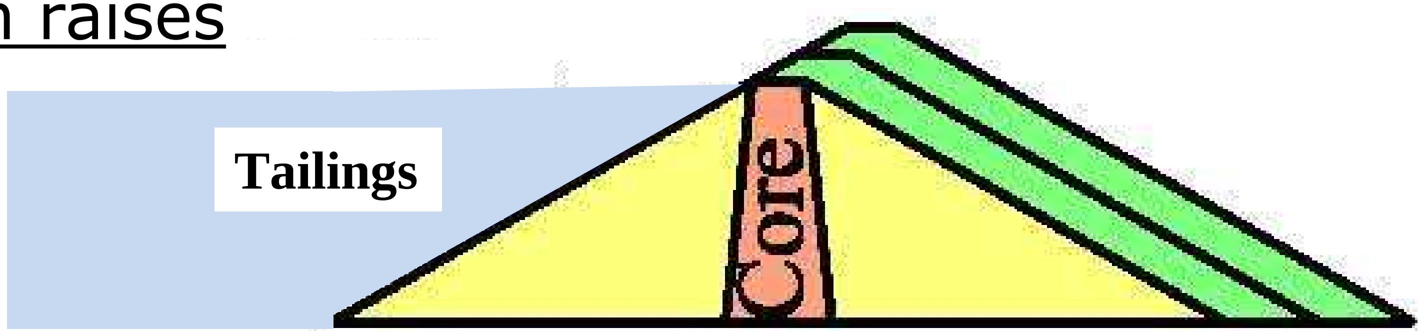
Trigger/event \ Time in dam life	1.5 yrs	4 yrs	9-12 yrs	16 yrs
10.000-yr earthquake *	x			x
10,000-yr rainfall/flood/snowmelt *	x			
Operational delays	x	x		
Failure of valley slopes (natural terrain)		x		
Failure under waste stockpile			x	x
Internal erosion	x			
Liquefaction of tailings			x	x

** Includes all failure modes, from foundation failure, dam slope instability, dam abutment failure, internal erosion and toe unravelling, when relevant.*

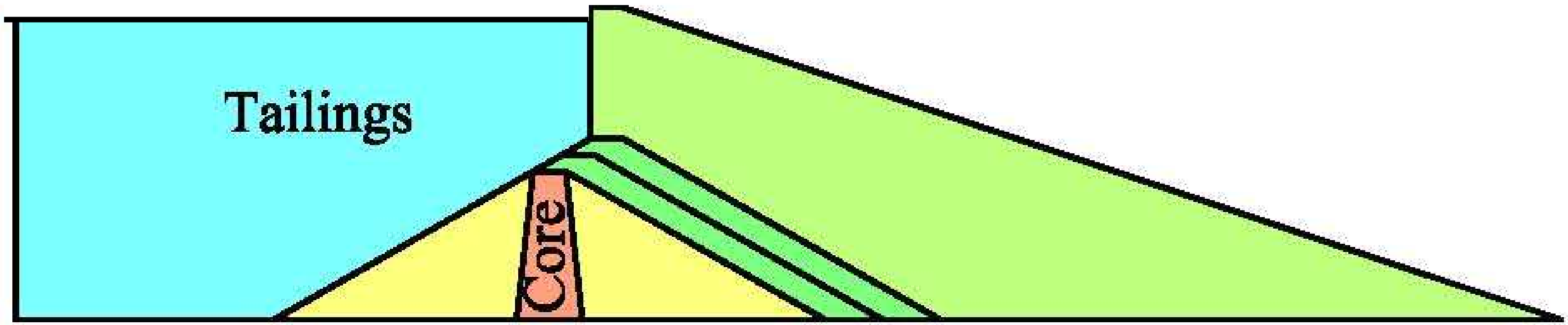
Starter Dam



Downstream raises

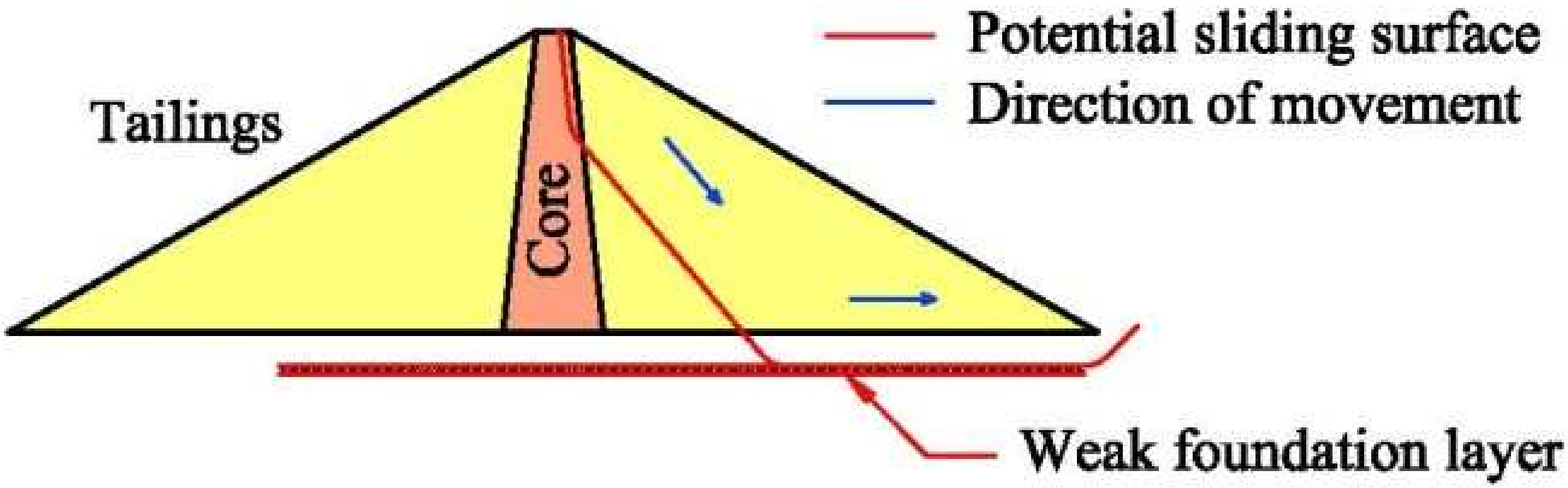


Completed dam (TMF)



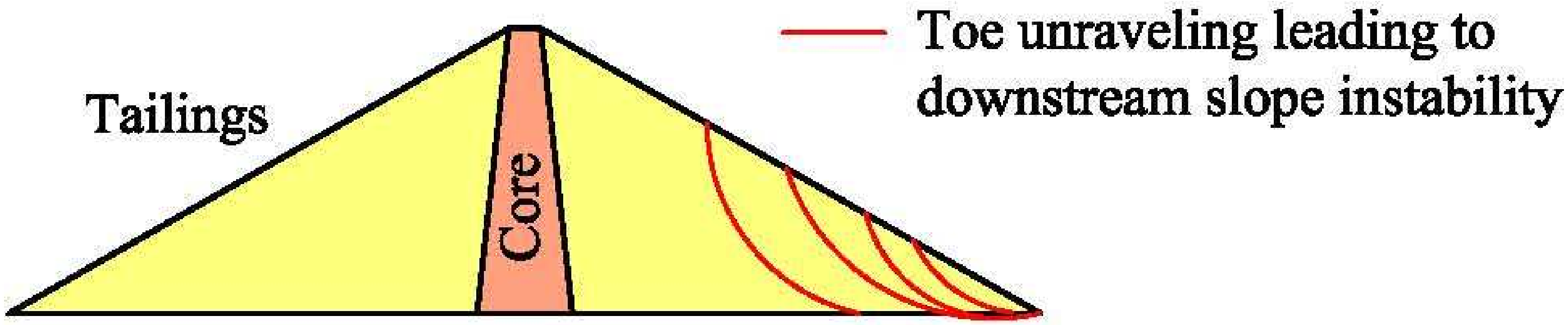
Example of a scenario

-Starter Dam



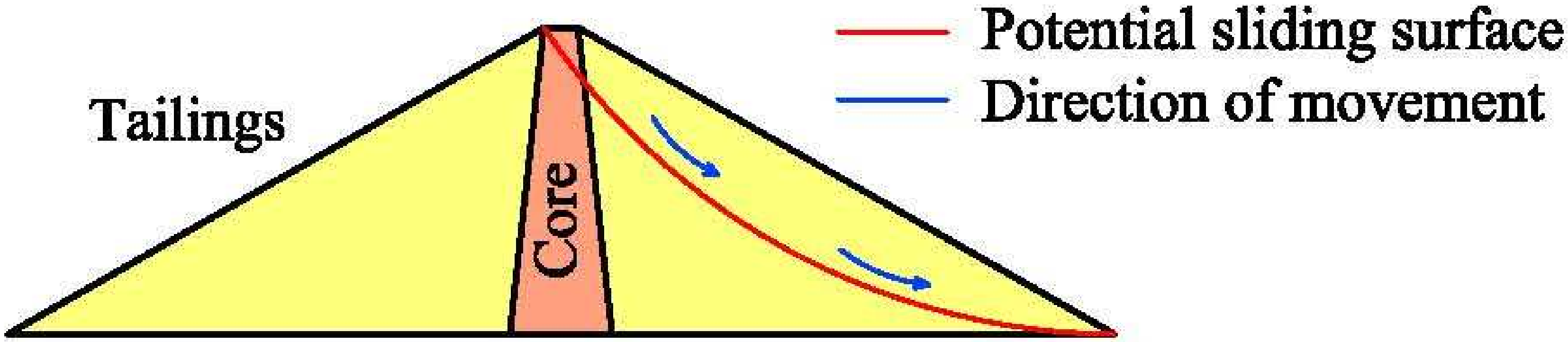
Example of a scenario

-Starter Dam



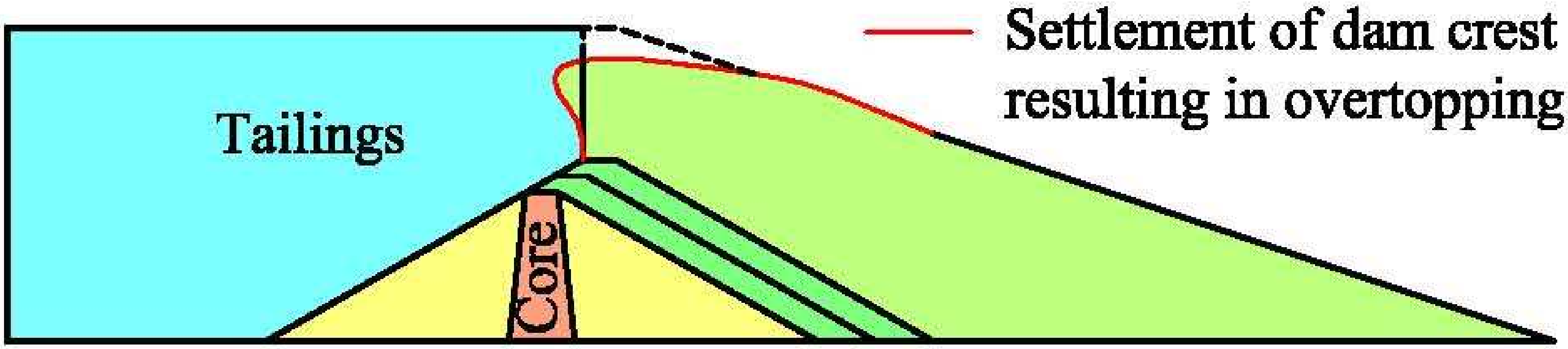
Example of a scenario

-Starter Dam



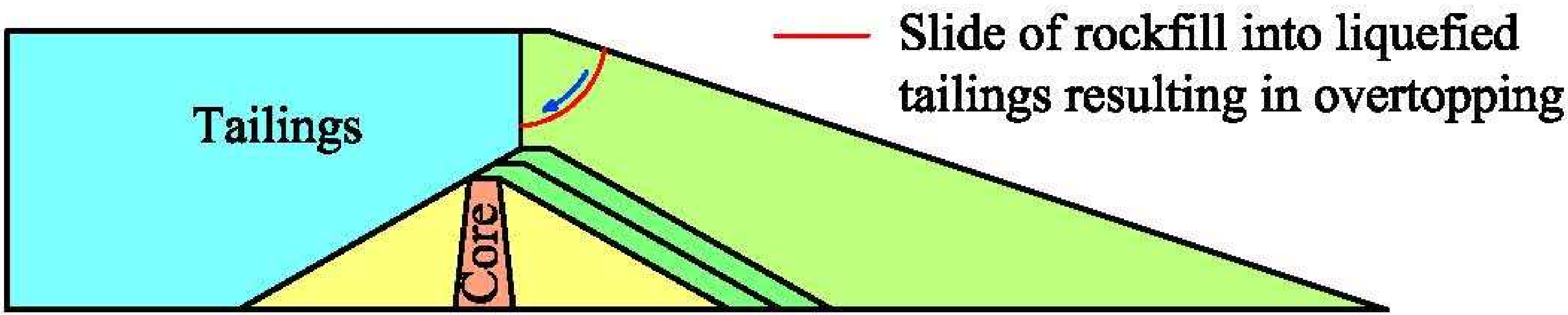
Example of a scenario

-Completed Dam



Example of a scenario

-Completed Dam

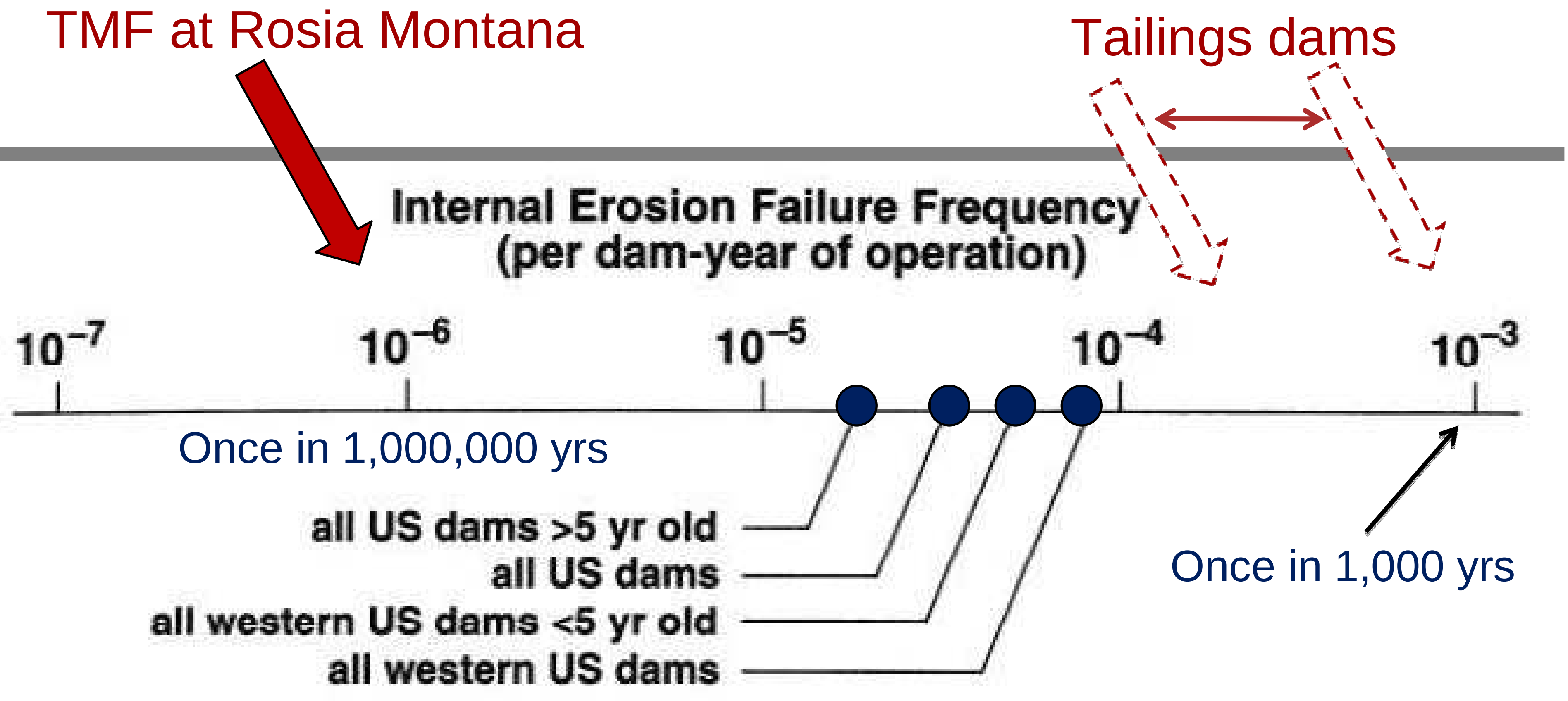


Total probabilities of non-performance per configuration

Configuration	Trigger/Event	P[Consequence	P[Consequence
Starter Dam Configuration A, (1,5 yr, internal erosion)	All triggers All non-performance modes	1.4 x 10^{-6}/yr	---
Final Corna Dam Configuration C (16 yrs)	All triggers All non-performance modes	---	1.3 x 10^{-6}/yr
Corna Dam Configuration B (4 years)	All triggers All non-performance modes	---	6. 5 x 10^{-7}/yr
Corna Dam Configuration D (9-12 yrs)	Static liquefaction in tailings		1.3 x 10^{-6}/yr

NGI NGI

Probability of dam breach
Comparison with existing dams

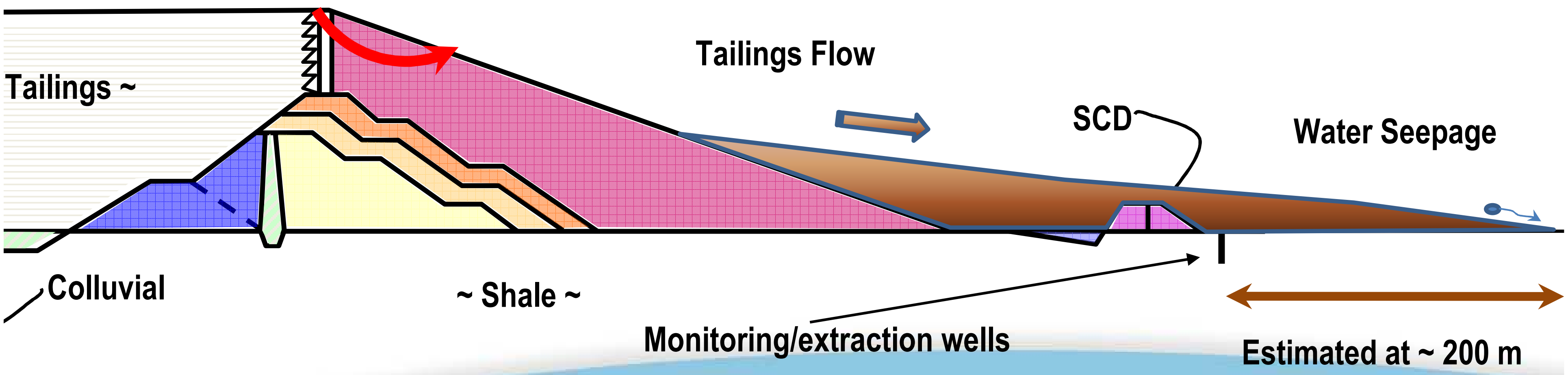


Physical Impacts

MWH
BUILDING A BETTER WORLD

Physical impacts if dam breach occurs:

- Tailings flow a couple of 100 meters
- Tailings volume of 250,000 m^3 and 26,000 m^3 of water
- Conducted water model with this discharged into Abrud river
- Limited and temporary Cyanide levels above regulated standards in vicinity of downstream valley

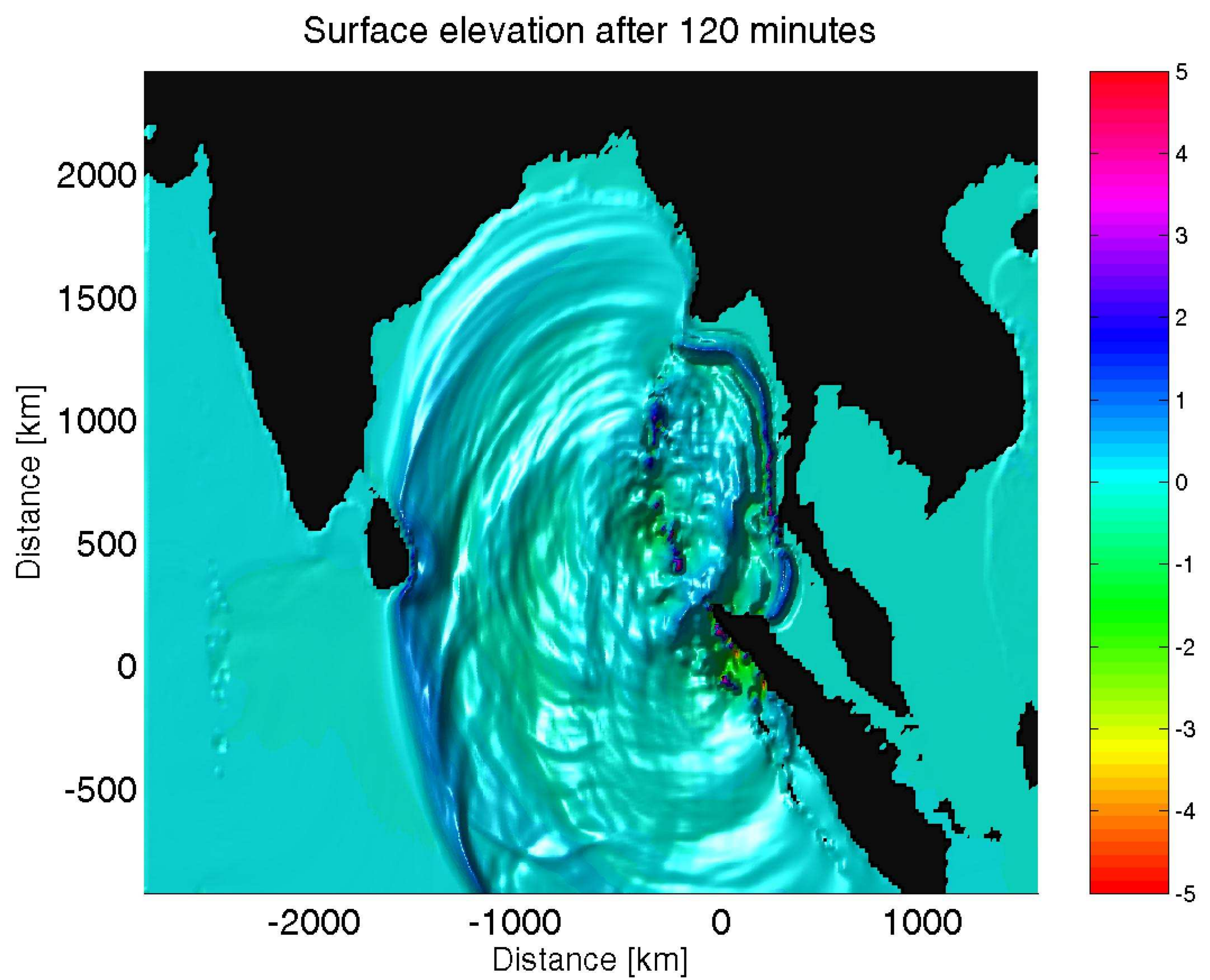


Confidence in risk estimate?

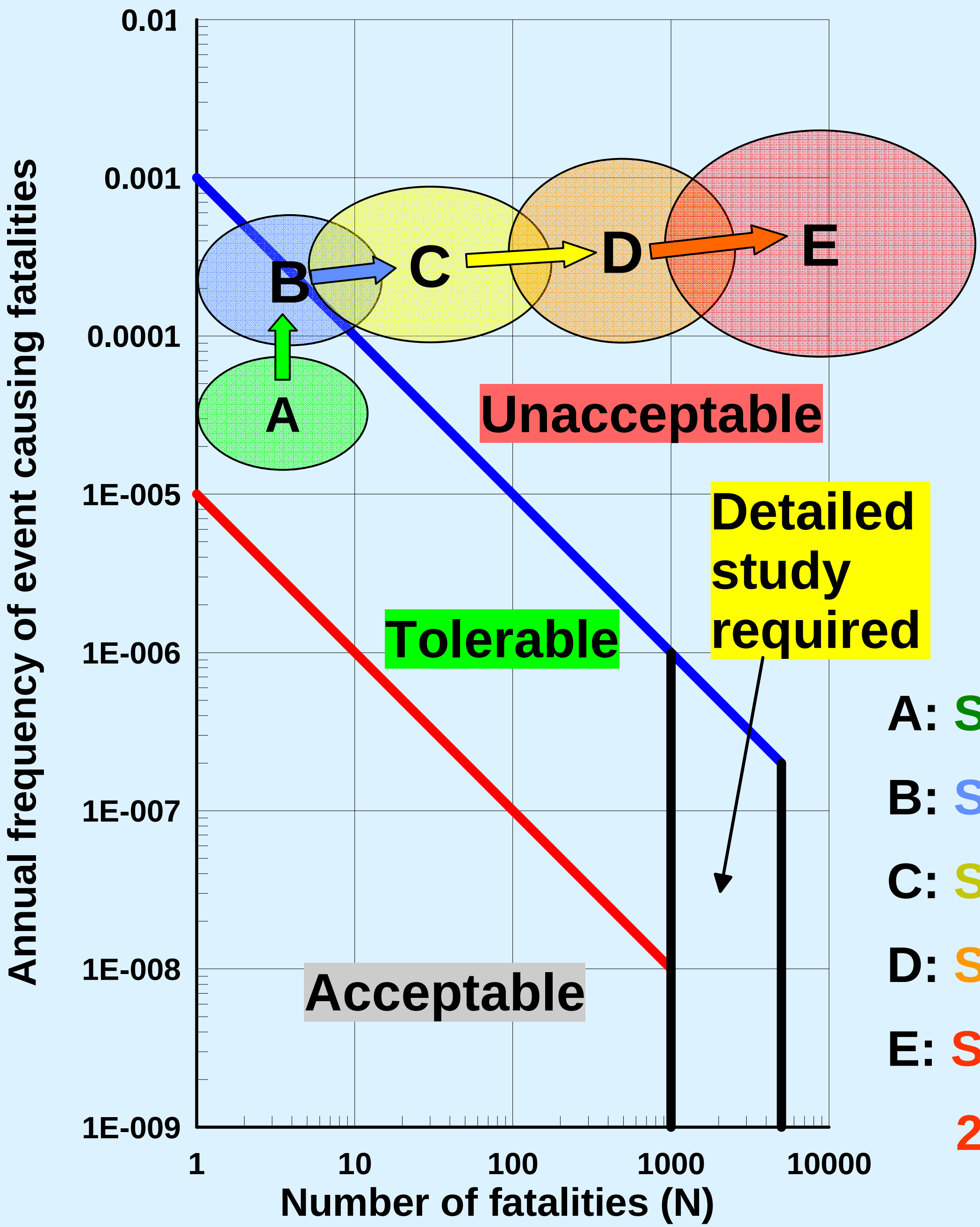
Tsunami in Indian Ocean, 26 Dec. 2004

Risk associated with earthquake followed by tsunami extremely difficult to quantify: Low hazard and catastrophic consequence: mathematically close to ”$0 \times \infty$ problem”

Wave pattern



Evolution of tsunami risk with time



A: Situation today (June 2005)

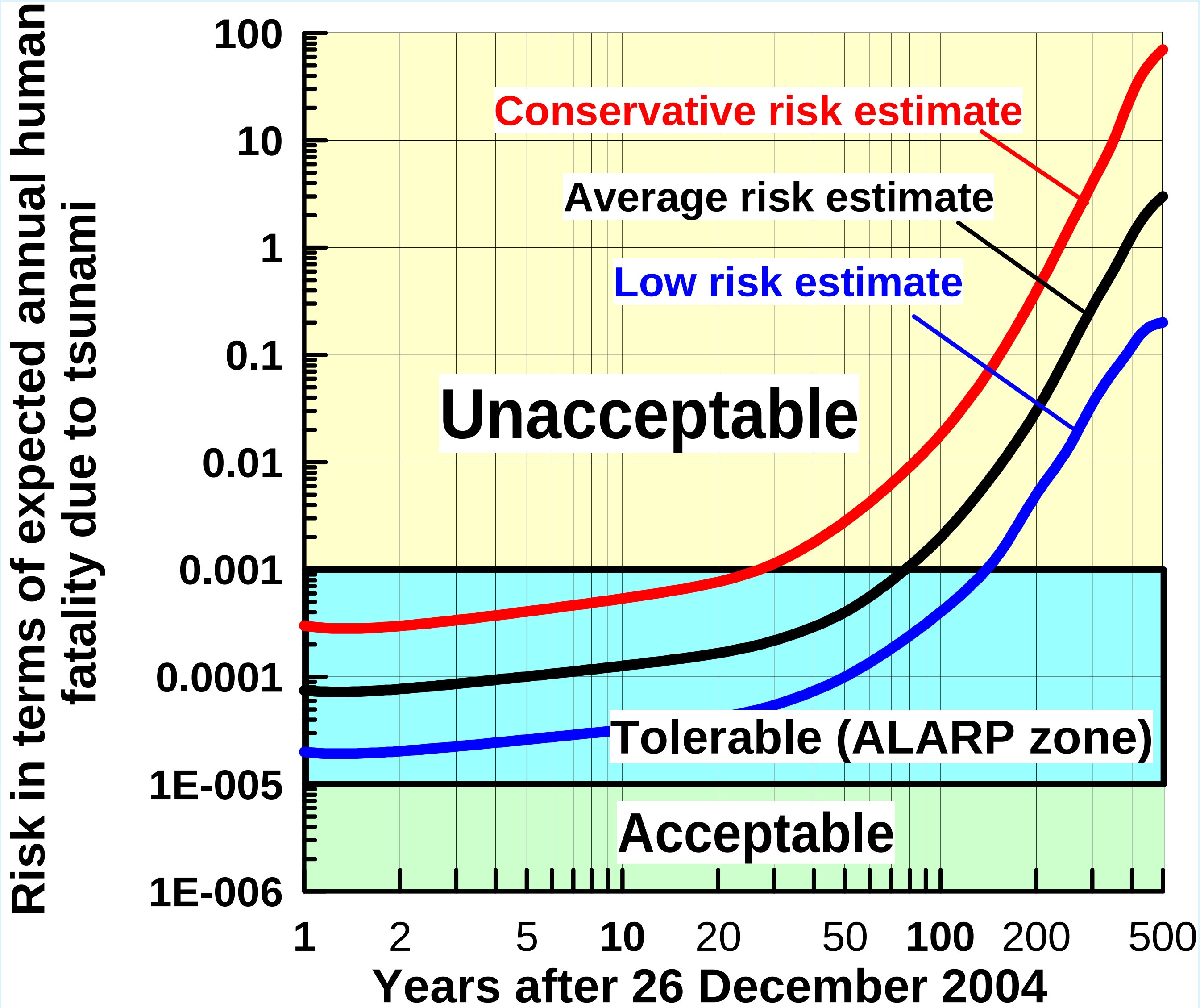
B: Situation in 50-100 years

C: Situation in 100-200 years

D: Situation in 200-300 years

E: Situation before 26 Dec. 2004 and after ~300 years

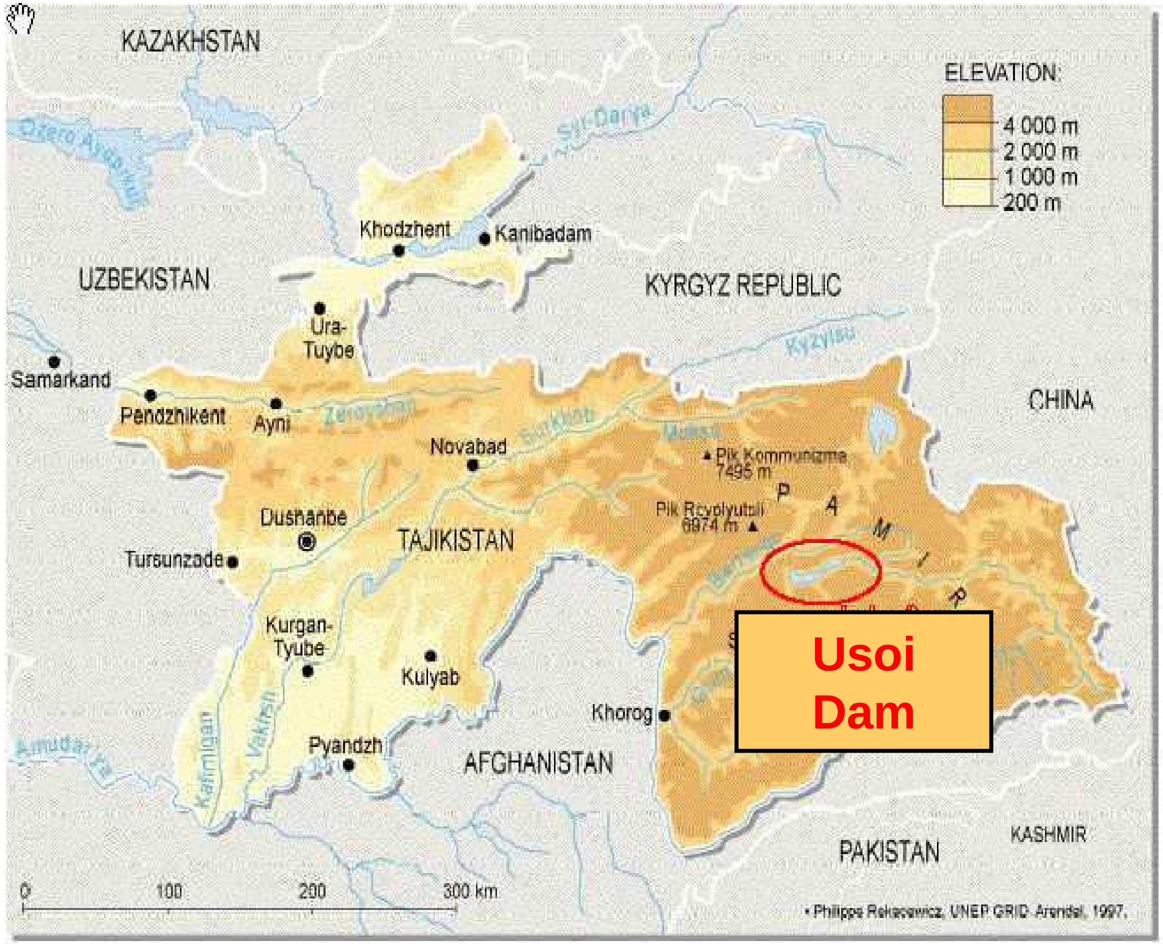
Confidence in risk estimate



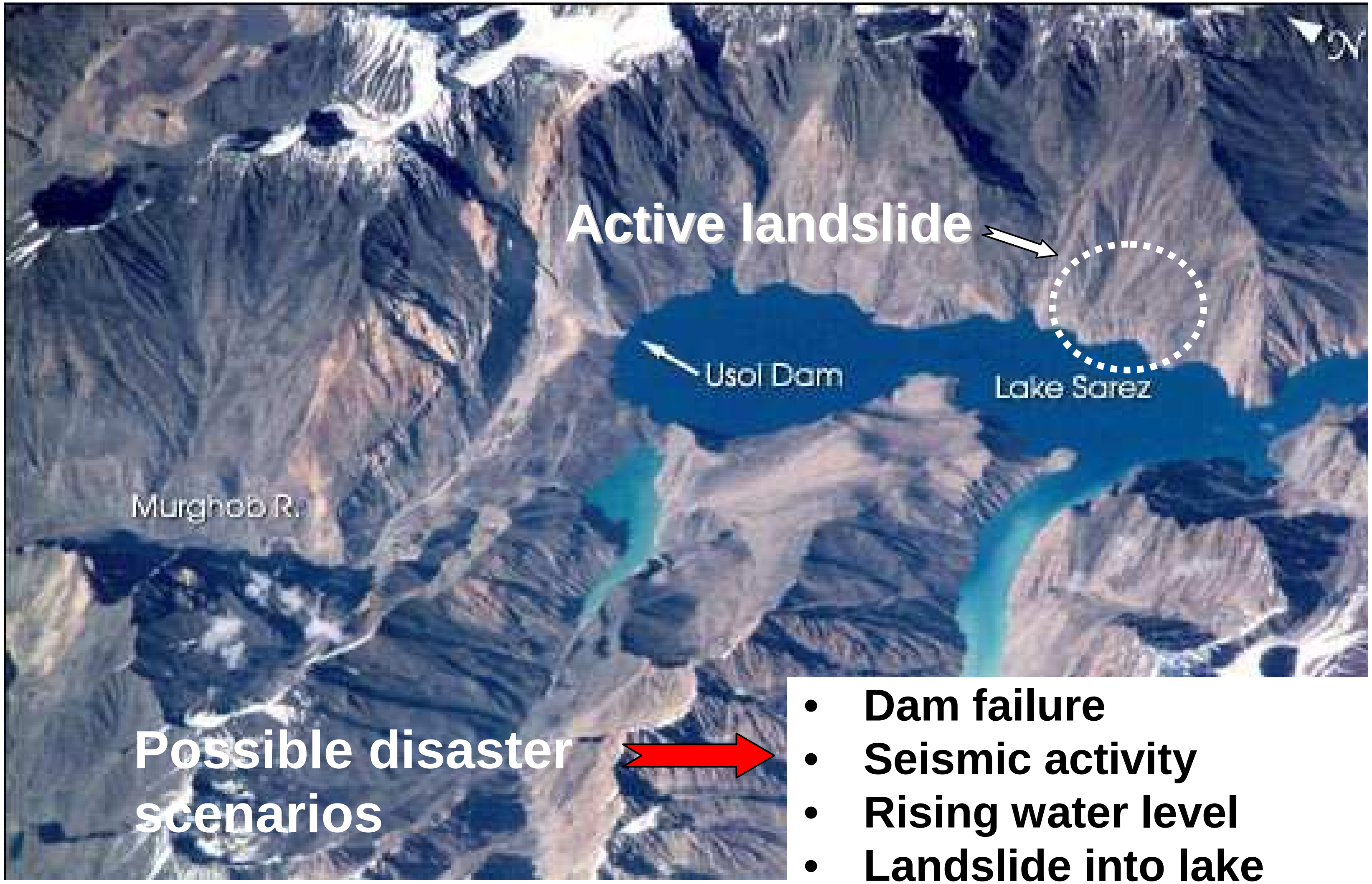
Example
Usoi Dam on Lake Sarez in Tajikistan

Usoi Dam is a 600m high <u>landslide dam</u>.

It is the largest dam in the world!

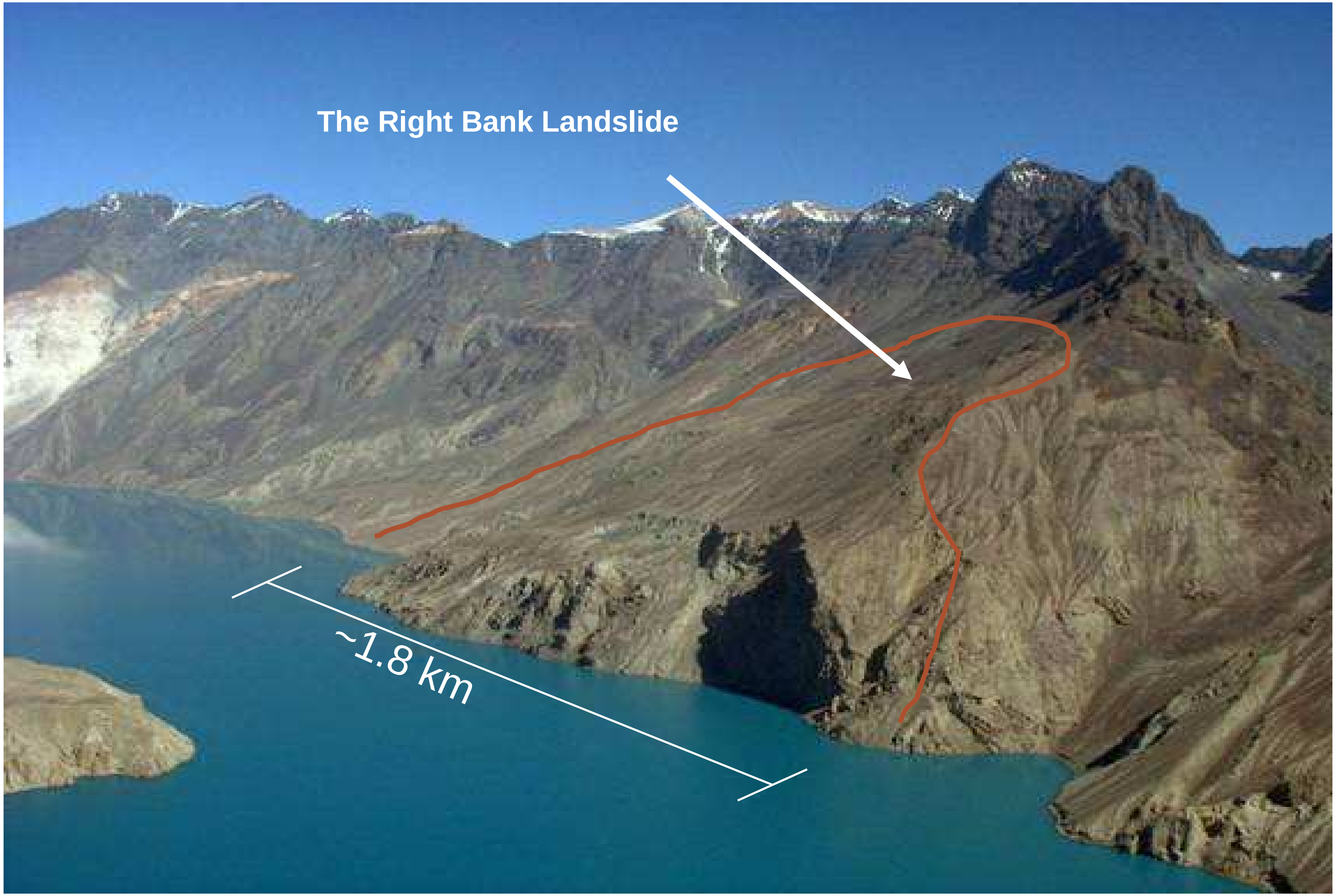


Disaster scenarios at Lake Sarez



- **Dam failure**
- **Seismic activity**
- **Rising water level**
- **Landslide into lake**

Right bank active landslide

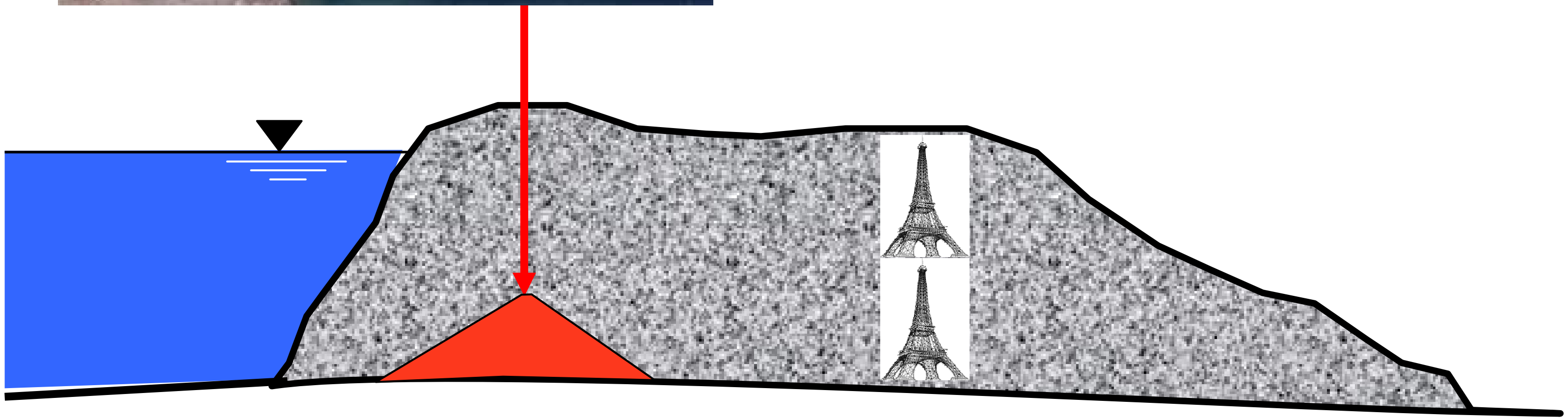


Current rate of movement is ~15 mm/year

How big is Usoi dam?

Bennett dam, 183 m
One of the largest dams in North America

Eiffel tower in Paris



Horizontal scale of Usoi Dam is compressed

Threat and consequences

- Lake Sarez behind the dam currently holds 17 km^3 of water.
- If the dam were to fail, the resulting flood would be a catastrophe of inconceivable dimensions!

NGI

Valleys downstream

Flood waters would flow down the Bartang valley to the Panj River valley and end up in the Aral Sea.

Bartang valley

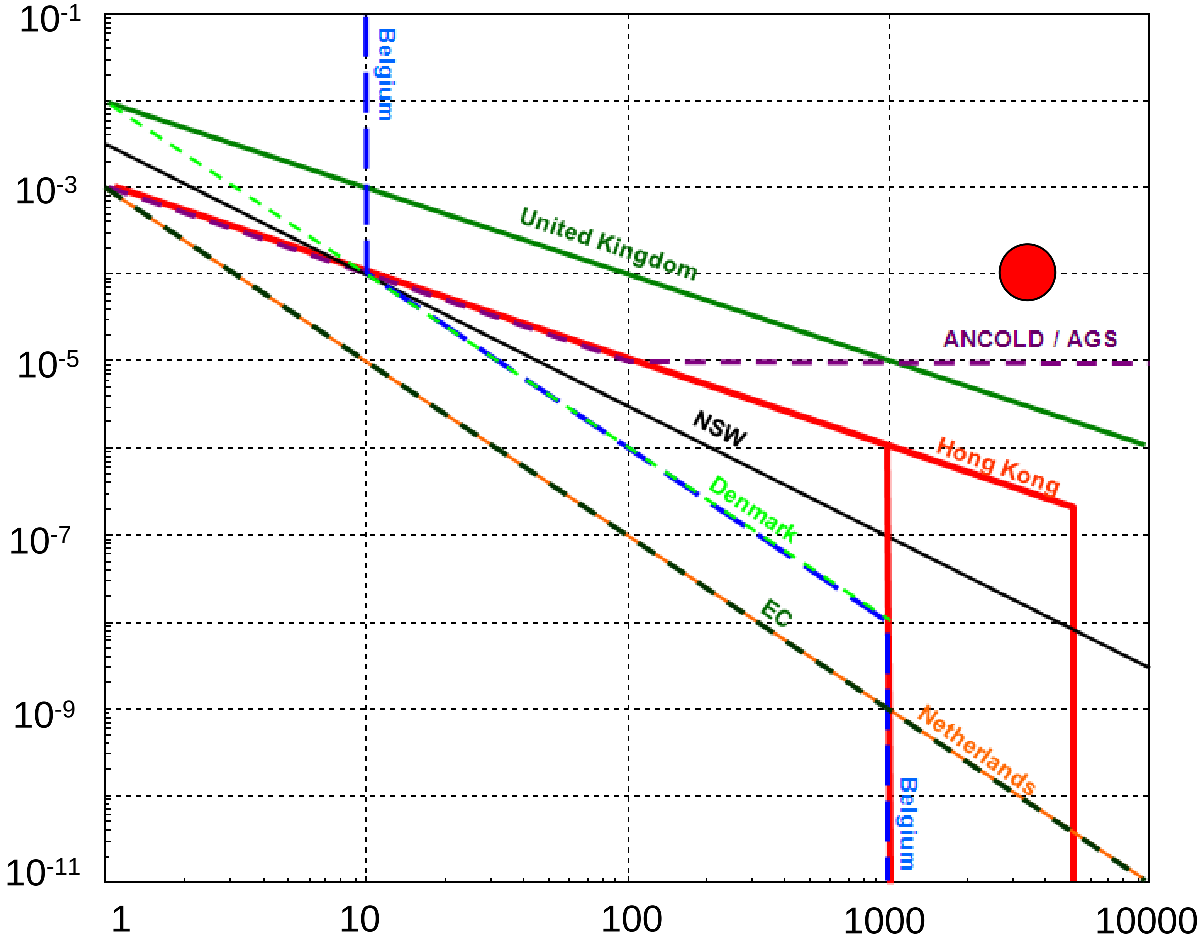
Panj valley between Tajikistan and Afghanistan

Risk with no mitigation measures

Risk diagram

Annual probablility vs number of casualties

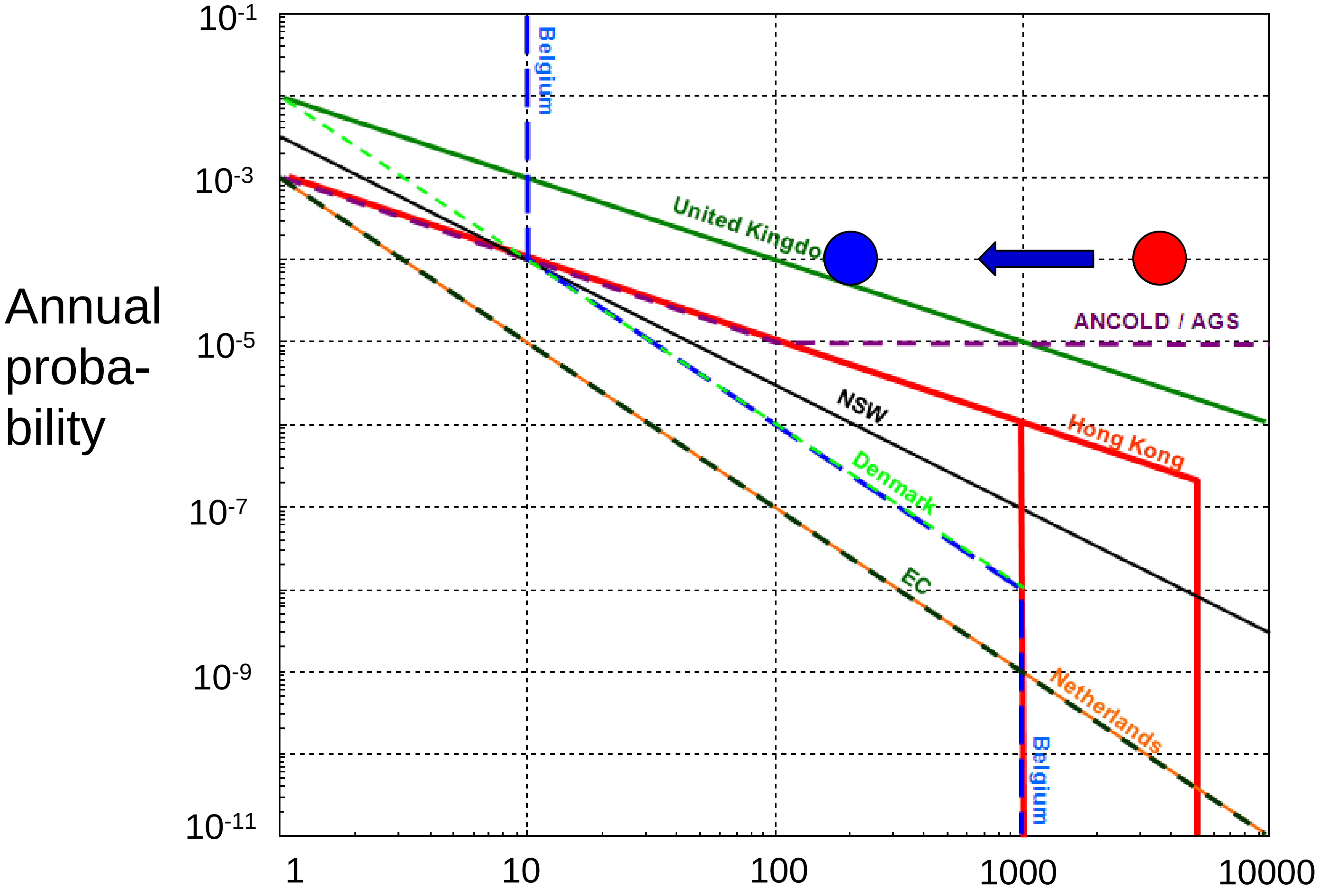
Annual proba-bility



Adding an early warning system (EWS)

Risk diagram

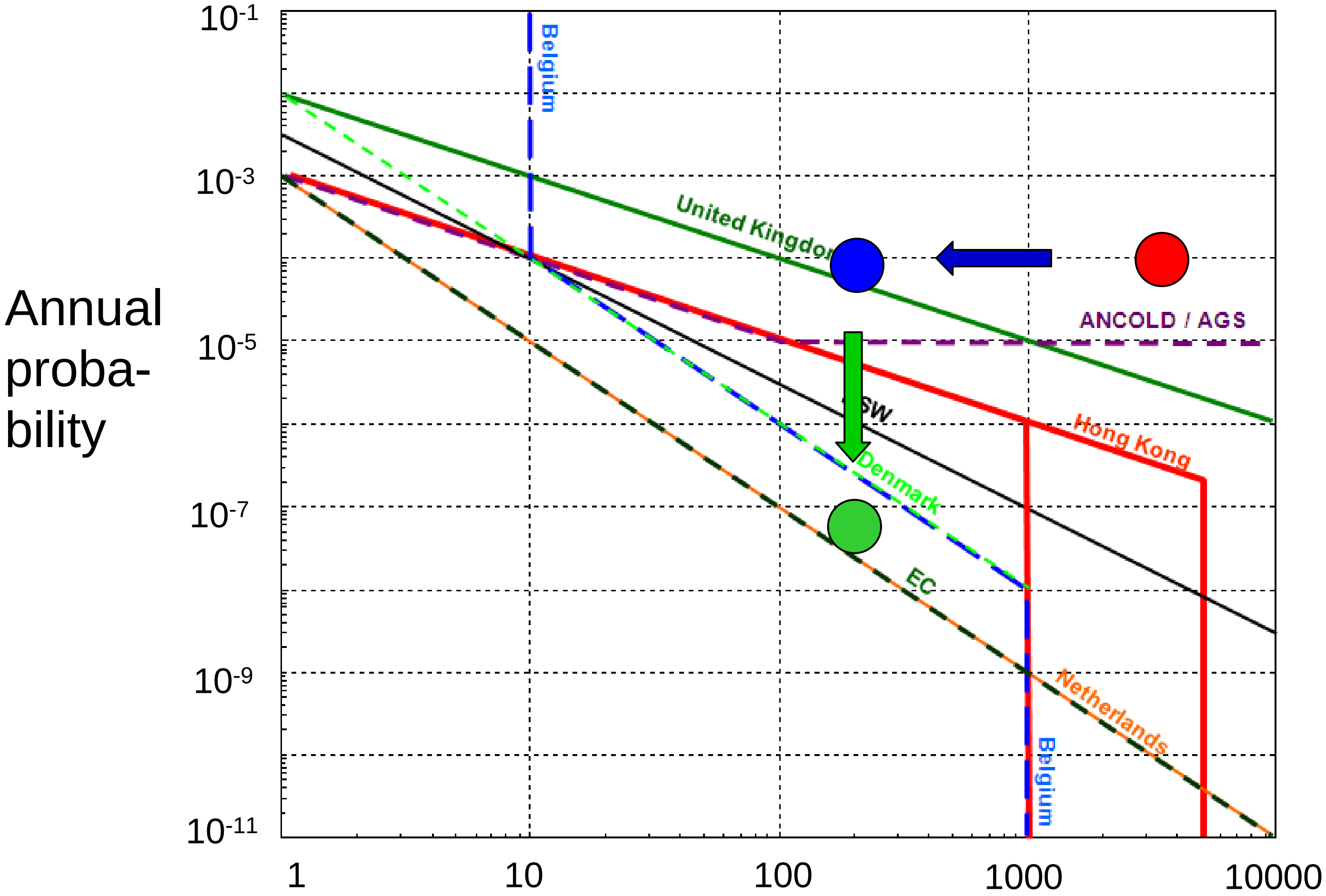
Annual probablility vs number of casualties



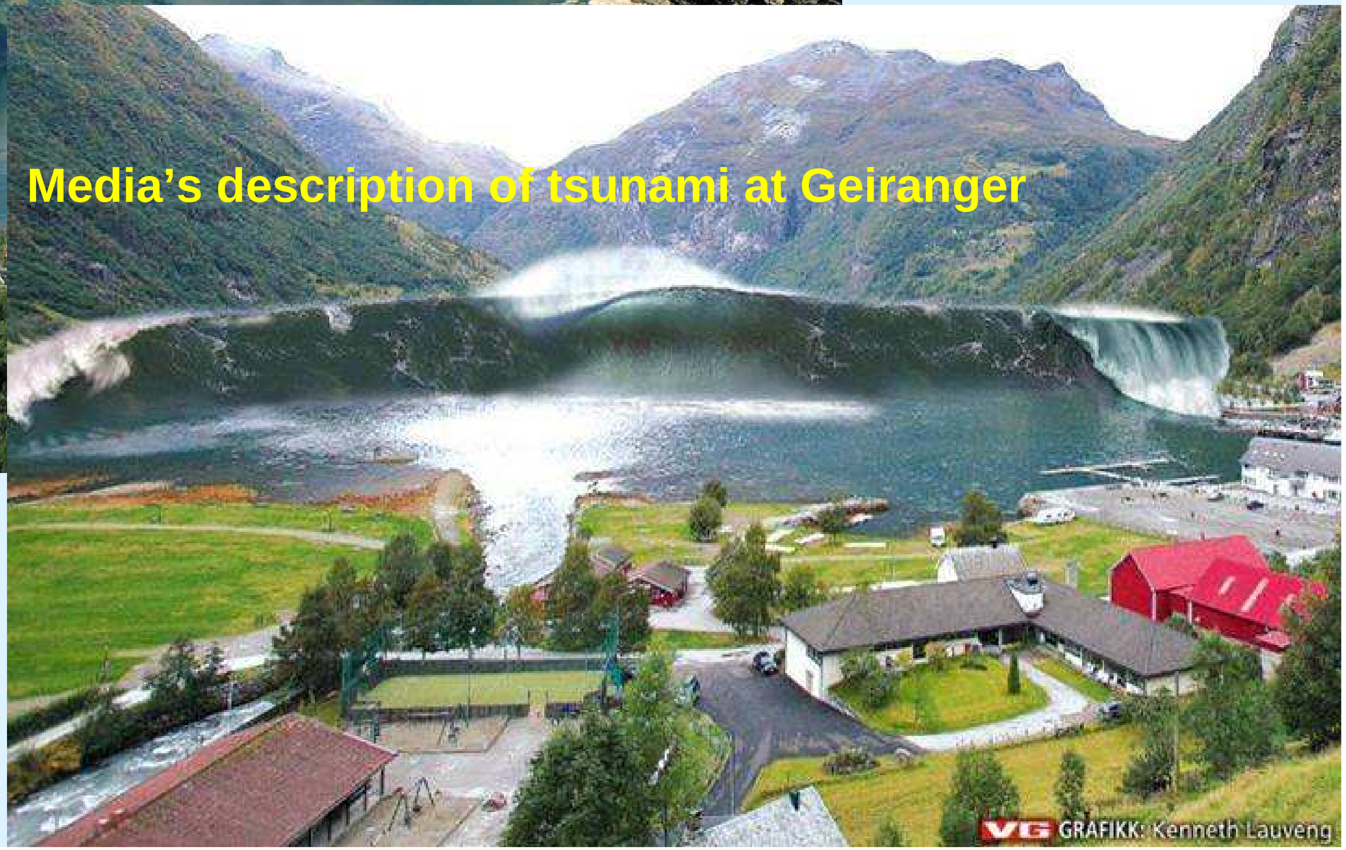
Mitigation with EWS and lowering of reservoir

Risk diagram

Annual probablility vs number of casualties



Media's description of tsunami at Geiranger

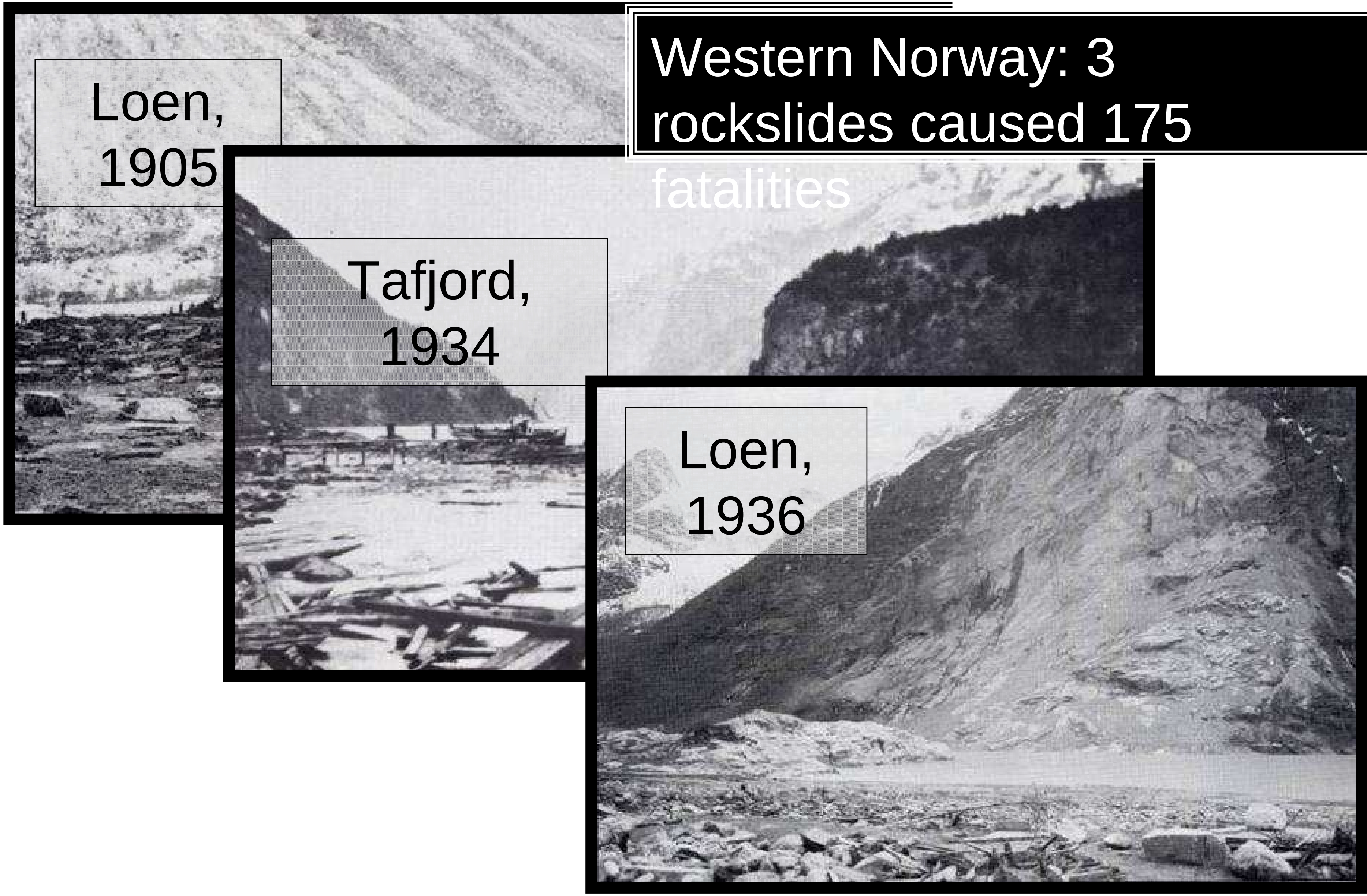


On safe ground

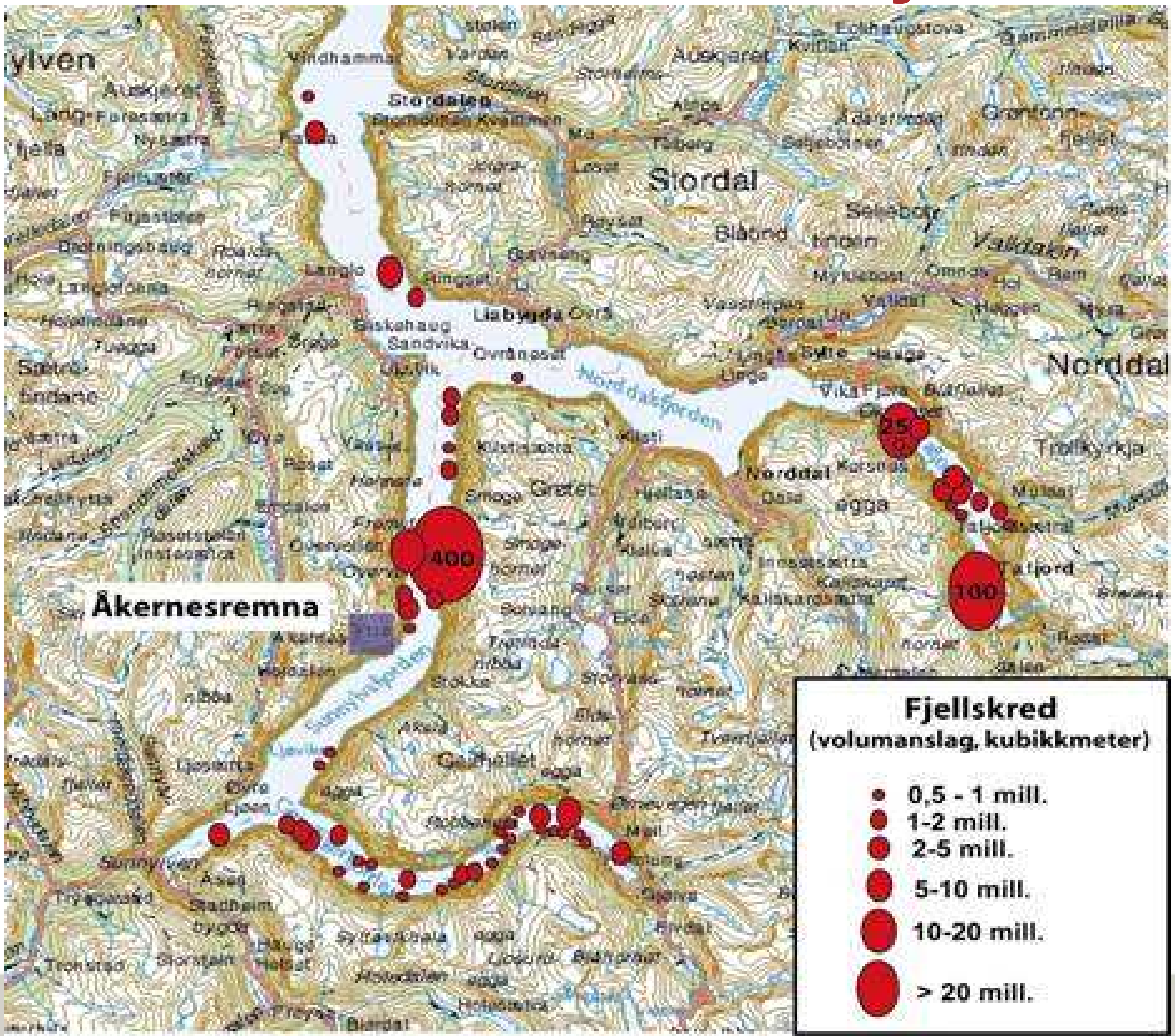
NGI

ICG
International
Centre for
Geohazards

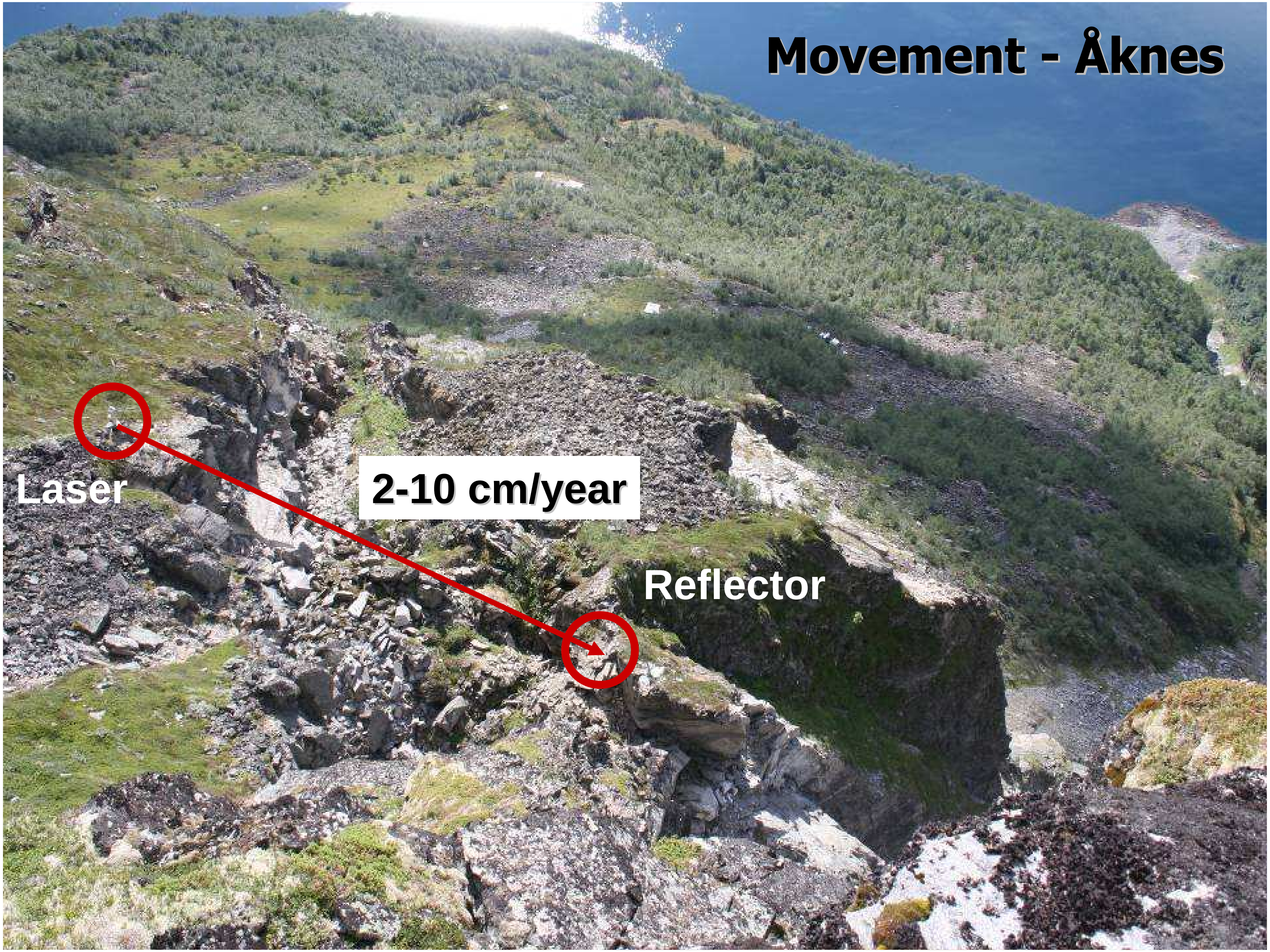
Western Norway: 3 rockslides caused 175 fatalities



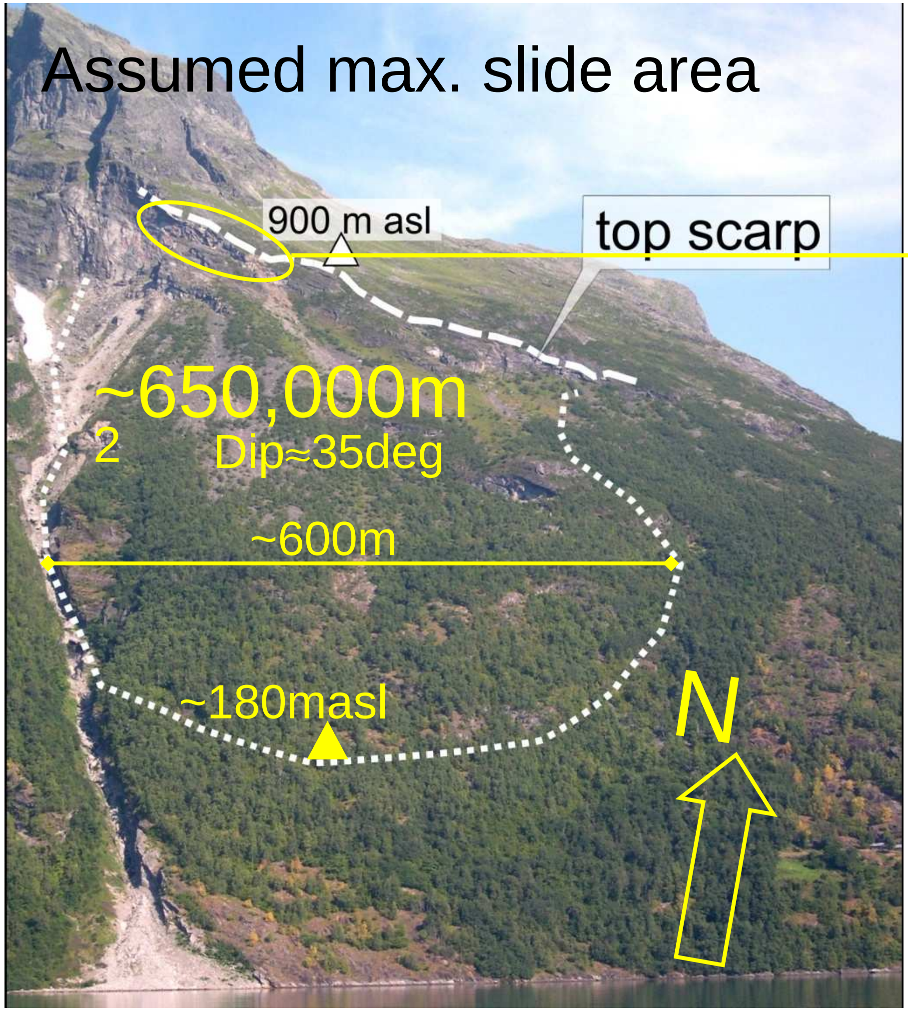
Previous rockslide events in post-glacial times in the Storfjord region

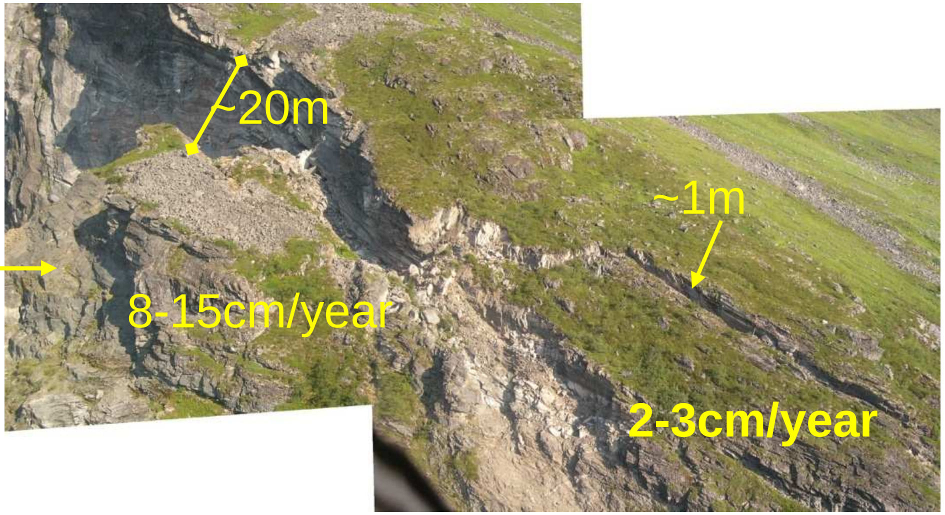


Movement - Åknes

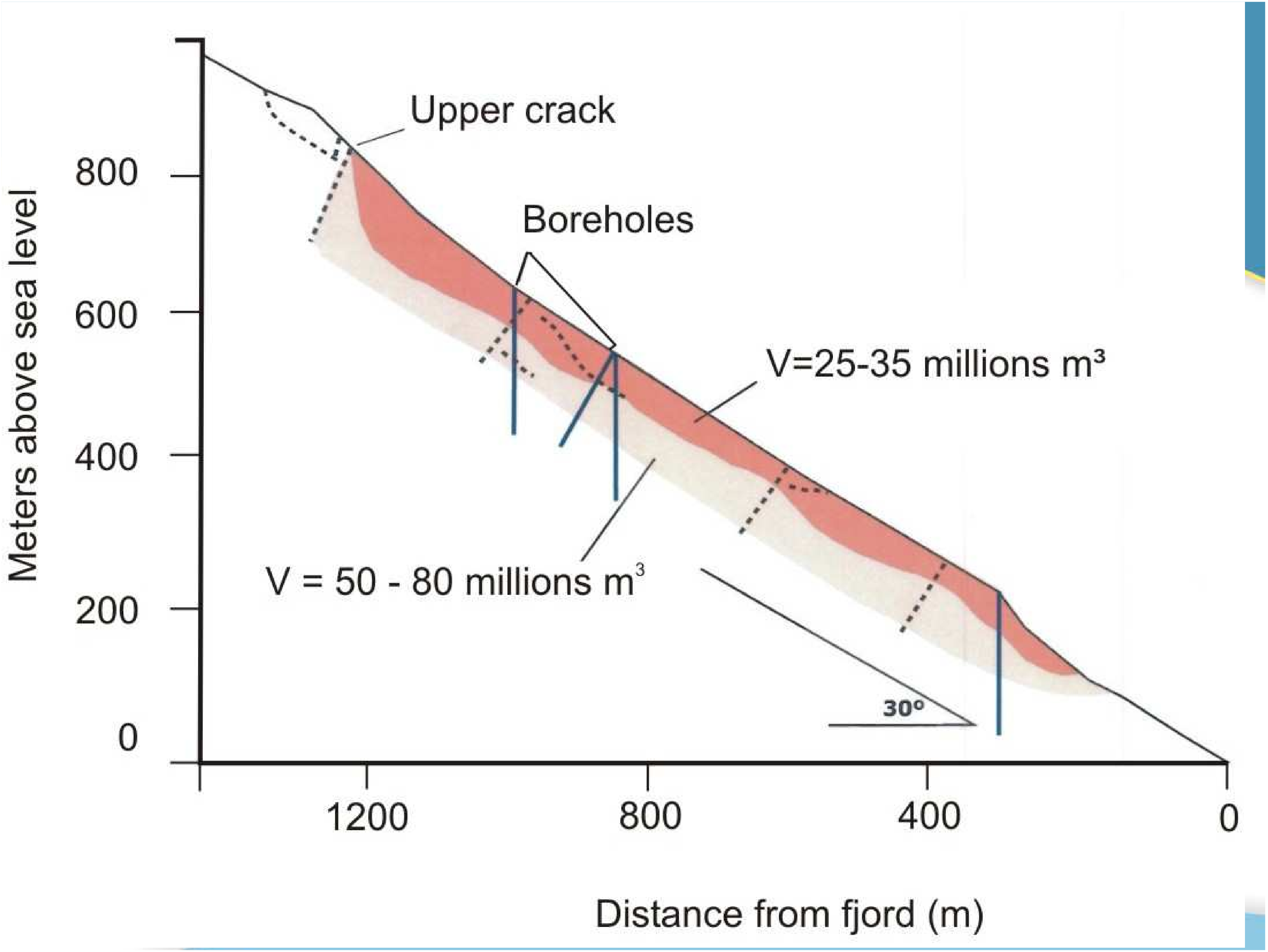


Overview of the Åknes rock slope

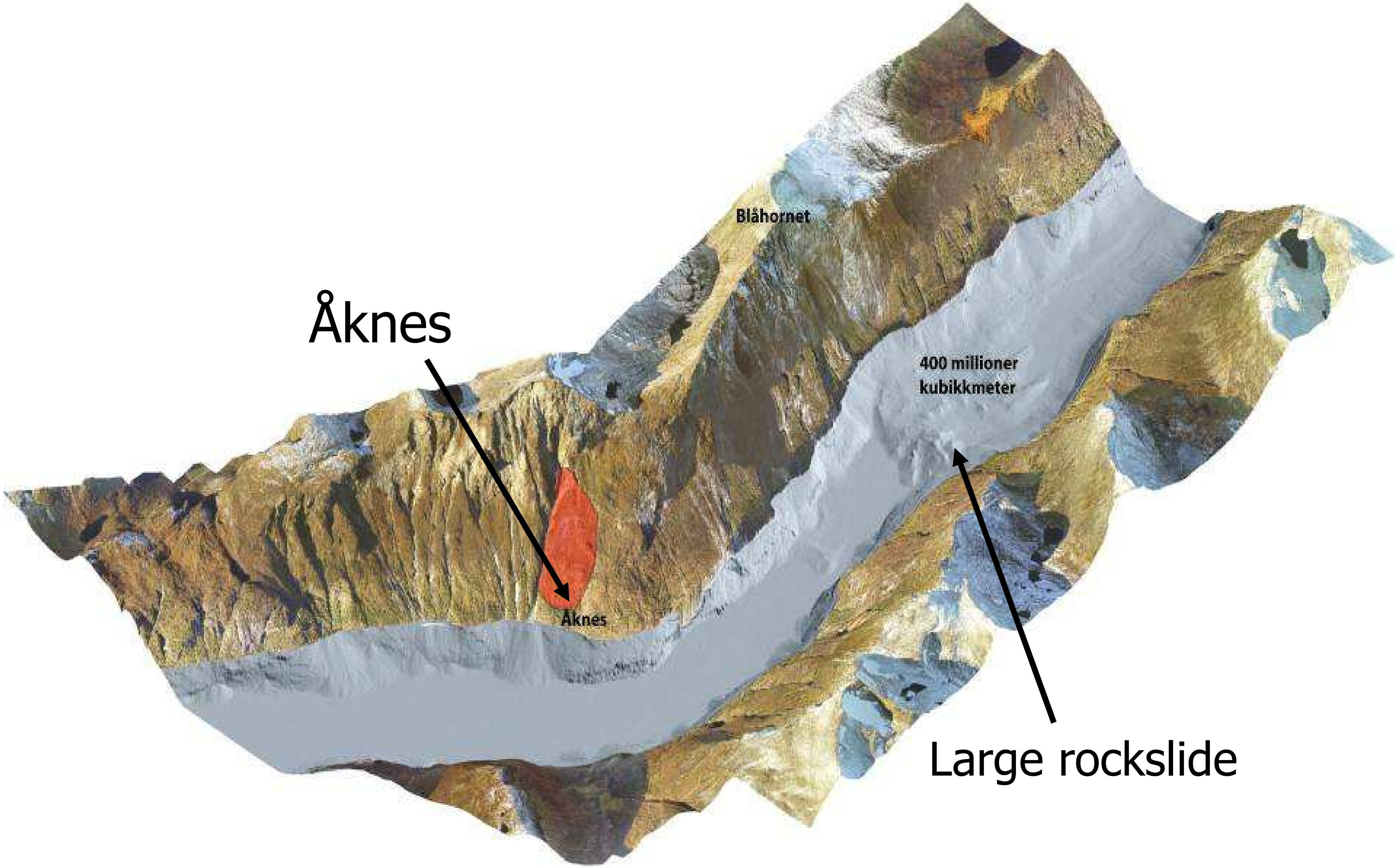




Volume that might fail:
Up to (?) 70 x 10^6 m^3

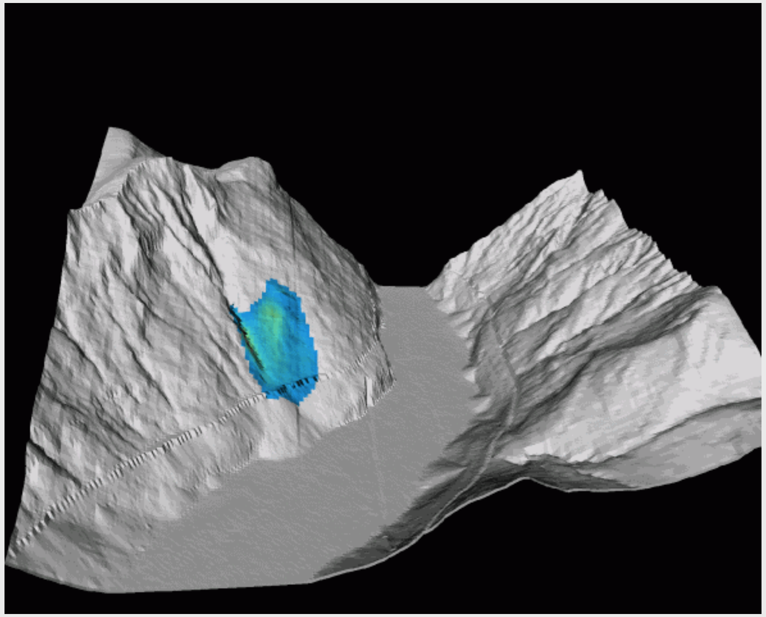


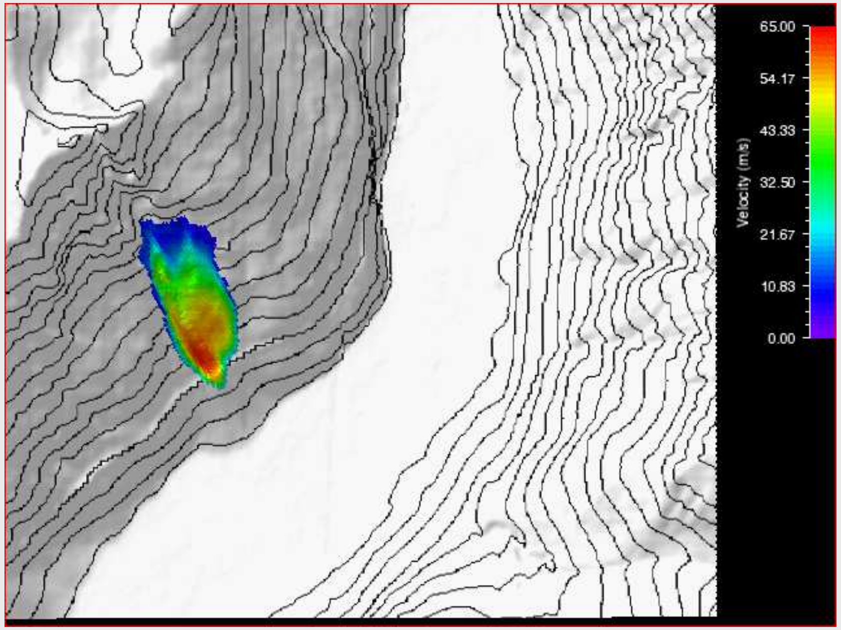
Upper crack
Boreholes
V=25-35 millions m³
V = 50 - 80 millions m³
30°
Meters above sea level
800
600
400
200
0
1200
800
400
0
Distance from fjord (m)

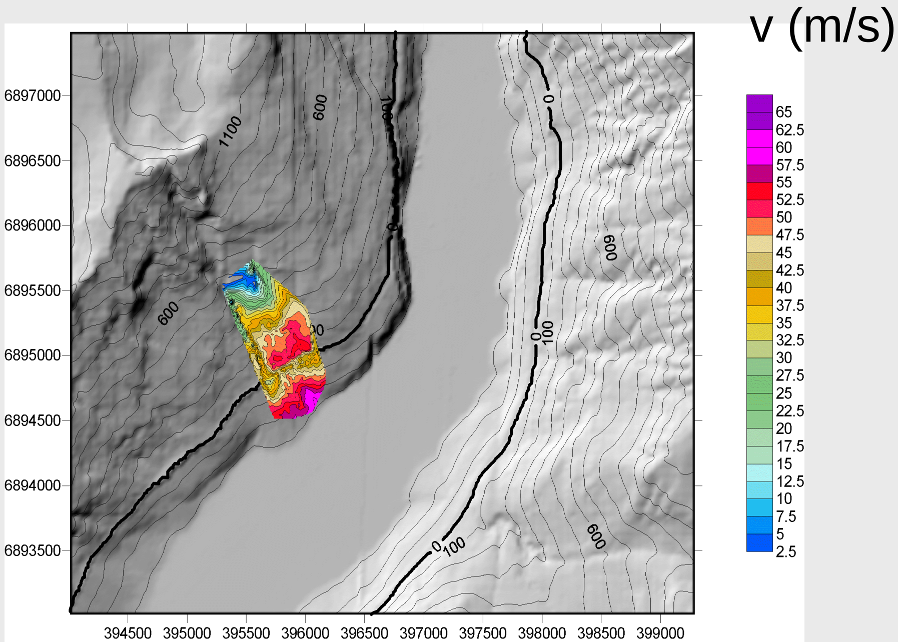

Åknes
Blåhornet
400 millioner
kubikkmeter
Åknes
Large rockslide

Modelling of rock slide

- **TITAN2D** (GMFG Buffalo)
- **DAN3D** (McDougall & Hungr UBC)
- **RAMMS** (SLF)



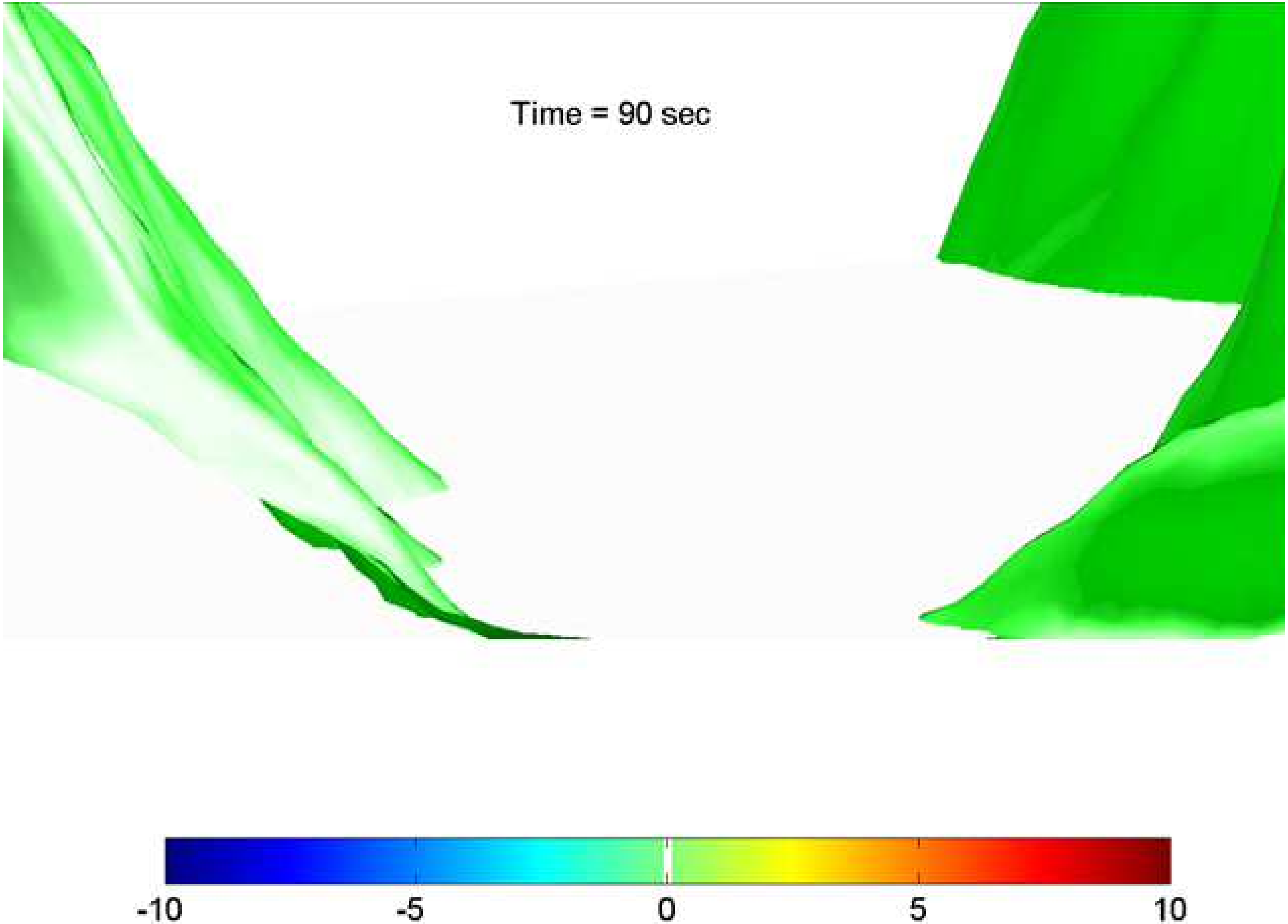




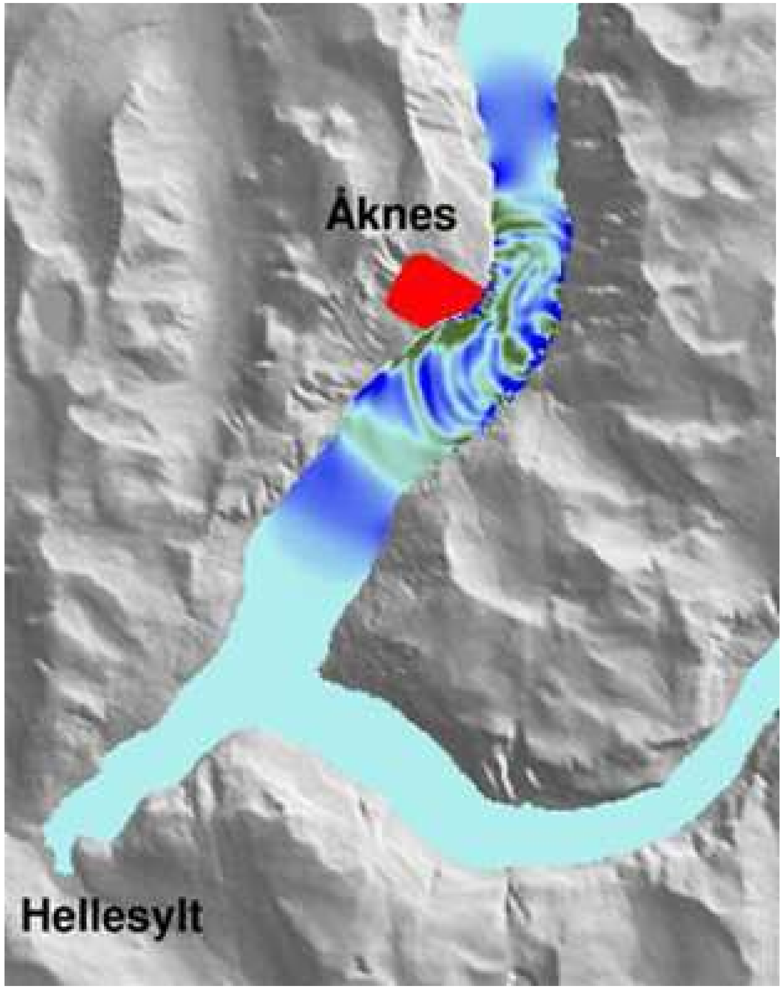
ICG

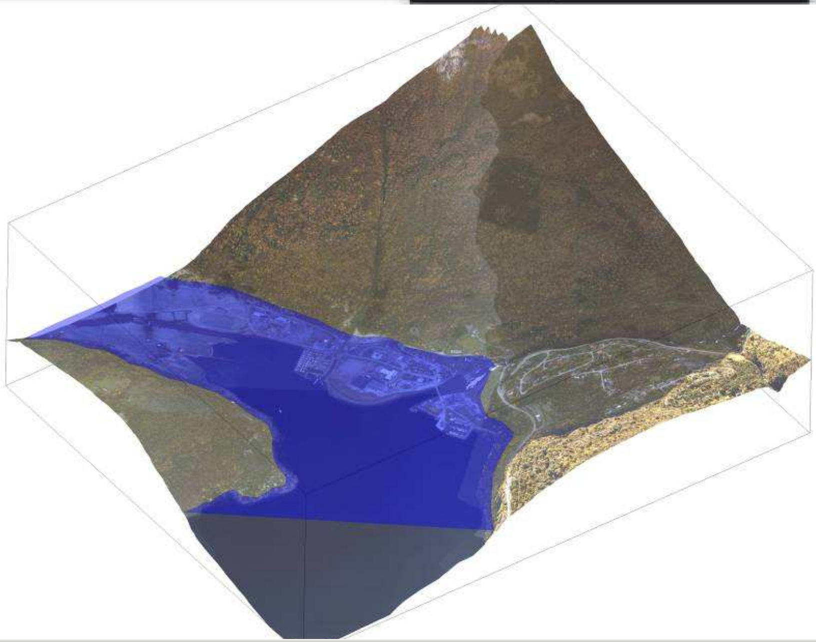
Åknes/Tafjord-prosjektet

NGI


Time = 90 sec
-10
-5
0
5
10

Numernical modelling of generated tsunami





Participatory process
Event tree analyses

- rockslide due to seismic trigger
- rockslide due to high pore pressure trigger
- rockslide due to weathering and creep trigger
- tsunami wave against Hellesylt
- consequences of tsunami
- optimum observations for early warning

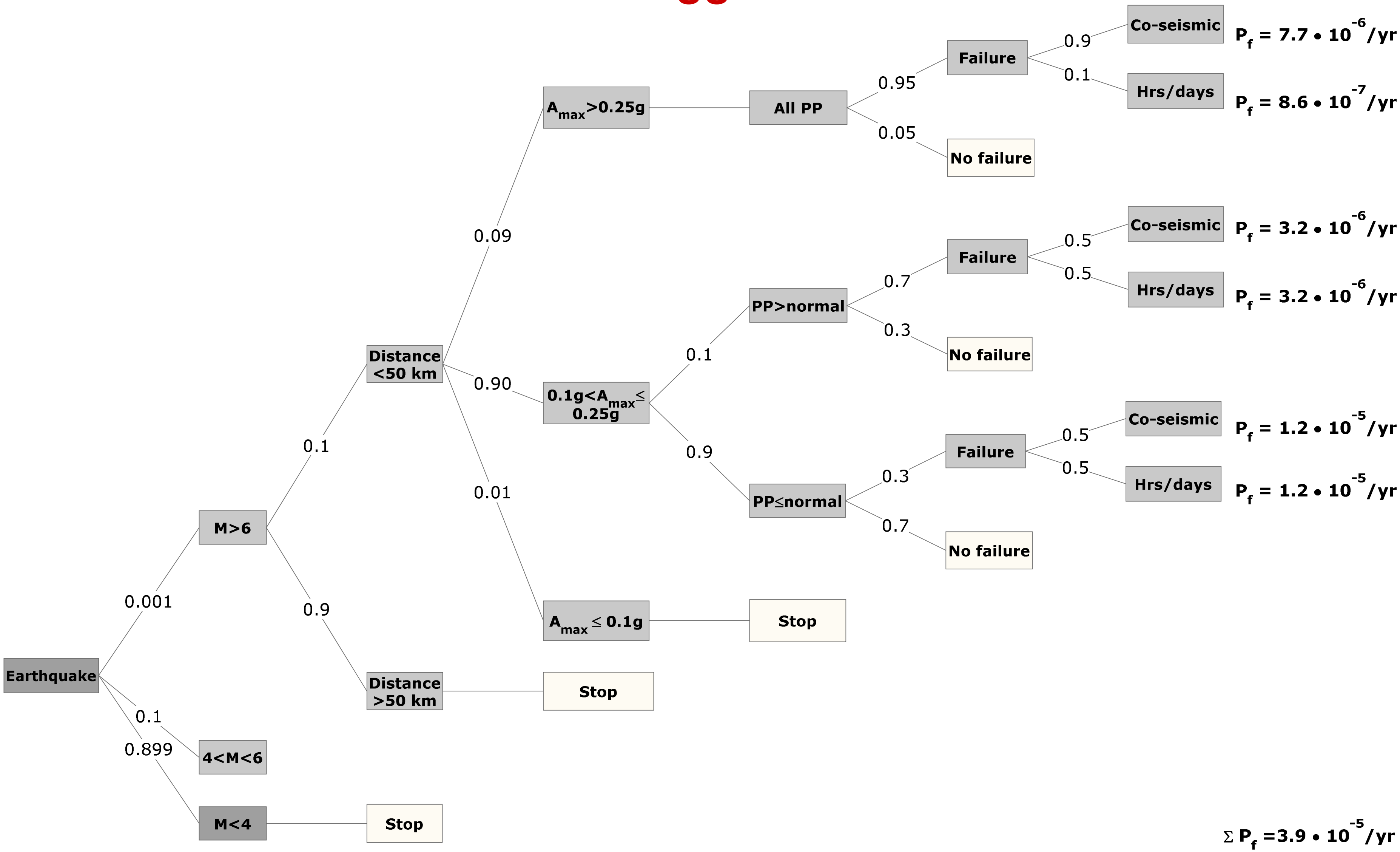
People involved

- manager for Åknes/Tafjord project
- mayor of community
- social scientist from community
- city planner from community
- policeman working on emergency plans and evacuation
- local politician
- representative from community
- journalist/media
- officer from ministry of highways
- directorate for safety and emergency preparedness
- risk analysis specialist
- meteorologist
- physical geographer
- social geographer
- geologist
- engineering geologist
- rock mechanics specialist
- geotechnical engineer
- tsunami specialist
- instrumentation specialist
- earthquake engineer
- seismologist
- mathematician
- statistician

ETA done

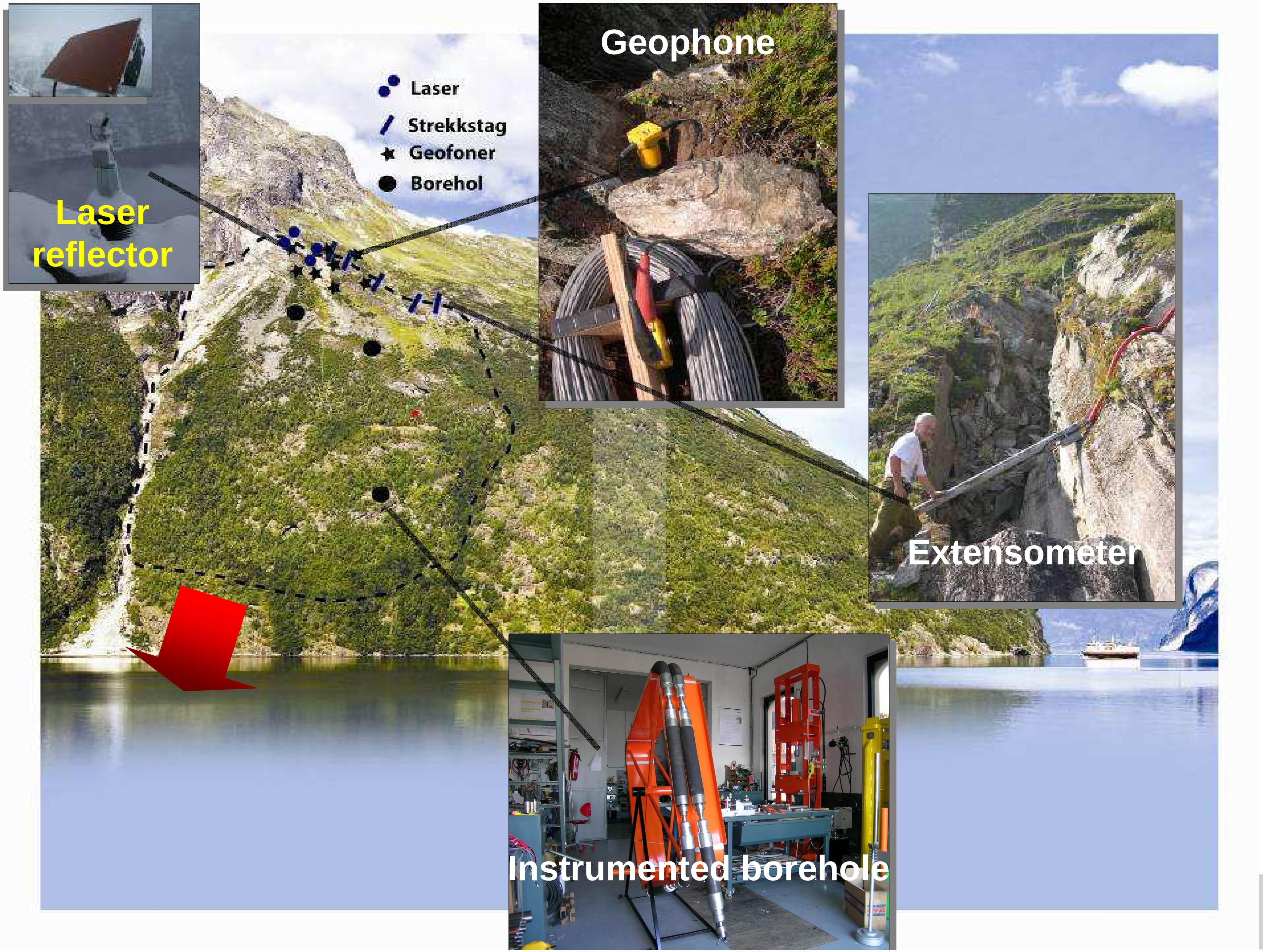
- rockslide due to seismic trigger
- rockslide due to high pore pressure trigger
- rockslide due to weathering and creep trigger
- tsunami wave against Hellesylt
- consequences of tsunami
- optimum observations for early warning

ETA
Rockslide due to seismic trigger



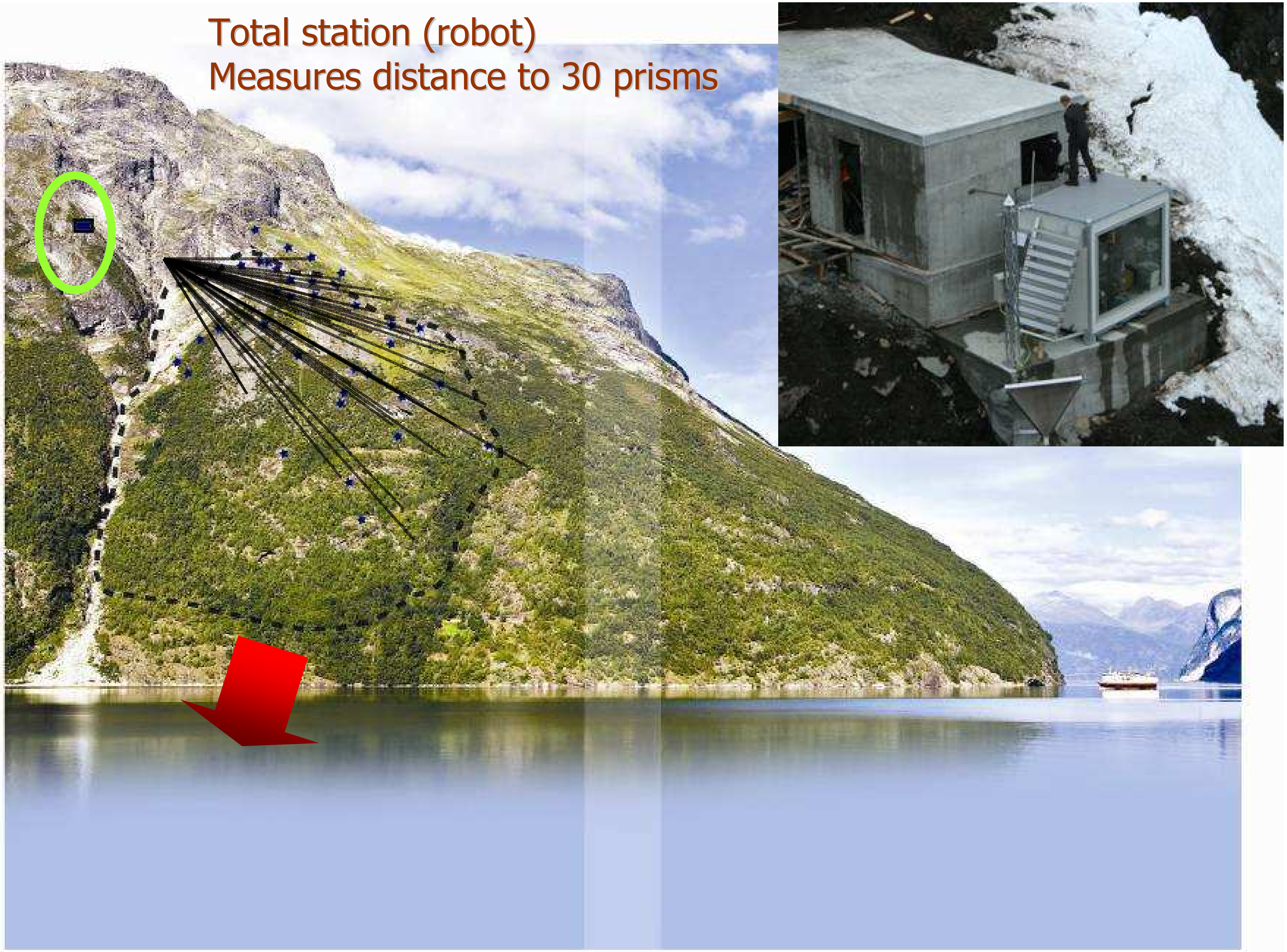
Resulting run-up heights
if P_f (slide occurred) = 10^{-3} /yr

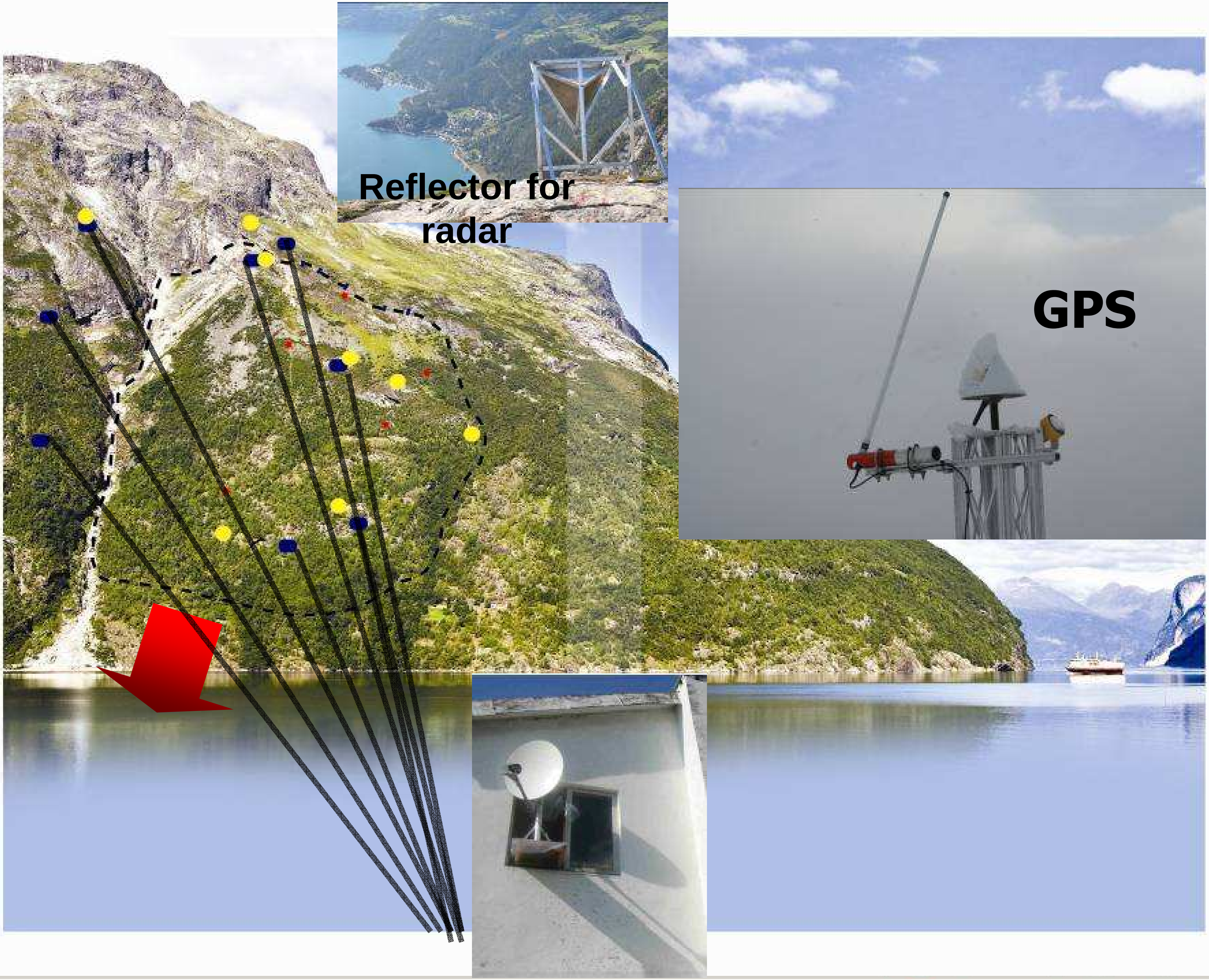
Run-up height ≤ 5 m	Run-up height > 5m; ≤ 20 m	Run-up height > 20 m
$P = 3 \times 10^{-4}$/yr	$P = 5 \times 10^{-4}$/yr	$P = 1 \times 10^{-4}$/yr



Laser reflector
Geophone
Laser
Strekkstag
Geofoner
Borehol
Extensometer
Instrumented borehole

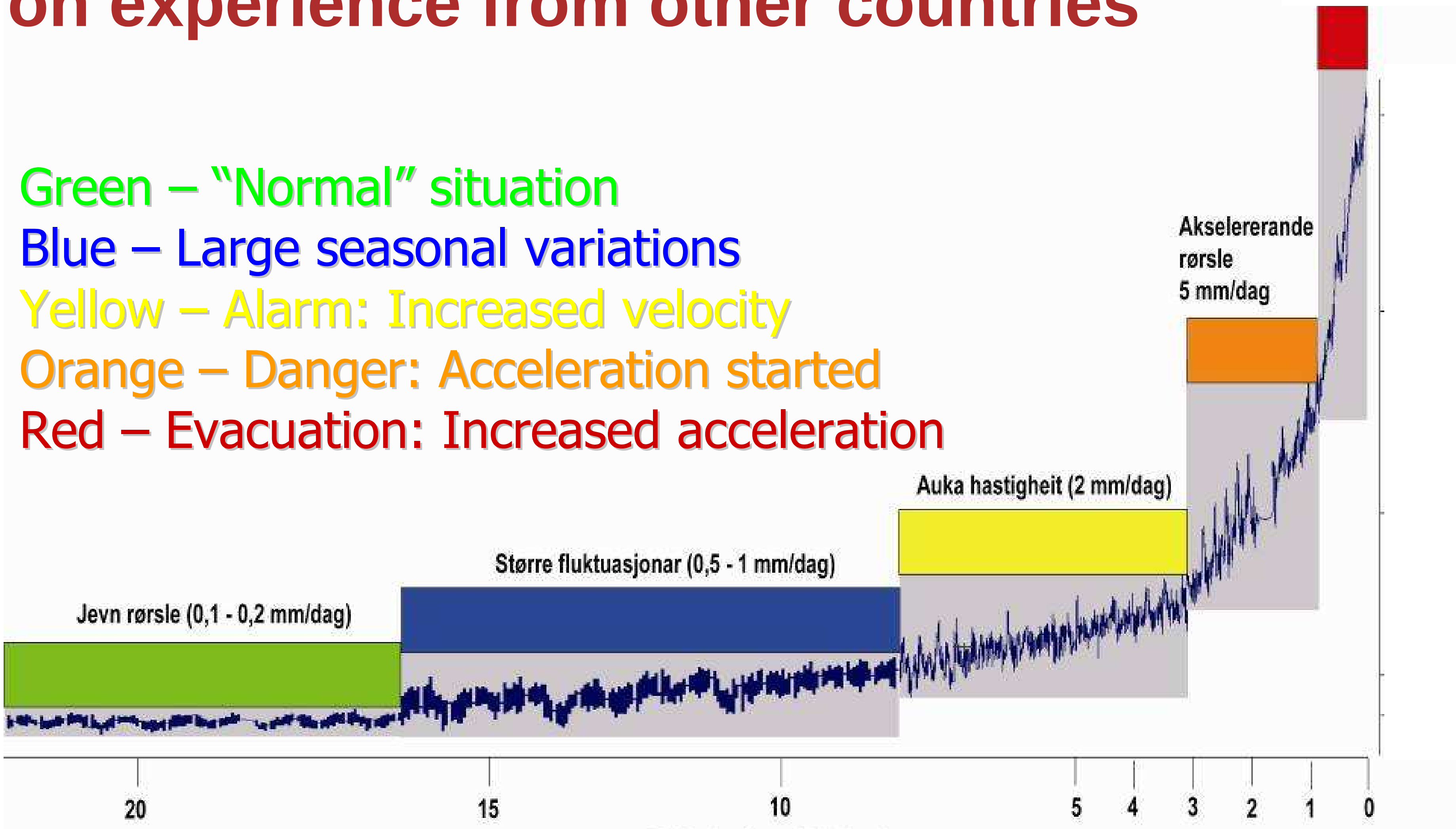
Total station (robot)
Measures distance to 30 prisms




Reflector for radar
GPS

Åknes: Preliminary threshold values based on experience from other countries

Green – "Normal" situation
Blue – Large seasonal variations
Yellow – Alarm: Increased velocity
Orange – Danger: Acceleration started
Red – Evacuation: Increased acceleration

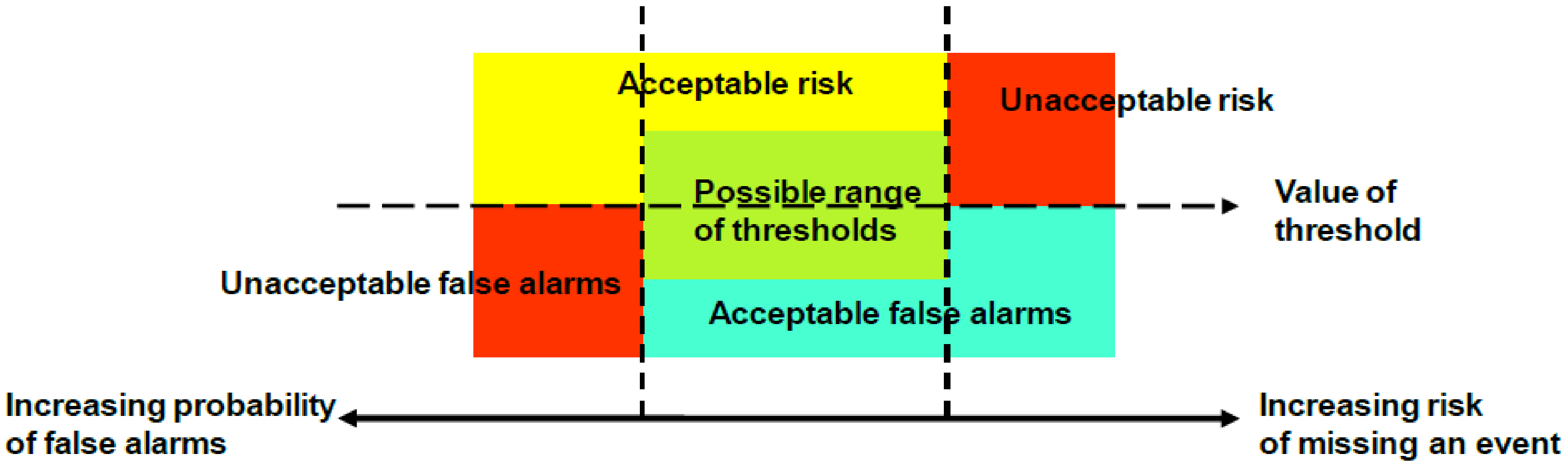


Time before rockslide (weeks/days)

Two major problems with EWS: False alarms and missed events

- One of the most difficult problem in designing an EWS is the specification of proper threshold values for the alarms.

- Avoiding false alarms and missed events. The consequences of false alarms and missed events are often so serious that every possible action must be taken to avoid them.



Emergency plans have been prepared and tested

- Deal with the two situations: (i) high rock avalanche has occurred
- Responsibility, organization and du
- Where to evacuate fro
- Special emergency pla institutions (e.g. hospit private companies

Slope safety: public awareness in Hong Kong

Public Education Initiatives in Hong Kong

“Slope and Home Safety Programme”, jointly w/ HK Red Cross

- TV and Radio Announcements of Public Interest

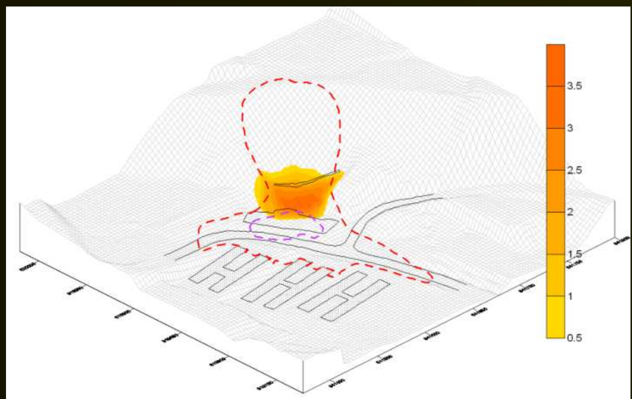
Visit elders at squatter huts

NGI

Public Education to secondary school students

Webpage.

3D animation on 1972 and 1976 landslides



Don’t imprint on the public a false sense of security

Remind the public to stay vigilant about landslide danger

Plan de la conférence

- Management du risque
- Hazard[1], vulnerabilité et appréciation du risque
- Traitement du risque
- Conclusions

Exemples

[1] Phénomène dangereux

NGI

ICG International Centre for Geohazards

L’estimation et la prédiciton du risque

Prediction ?

Berlin, 1919, “The World in 100 Years” – Predicting the life in the “Colonies”

“The citizens of the wireless age will walk everywhere with their RECEIVER, which will, despite its smallness, be a wonder of miniature mechanics. ... Kings, diplomats, bankers, officials and directors, will make their business and give their signatures where ever they are, on the top of the Himalayas or on a beach…”

Concluding Remarks

- Les analyses du risque (quantitative ou qualitative) sont utiles, surtout pour comparer les alternatives et prendre une décision sur la nécessité et les coûts requis pour réduire les risques.
- Le traitement du risque: réduire les hazards, et/ou réduire la vulnérabilité.
- La vulnerabilité, qui plus en plus intéresse la gouvernance: complexe, appartient à plusieurs disciplines et présente des défis de communication.
- Les méthodes de réduction du risque optimales: un balancemet entre le technique et considerations politiques, sociales, etc; amener l'ingenieur civil, le géoscietifique et les experts des sciences sociales et humaines sur une même longueur d'ondes.

Notre rôle

Hazards naturels et hazards anthropogéniques: apprendre à vivre avec ces hazards est la seule option car le risque ne sera jamais nul. L'on peut vivre avec les hazards, mais il faut savir que le risque est réduit à un niveau accetable ou tout au moins tolérable.

Notre profession doit contribuer à la prévention,
de sorte que les phénomènes dangereux (hazards)
ne puissent devenir des désastres:
les hazards sont le plus souvent incontournables,
les désastres ne le sont pas.

Notre rôle

Un besoin grandissant d'adresser les hazards et prendre des décisions informées sur les moyens de réduire les impacts.

Un besoin de réorientation: de la réponse par après à la prévention et au traitement du risque, à l'augmen-tation de la résilience et réduction du risque, et au recours à l'expérience pour éviter les erreurs du passé.

Notre profession doit se faire reconnaître comme

"réduisant le risque et protégeant les persones"

Un grand merci pour ce grand honneur,

et pour votre attention!