United States Nuclear Waste Technical Review Board

International Workshop on Siting of Radioactive Waste Facilities
29 August 2023

Site selection in Switzerland

A summary of factual information, combined with my personal interpretation

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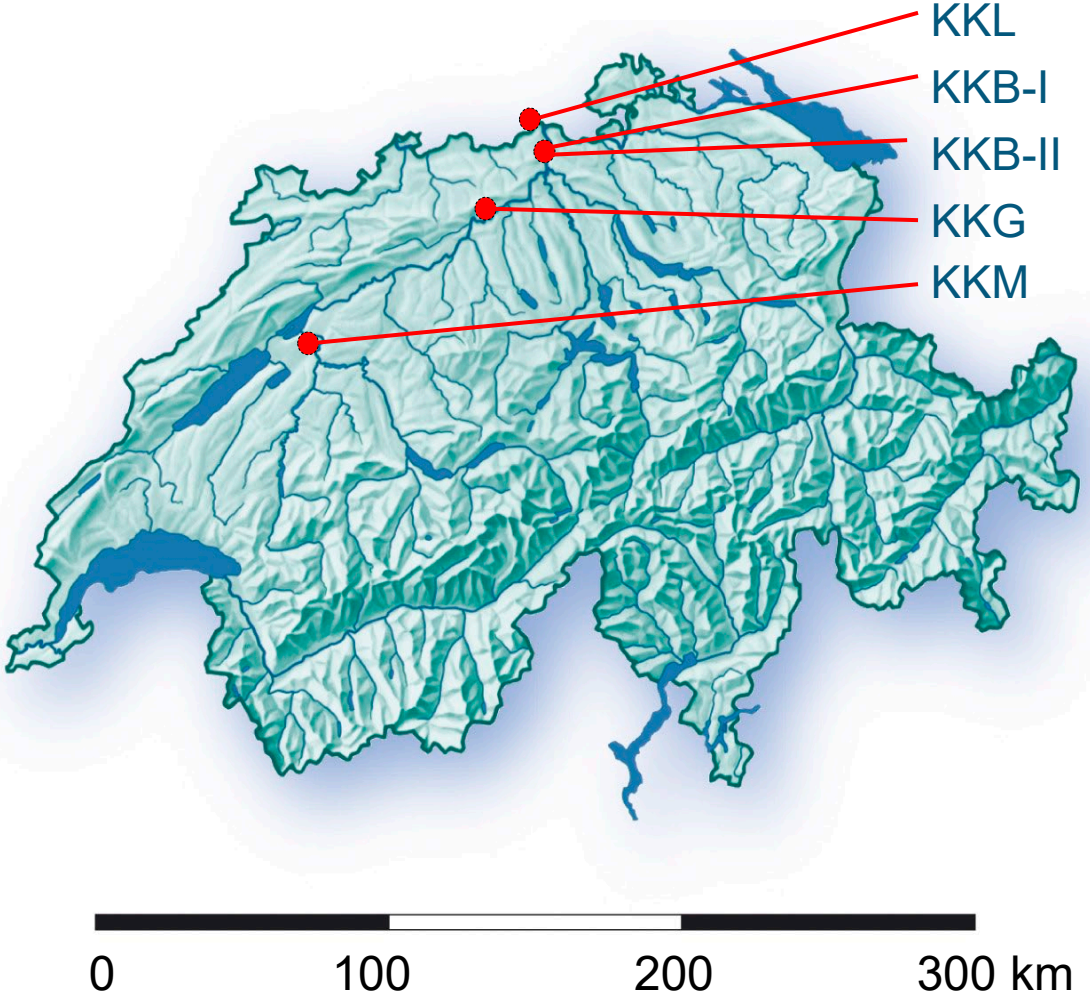
(former Director Science & Technology Nagra)

Nuclear Power in Switzerland



5 Nuclear Power Plants (3333 MW_e)

KKL	Leibstadt	(1984)	1220 MW_e
KKB-I	Beznau	(1969)	365 MW_e
KKB-II	Beznau	(1971)	365 MW_e
KKG	Gösgen	(1979)	1010 MW_e
KKM	Mühleberg	(1972)	373 Mw_e

Mühleberg shut down in 2019

'Starting point': Swiss disposal programme 1978

- Start of NPP in 1969
- HLW: spent fuel → reprocessing (F, UK) → no urgent need to manage SF
- But: return of waste → HLW repository needed → HLW disposal discussed (utilities, government, parliament, …)
- Concept proposal developed by industry
- Swiss government decision (1978): stepwise approach → 1st step: *demonstration of disposal feasibility* (with 'real data') for continuing with NPPs
- The start of a technical-scientific program by utilities → Nagra-mandate for all wastes (government-set milestone: 1985)
  - Waste inventory
  - Geological siting possibilities → fieldwork: seismics, boreholes → synthesis
  - Design concepts
  - RDD (studies, lab work, URL in Grimsel)

Swiss programme: Stepwise approach to site selection

… falling into two phases (with the 2nd phase initially not yet foreseen)

- **Demonstration of disposal feasibility** (L/ILW: 1988, SF/HLW: 1988 / 2006)
  - … as a pre-requisite for continuing with NPPs → start of programme in 1978
  - … required the building of a team with the needed competences, some infrastructure (labs, URLs) & acquisition of geological information
  - … allowed to build-up a sound scientific basis (team, infrastructure, know-ledge on siting possibilities → **proposals** & corresponding design options)

- **Site selection** ('Sectoral Plan'; started in 2008) in 3 phases, covering …
  - Science & technology (geology, safety, repository concepts, …)
  - Societal involvement

  General license (site announced ~ 2024, political process ~ 2030)

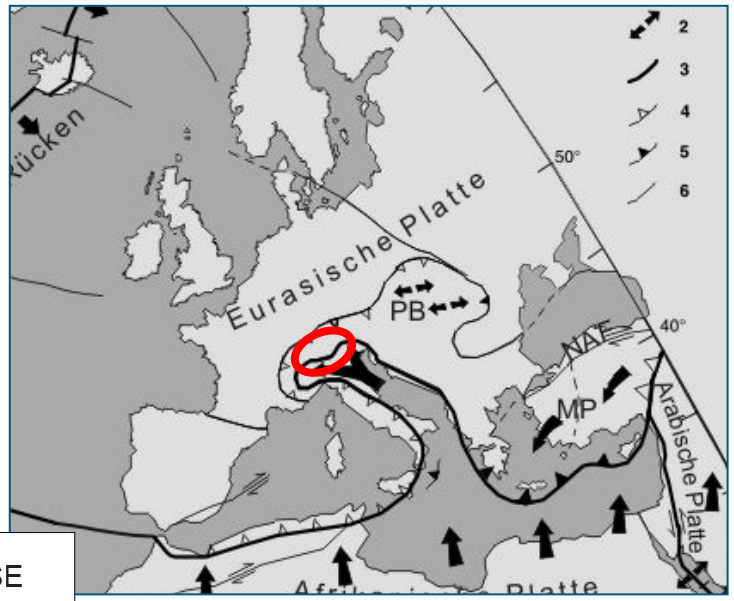
- Construction license (HLW ~ 2050)
- Operation license (HLW ~ 2060)
- License for closure

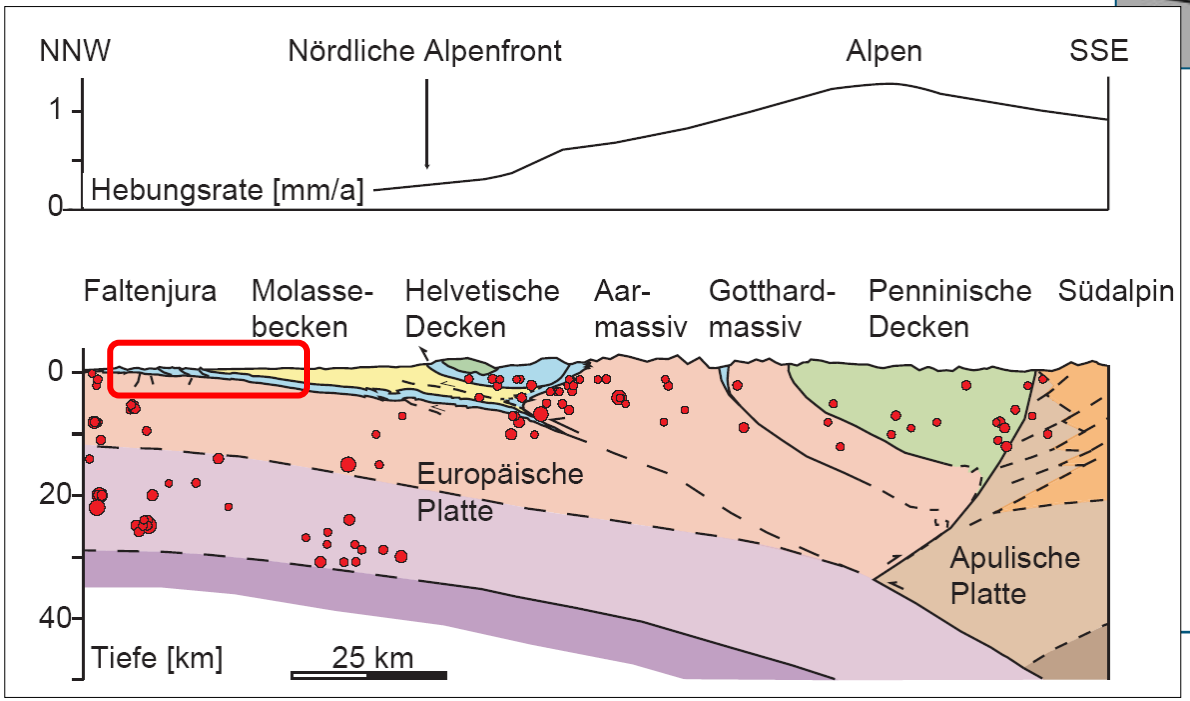
Switzerland: Plate tectonics – situation

Switzerland: Geological and tectonic environment

Complex geology

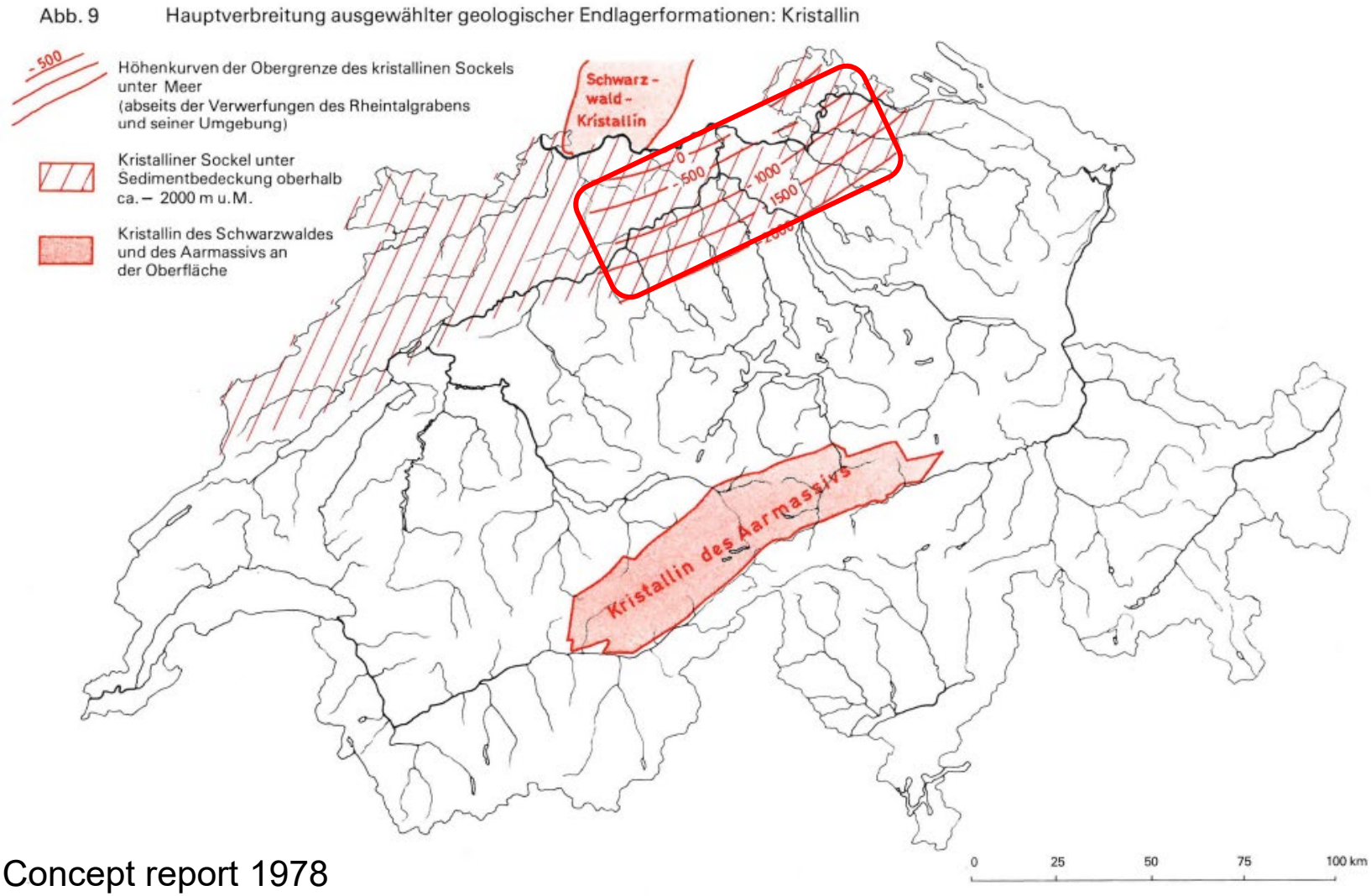
- Alps (erosion (incl. continuing uplift); glaciation)
- Differences in neotectonic activity (more quiet in Northern Switzerland)
- Broad range of (host) rocks, but: Molasse basin (→ suitable rocks too deep in the south)
- → HLW siting region: Northern Switzerland





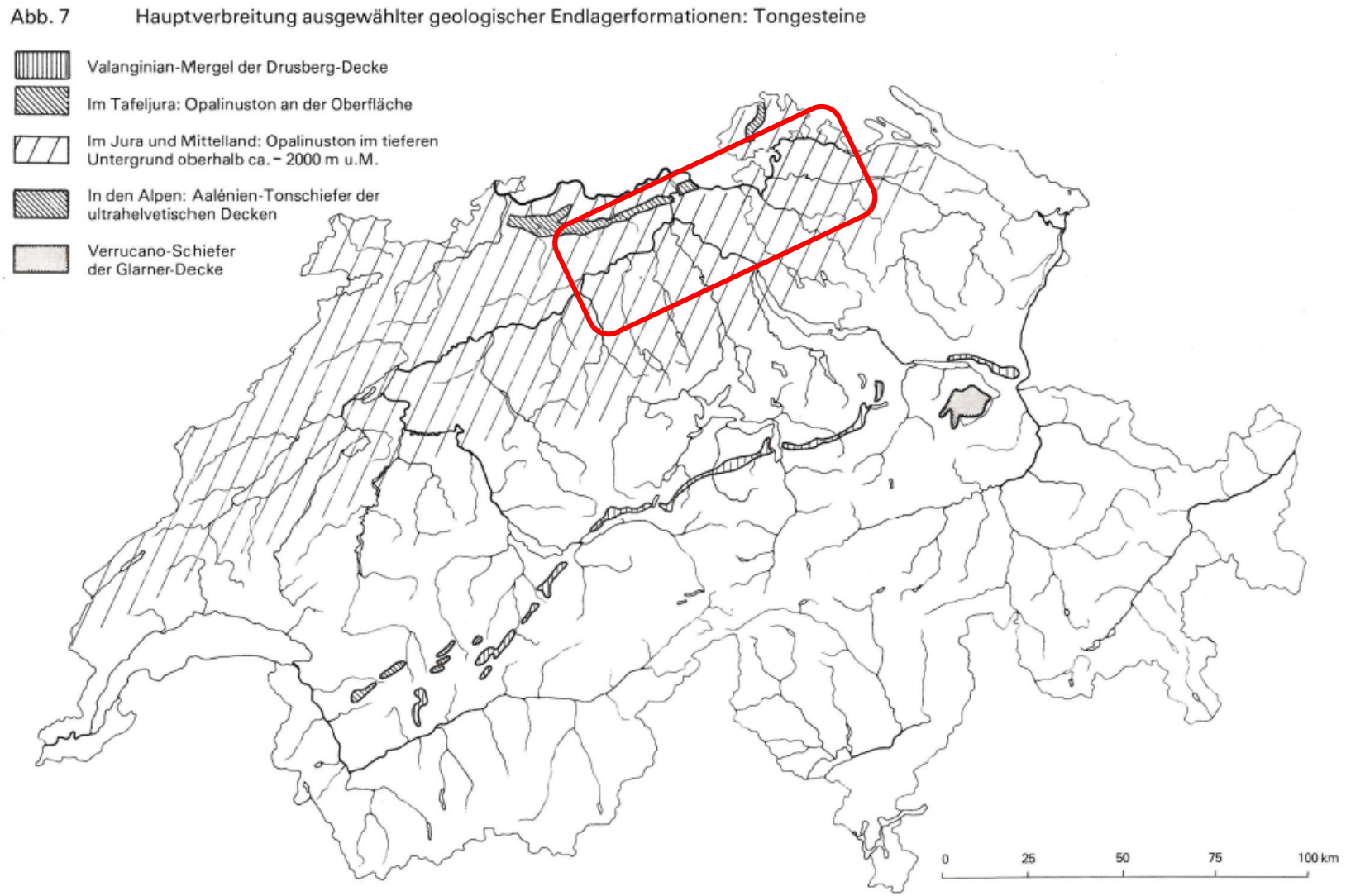
North - South cross-section

Potential host rock: Crystalline basement (for HLW)



Concept report 1978

Potential host rock: Opalinus clay (for HLW)



Concept report 1978

Crystalline Programme: Drilling rig 'Weiach' (early 80-ies)

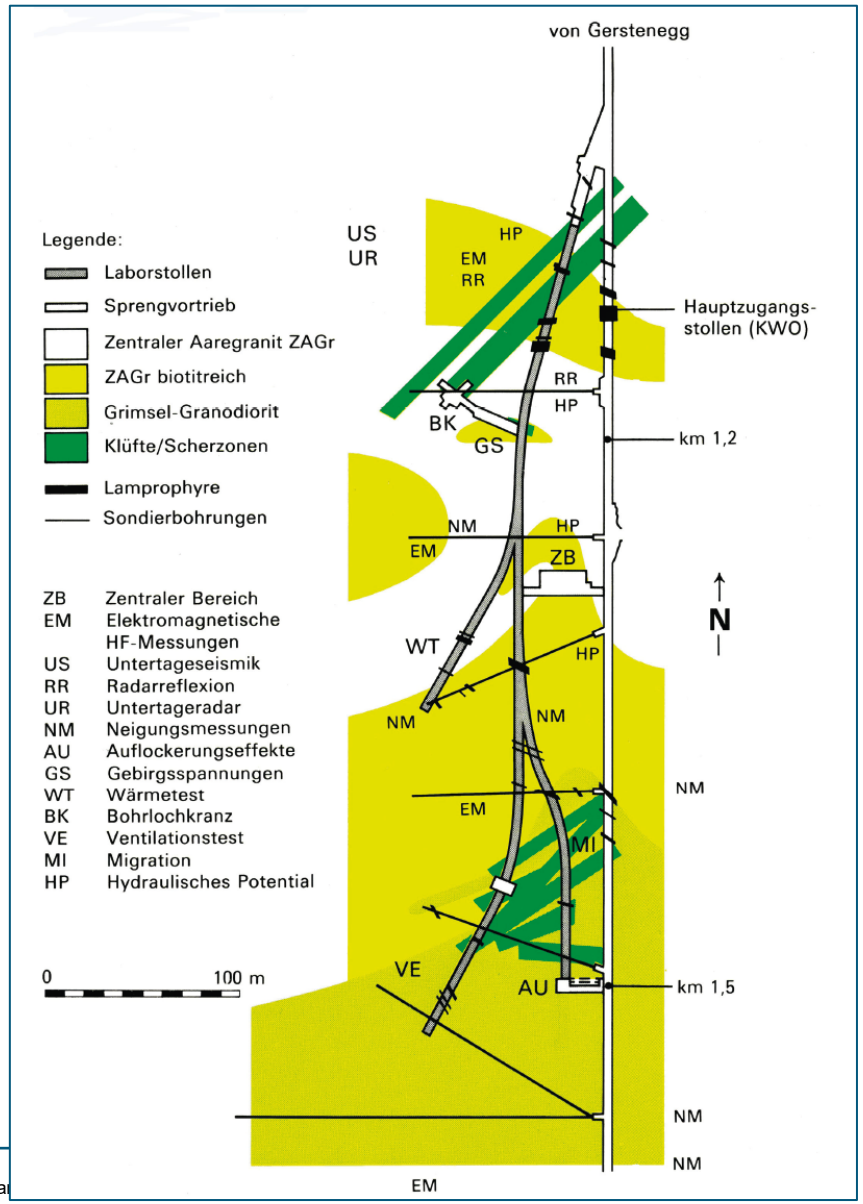
Today's rigs are much smaller

Start of Grimsel Test Site (underground rock laboratory)

Excellent platform …

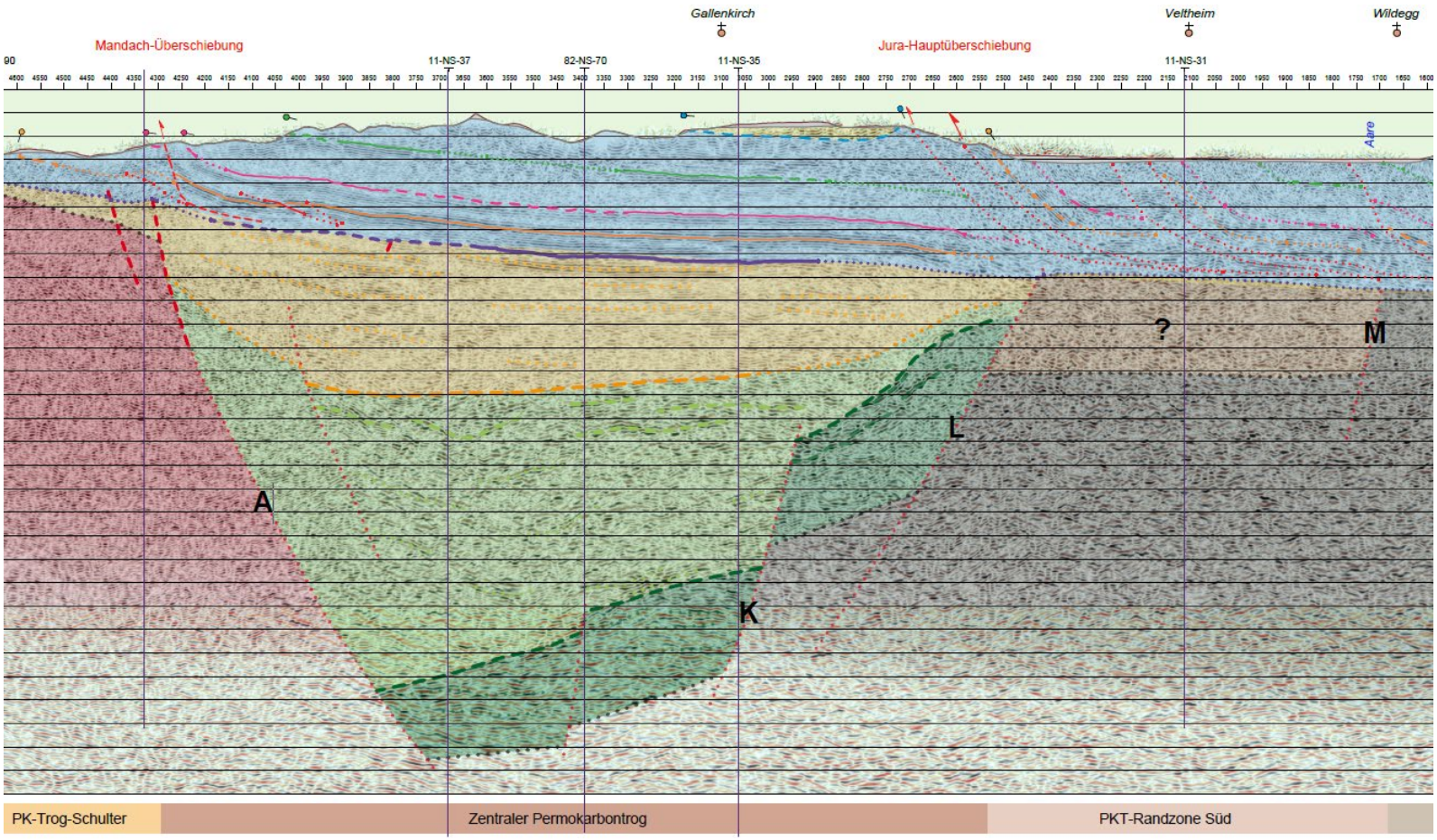
- for science and technology
- broad international participation
- interaction with society

… evolved over time!



A big surprise: Permo-Carboniferous troughs

Recent interpretation (with boreholes)

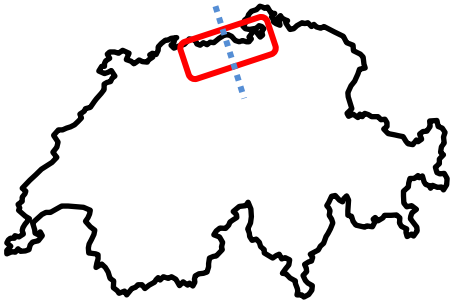


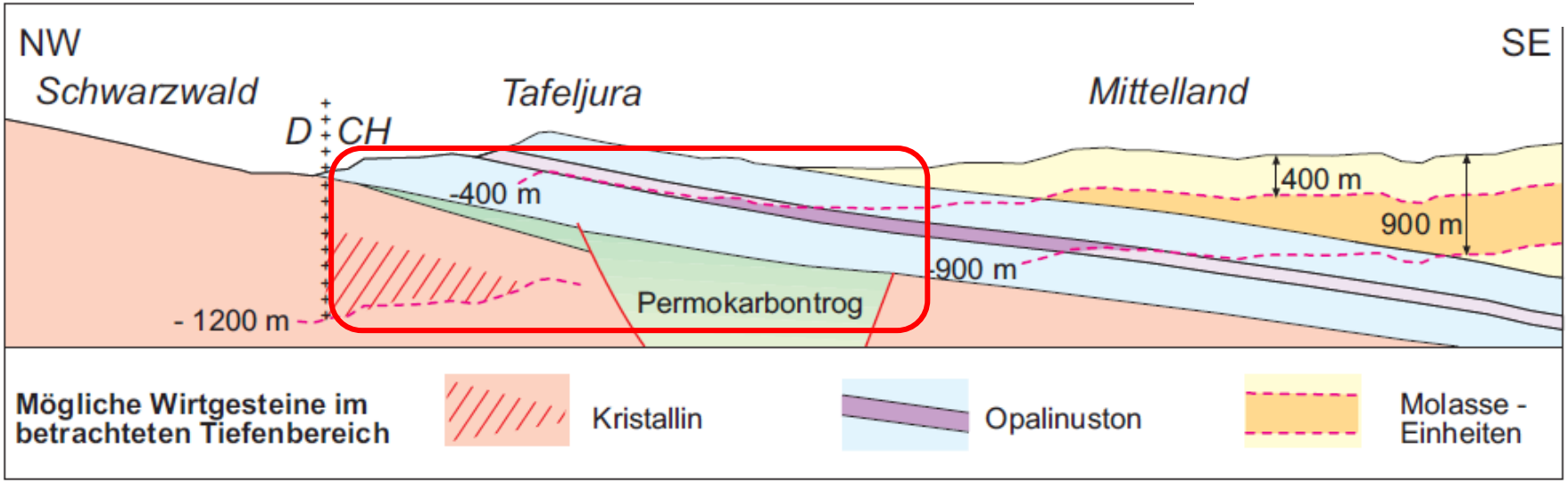
Naef & Madritsch (2014)

Geological situation Northern Switzerland

Crystalline basement & sedimentary basin (Molasse and Opalinus Clay)

… area much smaller due to permo-carboniferous trough



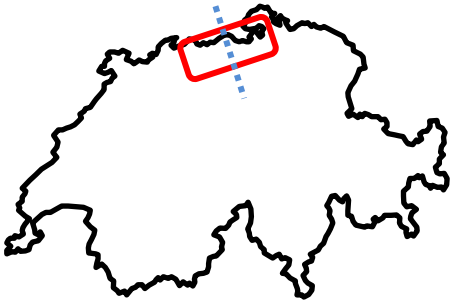


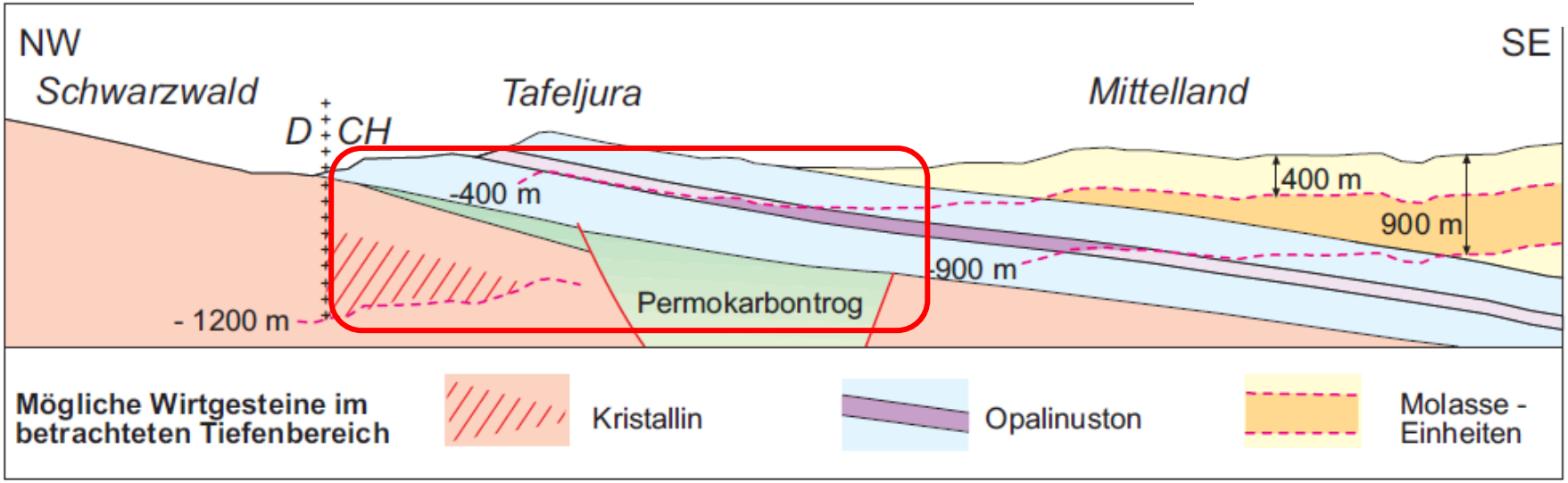
Geological situation Northern Switzerland

Crystalline basement & sedimentary basin (Molasse and Opalinus Clay)

… area much smaller due to permo-carboniferous trough

… but; safe repository in principle feasible



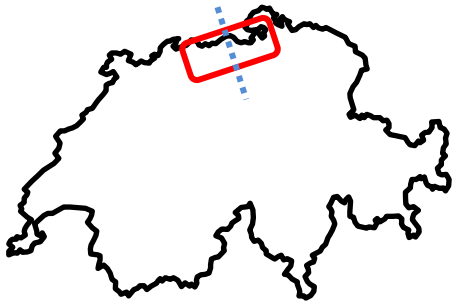


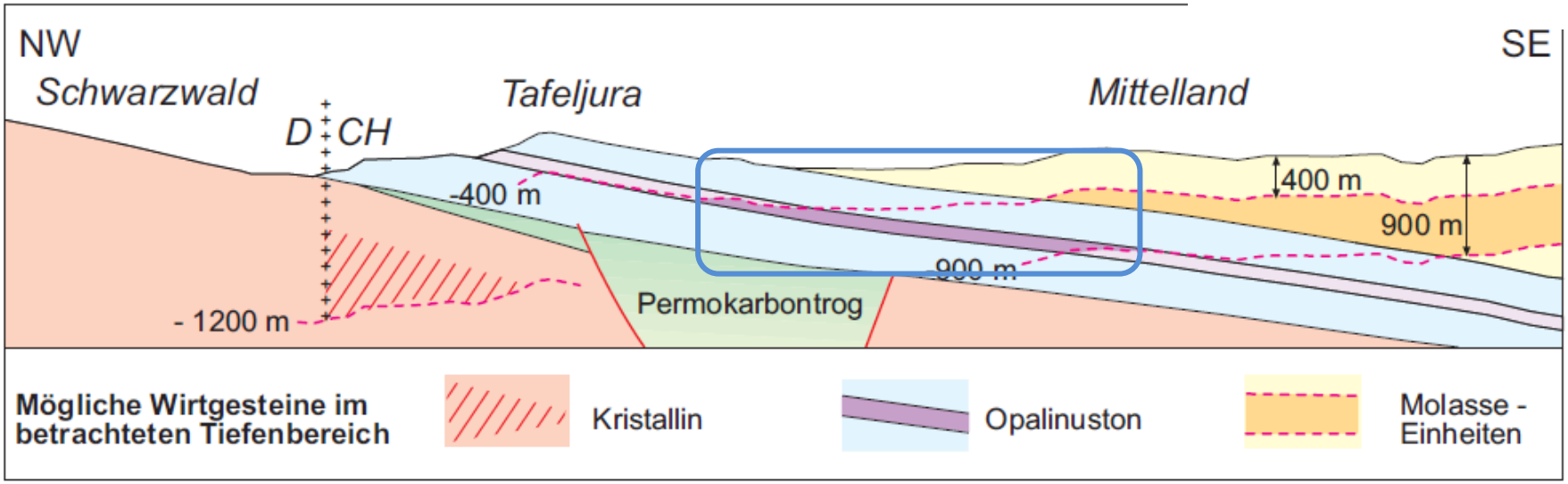
Experiences made …

- Field work can lead to surprises – solid geological information basis important, role of good 'explorability' ('visibility of geology' e.g. by geophysics)

Geological situation Northern Switzerland

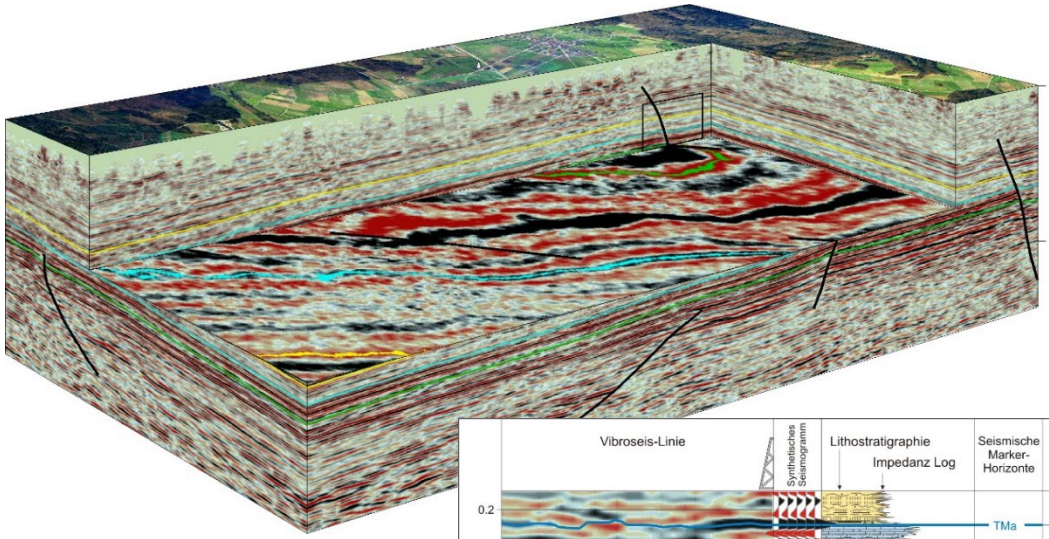
Crystalline basement & sedimentary basin (Opalinus Clay)

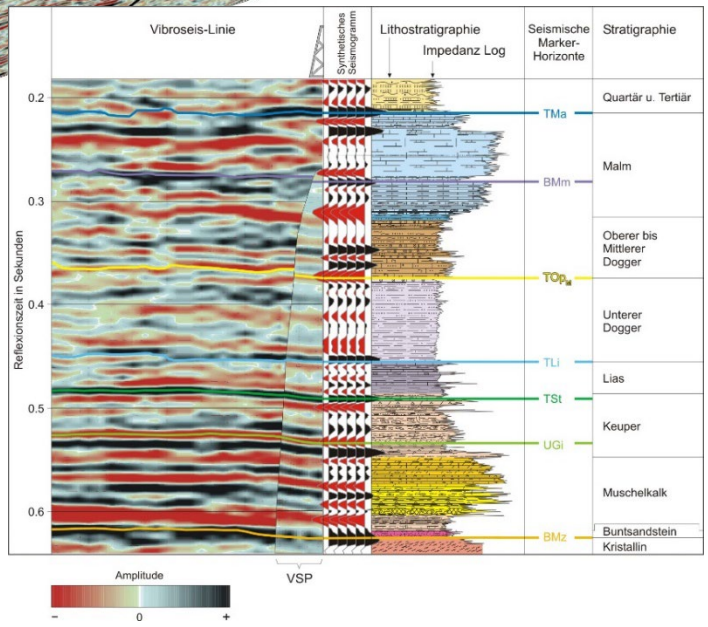




Field investigations (Zürcher Weinland – Benken)

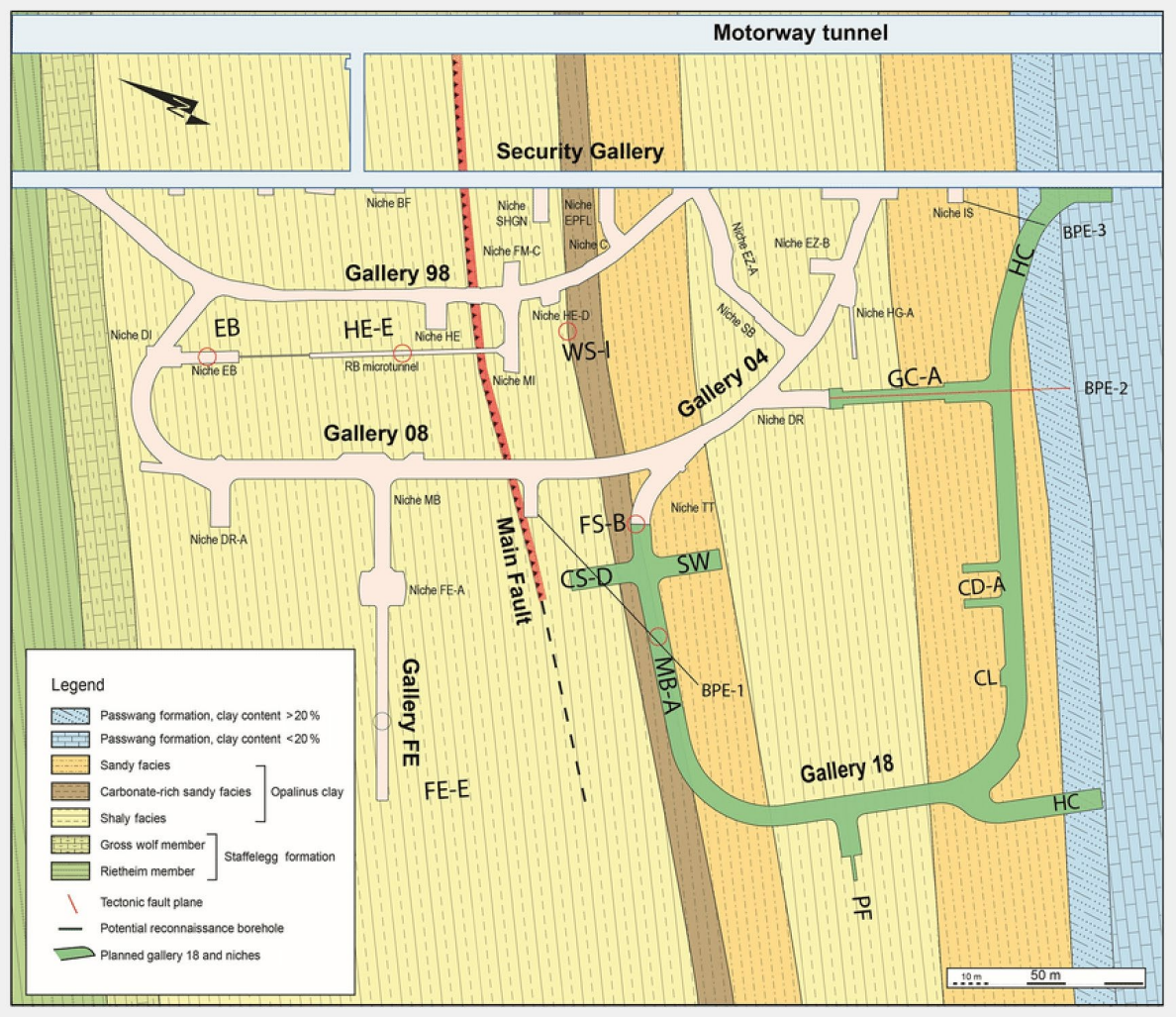
3D-seismics ('good visibility'), borehole Benken (wireline, tripple core barrel)





Mont Terri URL: Current status

- In Opalinus Clay
- Large infrastructure (growing over time)
- Very broad programme
- Broad international participation
- Very different disciplines
- Easy access (visitors, logistics)
- Corner stone of Swiss program



Swiss programme: Stepwise approach to site selection

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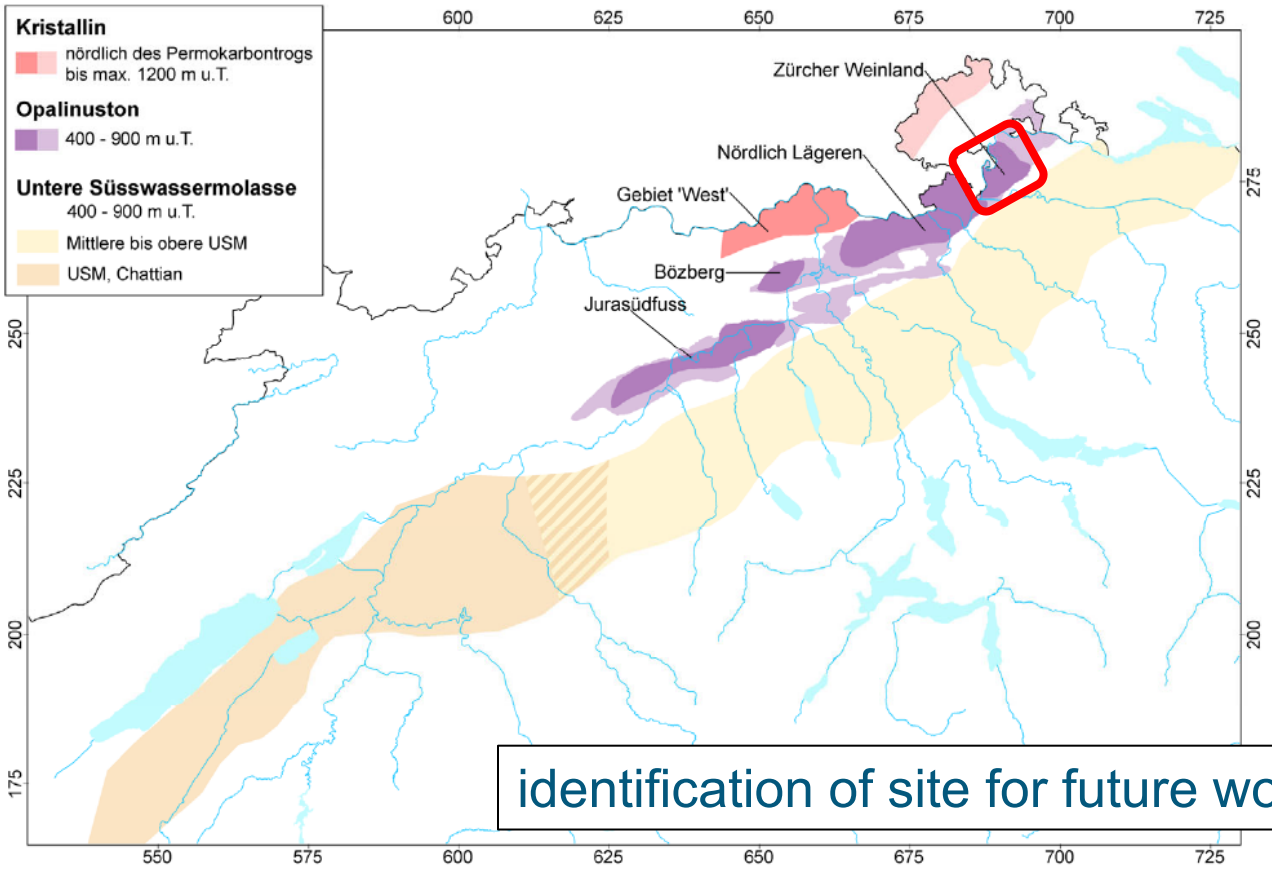
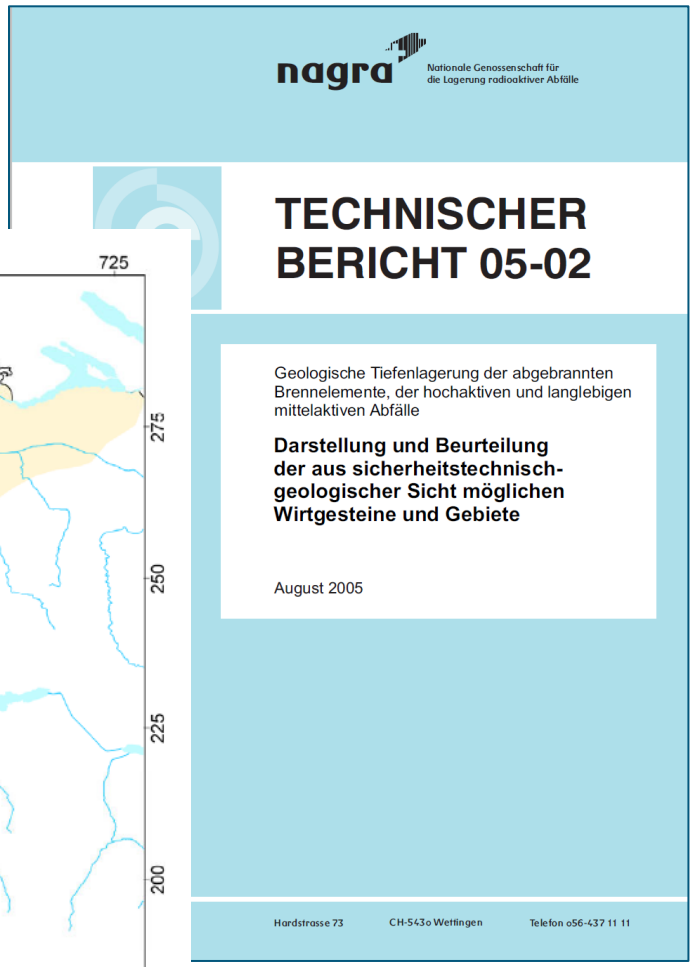
- Operation license (HLW ~ 2060)
- License for closure

HLW programme: Formal application to focus future work

additional report with more explanations

… not accepted (missing societal process)

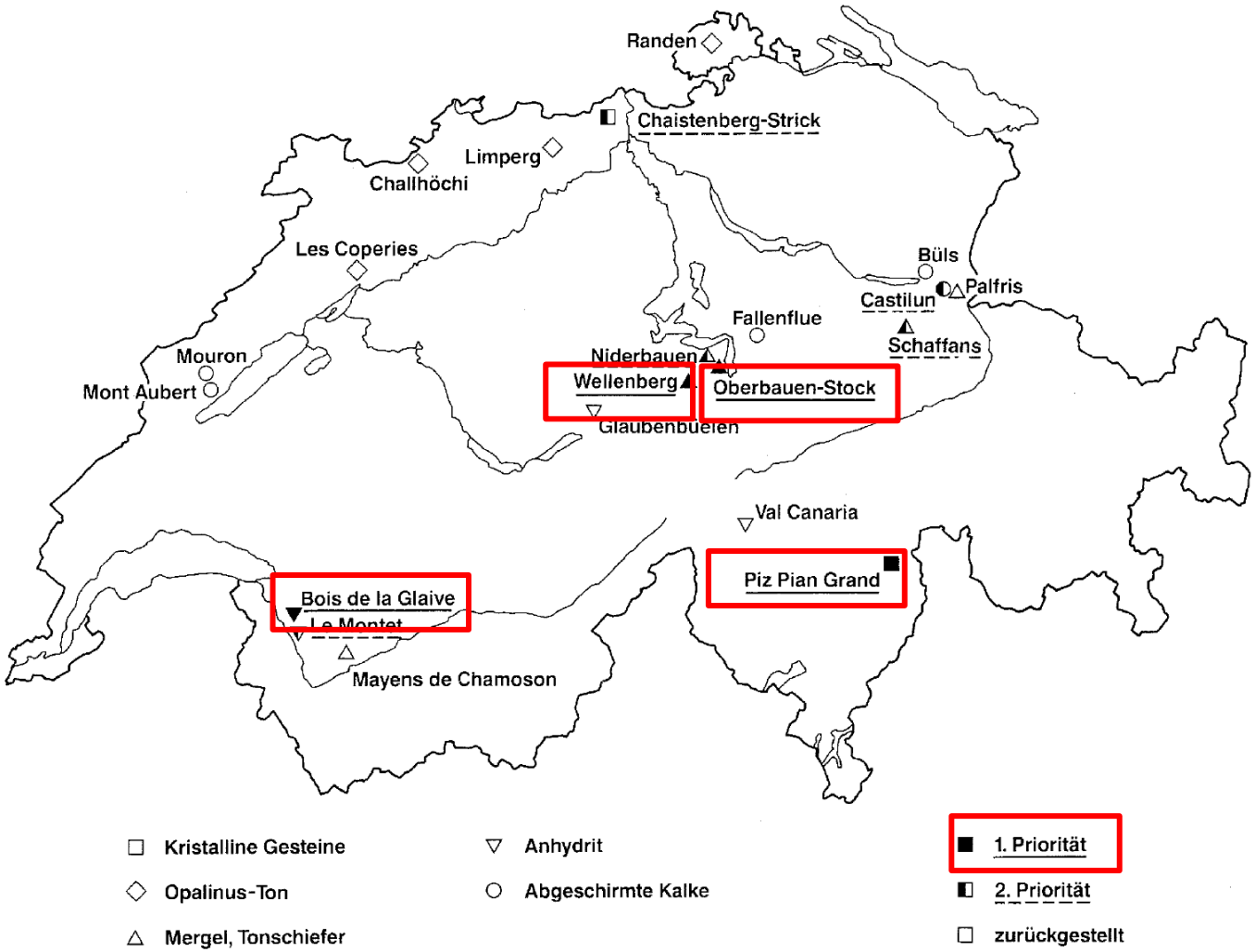




identification of site for future work proposed in 2002

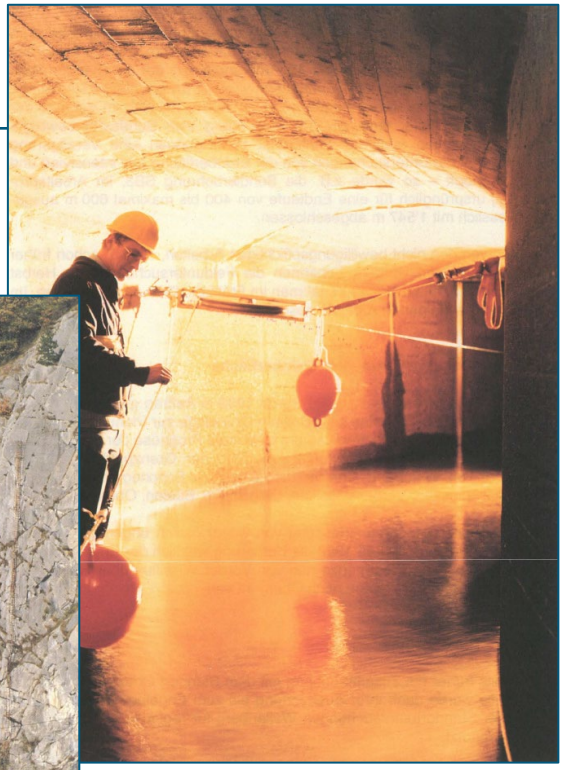
In parallel to HLW programme …

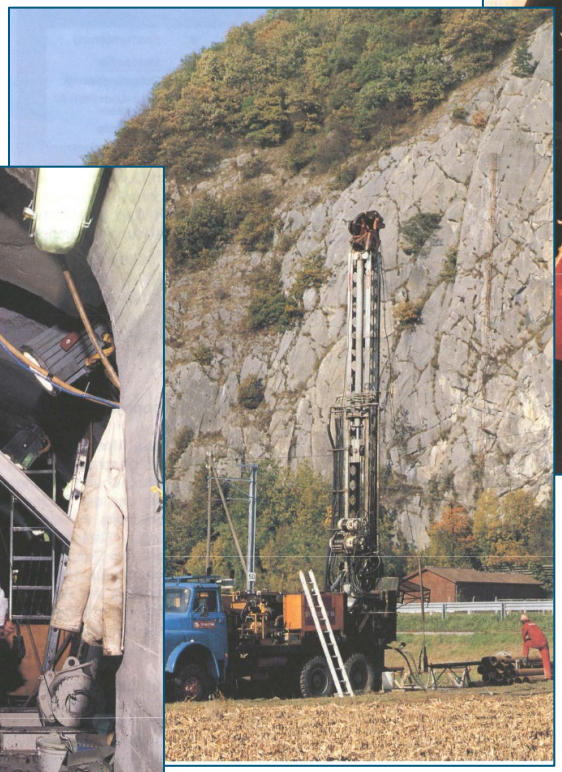
Siting of geological repository for L/ILW (100 → 20 → 3 (+1))

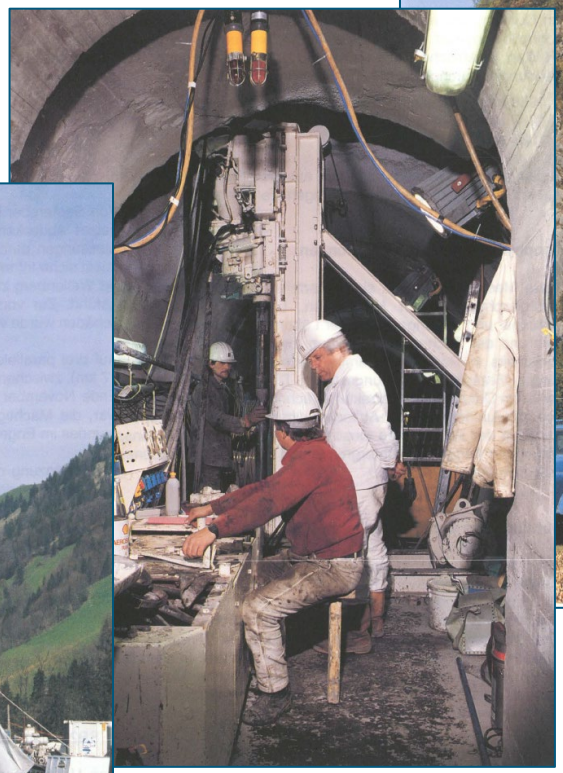


L/ILW programme

Field work at these sites …







L/ILW programme: Formal evaluation …

… review by external bodies

L/ILW programme: Formal evaluation …

… review by external bodies

License application submitted for Wellenberg

Positive regulatory review

L/ILW programme: License application Wellenberg

… rejected because of growing public protests – starting small, getting bigger over the years → project abandoned in 2002

… awareness that something has to be changed – formal siting process, included in revised nuclear energy legislation (2005)

Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects for several reasons (novel, creates fears, etc.) – slow progress & failure possible

  Different approach needed (disposal: not a 'Nagra issue' – a 'national issue')

Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects
- Disposal (NPP & other nuclear waste) is an issue of national importance – broad public support essential – requires specific site selection process

Swiss programme: Stepwise approach to site selection

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- License for closure

After decision to re-position site selection …

- Awareness that geological repositories are infrastructures of national importance → not anymore Nagra alone, but as 'expert' in broad framework
- Infrastructures of national importance have different legal boundary conditions than other infrastructures (land-use legislation)
  - 'normal' infrastructure: is competence of cantons (provinces / states)
  - infrastructure of national importance is competence of Federal Government offices
- For infrastructure of national importance – sectoral plan (part of land-use planning) – defines process & rules (criteria) in 'concept', with these steps:
  - develop 'concept': defines process, roles, criteria, etc.
  - stage 1: submission of proposals
  - stage 2: interim results
  - stage 3: final result (not official translation)
- Other infrastructures of national importance with sectoral plan: traffic, military, high voltage power lines, agriculture, …

Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects
- Disposal (NPP & other nuclear waste) is an issue of national importance
- … and: waste management programme to 'keep track of progress', revised every 5 years, review → approval by Government (with 'open issues')

'Concept' developed by process owner …

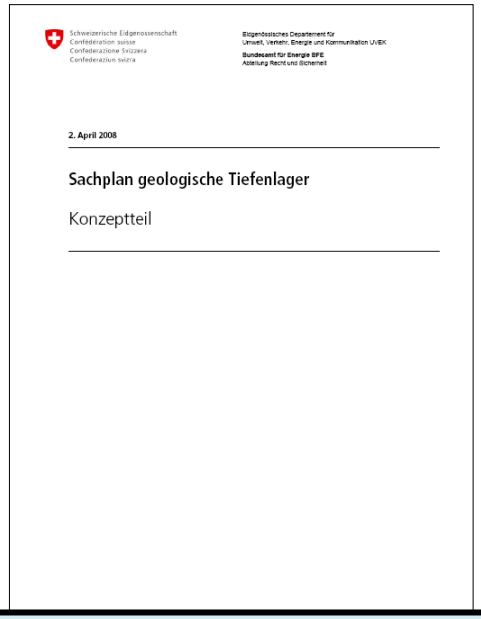
… in cooperation with all stakeholders (authorities (federal, cantonal), NGOs, implementer, NPP owners, public, …)

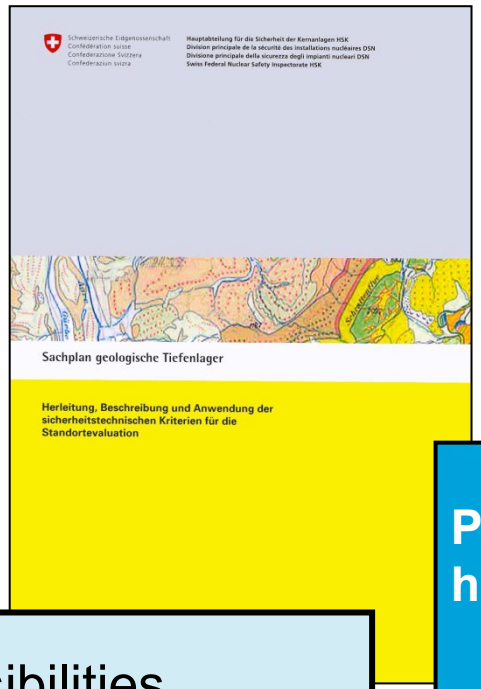
- working groups
- workshops / meetings
- consultation
- ….

Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects
- Disposal (NPP & other nuclear waste) is an issue of national importance
- Waste management programme to 'keep track', revised every 5 years
- 'Concept' for site selection process developed with involving broad spectrum of stakeholders, issued by Government (basis: nuclear legislation)

The 'Sectoral Plan': 'Concept' (rules for site selection)[1]

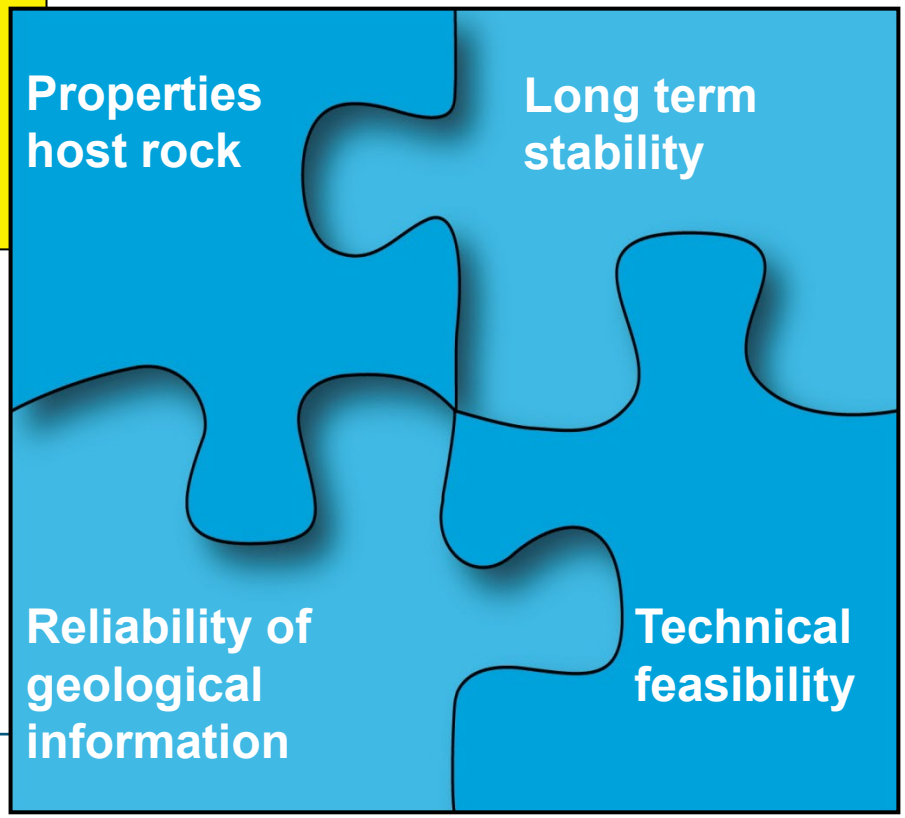




The documents

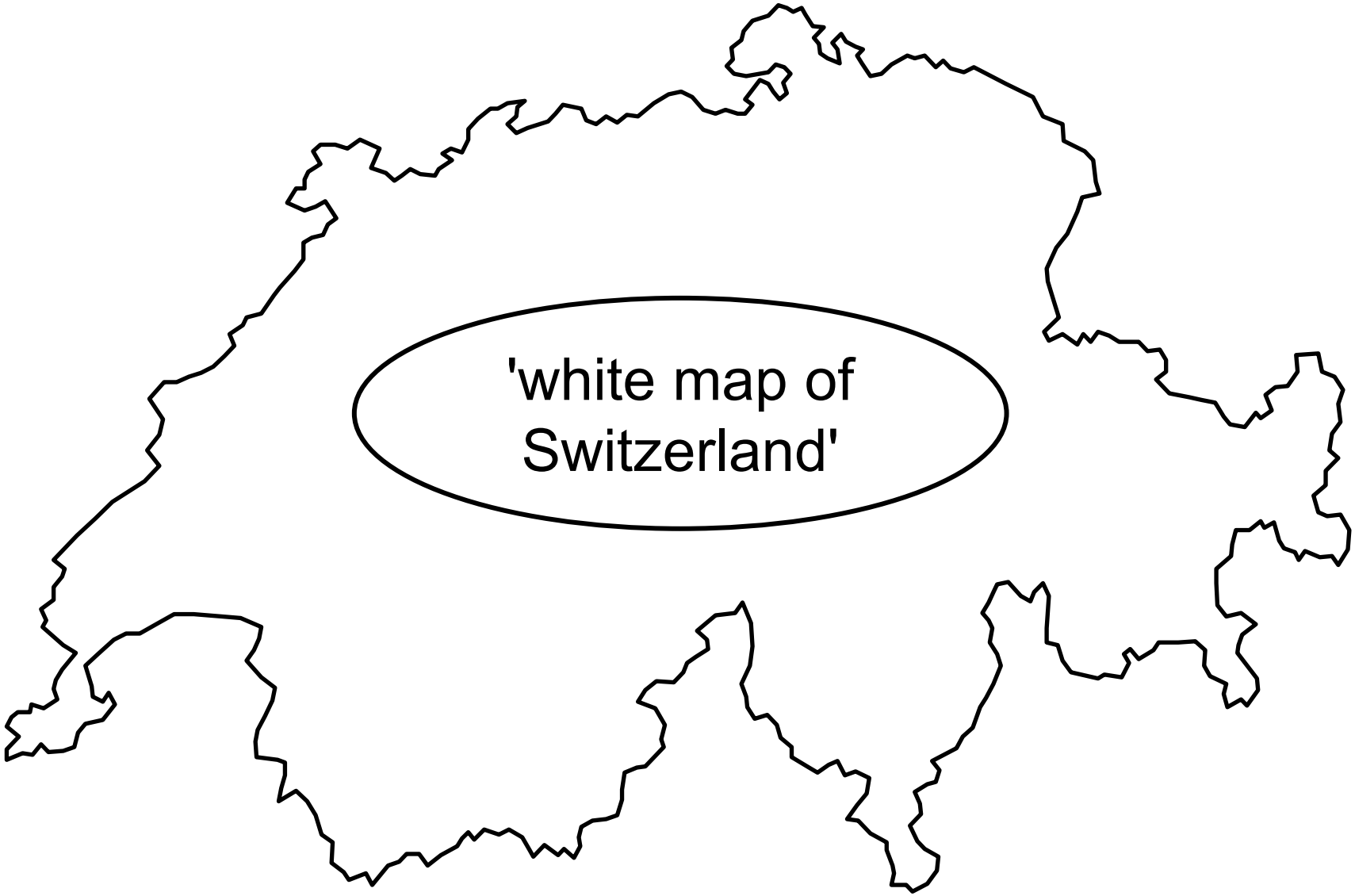
- Process & responsibilities
- Criteria (safety, environmental impact, socio-economic issues)

Safety: 13 technical criteria (4 interrelated groups)



[1] available in English

Site selection ('concept'): Starting point



Site selection ('concept'): Key principle …

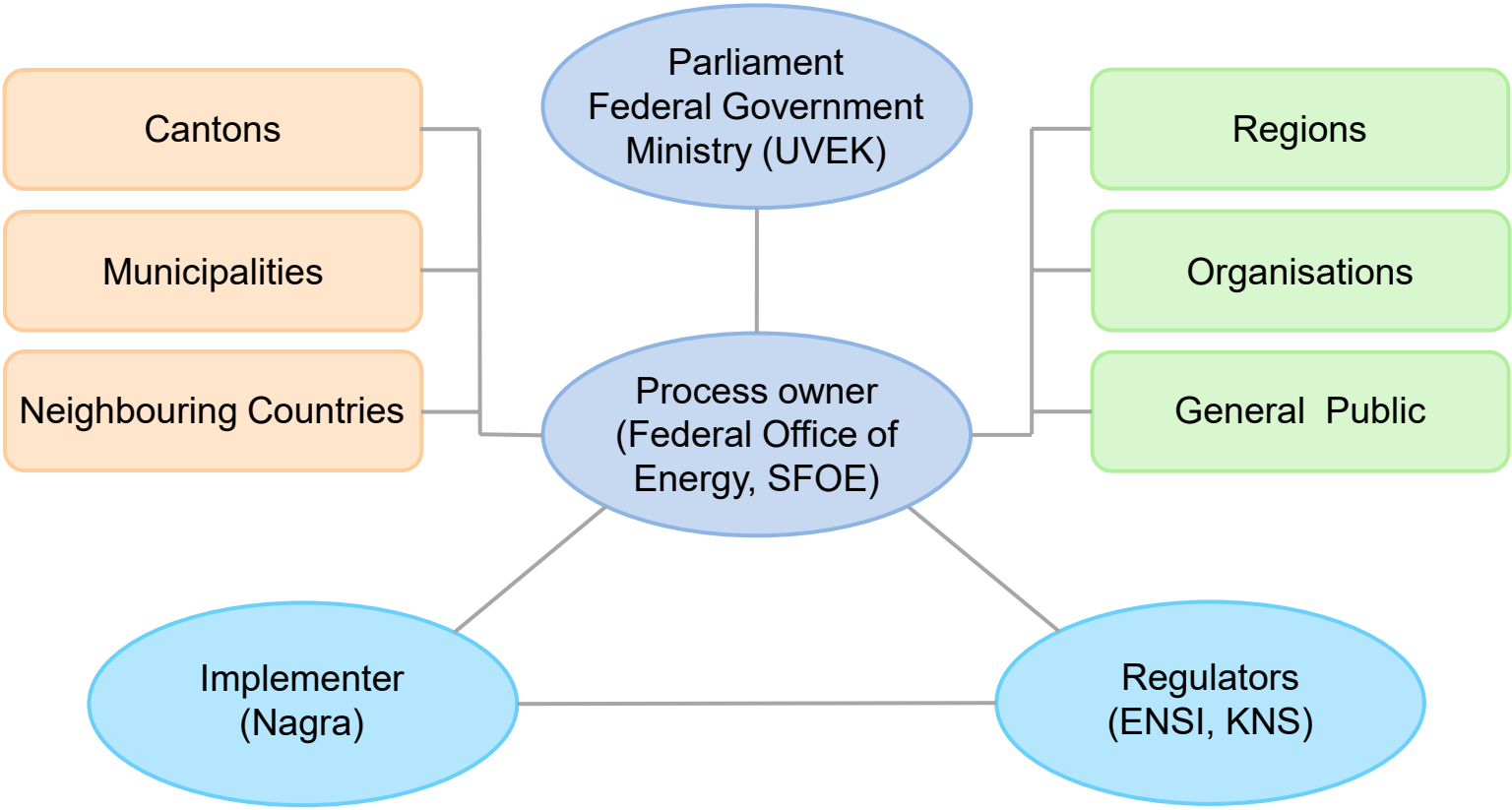
'Concept': Safety Criteria for Site Selection

Group of criteria	Criteria
1. Properties of host rock	1.1 Spatial extent 1.2 Hydraulic conductivity 1.3 Geochemical conditions 1.4 Migration paths
2. Long-term stability	2.1 Durability of properties 2.2 Erosion 2.3 Repository induced effects 2.4 Resource conflicts
3. Reliability of geological information	3.1 Characterisation of host rock 3.2 Spatial explorability 3.3 Temporal predictability
4. Suitability for construction	4.1 Rock mechanical properties 4.2 Underground access

Criteria are informed by indicators (derived by Nagra) → 49 indicators

Site selection: Broad involvement of stakeholders

'Concept': Roles and responsibilities as well as information flow clearly defined



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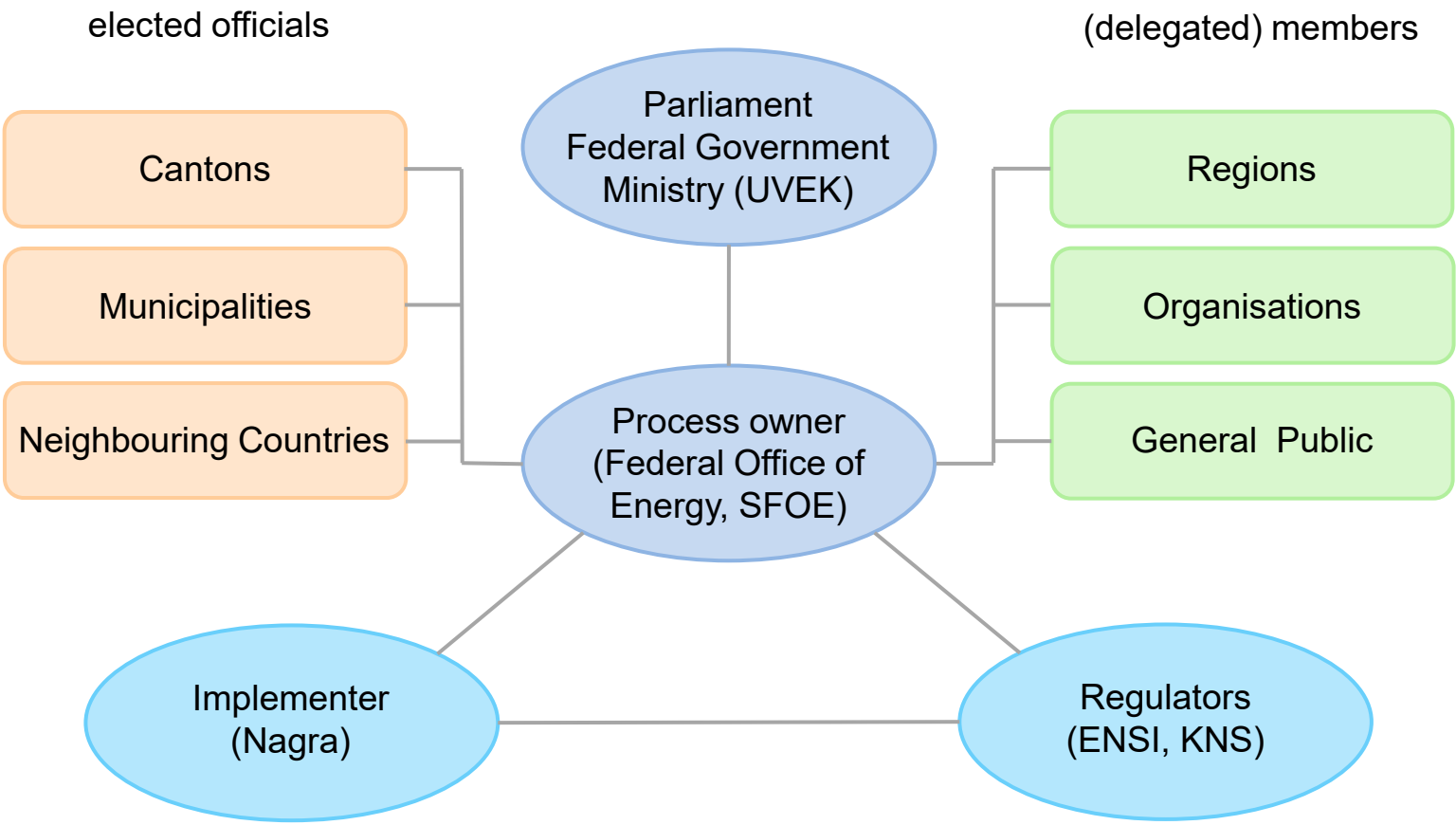
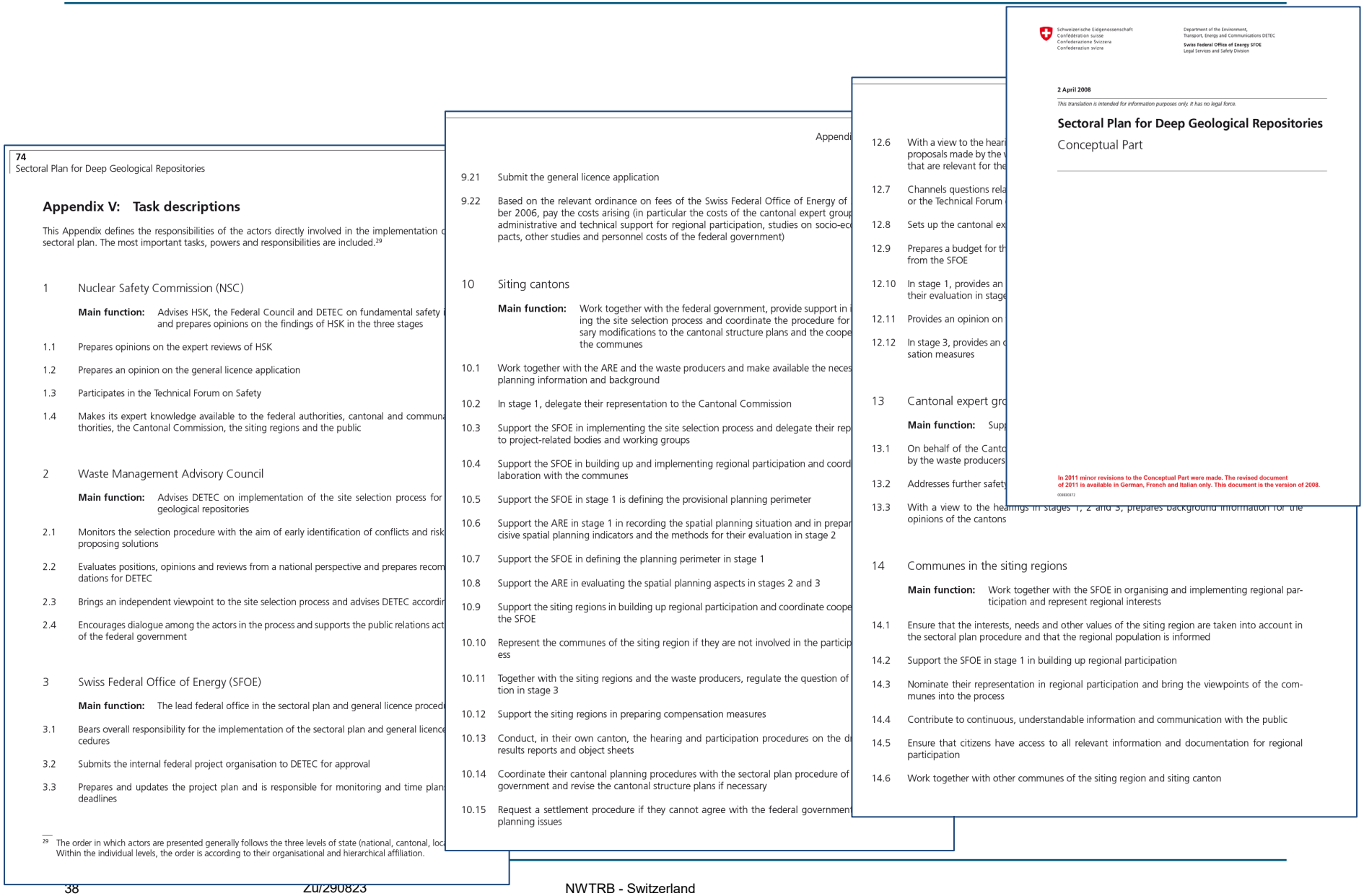


'Concept': Detailed definition of roles & responsibilities



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Sectoral Plan for Deep Geological Repositories

Appendix V: Task descriptions

This Appendix defines the responsibilities of the actors directly involved in the implementation o sectoral plan. The most important tasks, powers and responsibilities are included.[29]

1 Nuclear Safety Commission (NSC)

Main function: Advises HSK, the Federal Council and DETEC on fundamental safety i and prepares opinions on the findings of HSK in the three stages

1.1 Prepares opinions on the expert reviews of HSK

1.2 Prepares an opinion on the general licence application

1.3 Participates in the Technical Forum on Safety

1.4 Makes its expert knowledge available to the federal authorities, cantonal and communa thorities, the Cantonal Commission, the siting regions and the public

2 Waste Management Advisory Council

Main function: Advises DETEC on implementation of the site selection process for geological repositories

2.1 Monitors the selection procedure with the aim of early identification of conflicts and risk proposing solutions

2.2 Evaluates positions, opinions and reviews from a national perspective and prepares recom dations for DETEC

2.3 Brings an independent viewpoint to the site selection process and advises DETEC accordir

2.4 Encourages dialogue among the actors in the process and supports the public relations act of the federal government

3 Swiss Federal Office of Energy (SFOE)

Main function: The lead federal office in the sectoral plan and general licence proced

3.1 Bears overall responsibility for the implementation of the sectoral plan and general licence cedures

3.2 Submits the internal federal project organisation to DETEC for approval

3.3 Prepares and updates the project plan and is responsible for monitoring and time plan deadlines

[29] The order in which actors are presented generally follows the three levels of state (national, cantonal, loc Within the individual levels, the order is according to their organisational and hierarchical affiliation.

Appendi

9.21 Submit the general licence application

9.22 Based on the relevant ordinance on fees of the Swiss Federal Office of Energy of ber 2006, pay the costs arising (in particular the costs of the cantonal expert group administrative and technical support for regional participation, studies on socio-ec pacts, other studies and personnel costs of the federal government)

10 Siting cantons

Main function: Work together with the federal government, provide support in ing the site selection process and coordinate the procedure for sary modifications to the cantonal structure plans and the coope the communes

10.1 Work together with the ARE and the waste producers and make available the neces planning information and background

10.2 In stage 1, delegate their representation to the Cantonal Commission

10.3 Support the SFOE in implementing the site selection process and delegate their rep to project-related bodies and working groups

10.4 Support the SFOE in building up and implementing regional participation and coord laboration with the communes

10.5 Support the SFOE in stage 1 is defining the provisional planning perimeter

10.6 Support the ARE in stage 1 in recording the spatial planning situation and in prepar cisive spatial planning indicators and the methods for their evaluation in stage 2

10.7 Support the SFOE in defining the planning perimeter in stage 1

10.8 Support the ARE in evaluating the spatial planning aspects in stages 2 and 3

10.9 Support the siting regions in building up regional participation and coordinate coope the SFOE

10.10 Represent the communes of the siting region if they are not involved in the particip ess

10.11 Together with the siting regions and the waste producers, regulate the question of tion in stage 3

10.12 Support the siting regions in preparing compensation measures

10.13 Conduct, in their own canton, the hearing and participation procedures on the d results reports and object sheets

10.14 Coordinate their cantonal planning procedures with the sectoral plan procedure of government and revise the cantonal structure plans if necessary

10.15 Request a settlement procedure if they cannot agree with the federal government planning issues

12.6 With a view to the heari proposals made by the v that are relevant for the

12.7 Channels questions rela or the Technical Forum

12.8 Sets up the cantonal ex

12.9 Prepares a budget for th from the SFOE

12.10 In stage 1, provides an their evaluation in stage

12.11 Provides an opinion on

12.12 In stage 3, provides an c sation measures

13 Cantonal expert gro

Main function: Supp

13.1 On behalf of the Canto by the waste producers

13.2 Addresses further safety

13.3 With a view to the hearings in stages 1, 2 and 3, prepares background information for the opinions of the cantons

14 Communes in the siting regions

Main function: Work together with the SFOE in organising and implementing regional participation and represent regional interests

14.1 Ensure that the interests, needs and other values of the siting region are taken into account in the sectoral plan procedure and that the regional population is informed

14.2 Support the SFOE in stage 1 in building up regional participation

14.3 Nominate their representation in regional participation and bring the viewpoints of the communes into the process

14.4 Contribute to continuous, understandable information and communication with the public

14.5 Ensure that citizens have access to all relevant information and documentation for regional participation

14.6 Work together with other communes of the siting region and siting canton

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Department of the Environment, Transport, Energy and Communications DETEC
Swiss Federal Office of Energy SFOE
Legal Services and Safety Division

2 April 2008

This translation is intended for information purposes only. It has no legal force.

Sectoral Plan for Deep Geological Repositories

Conceptual Part

In 2011 minor revisions to the Conceptual Part were made. The revised document of 2011 is available in German, French and Italian only. This document is the version of 2008.

003893072

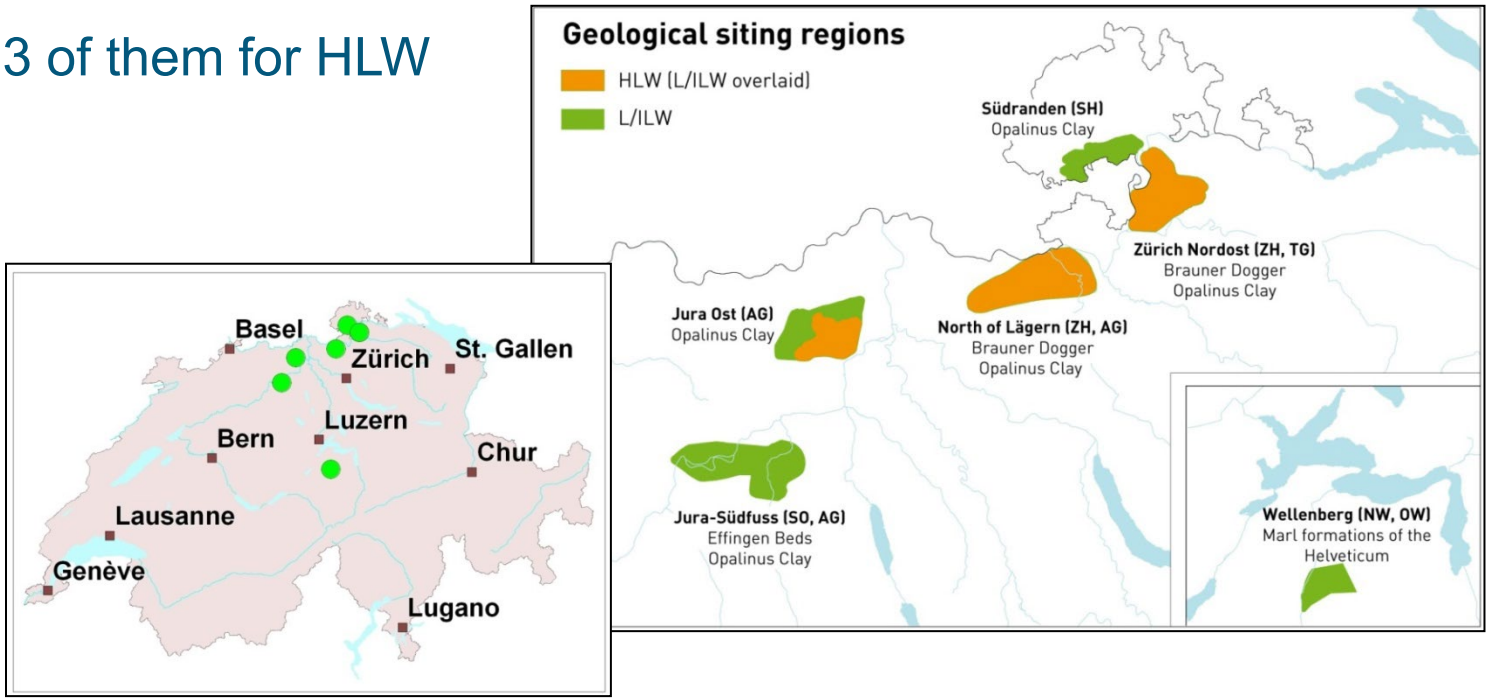
Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects
- Disposal (NPP & other nuclear waste) is an issue of national importance
- Waste management programme to 'keep track', revised every 5 years

'Concept': geology defines site (Swiss geology strongly differentiates), surface infrastructure developed in close consultation with siting region

First screening of Switzerland: Six siting regions …

with 3 of them for HLW



… developed in a <u>systematic stepwise narrowing down process</u> based on the safety-related requirements of sectoral plan

transparency in *'why these and not those'*

Experiences made …

- Solid geological information basis important, good 'explorability' important
- Disposal projects are for society different than other industry projects
- Disposal (NPP & other nuclear waste) is an issue of national importance
- Waste management programme to 'keep track', revised every 5 years
- 'Concept': geology defines site, develop surface infrastructure with region
- Time (delays) allowed to develop capabilities needed (persons, infrastructure (labs, URF, …), information, experience); ability to maintain the knowledge

Announcement by process owner …

… together with key stakeholders (federal / cantonal governments, authorities, implementer, …) – with Nagra as 'technical expert'

… in range of meetings (capital of Switzerland, siting regions, ….)

… well received by public; with ~ neutral coverage by media;

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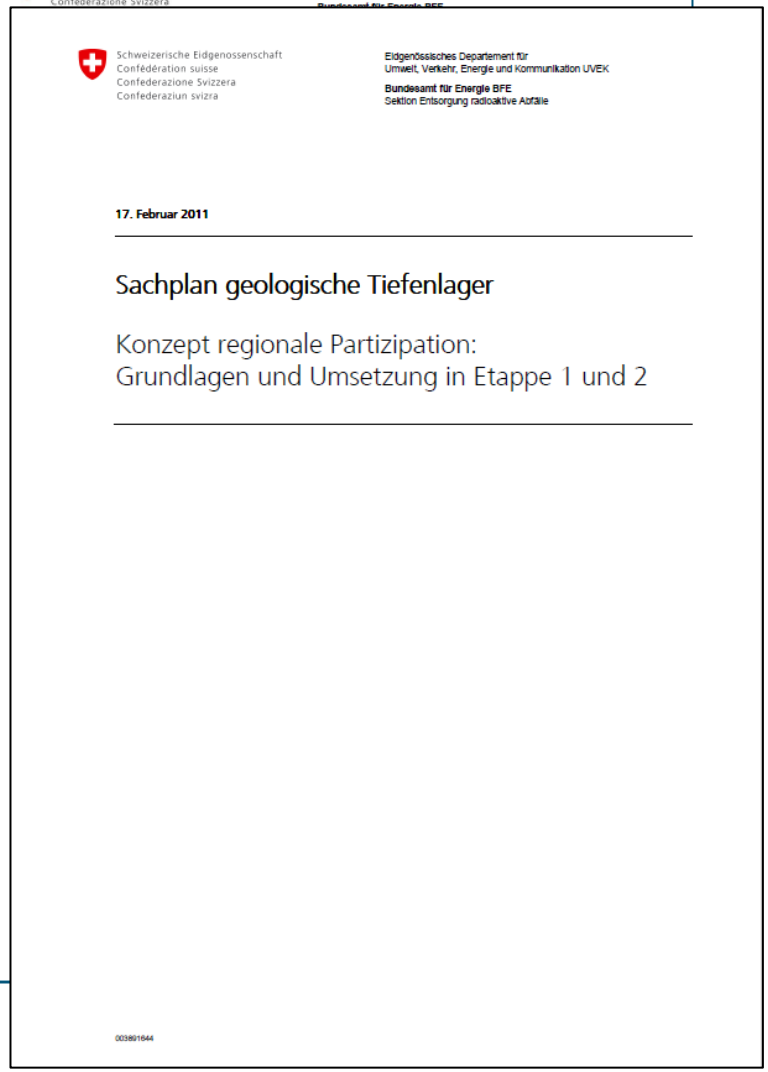
- Interaction of the different stakeholders (process owner, elected officials (politics), regulator, implementer) with public with clearly defined roles (…, listening, …)

Regional participation: Concept jointly developed …

… with affected regions to ensure successful societal involvement

- Tasks of communities & tasks of 'regional participation'
  - tasks communities
  - tasks regional participation
  - limits of regional participation
- Rules, organisation and structure of regional participation
  - process rules
  - participants
  - organisation & structure
  - important steps in initiation phase
  - initial moderation
  - preparatory phase
  - definition of siting region (involved communities)
  - development of technical & societal competencies
- Financing of work to be done


Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Umwelt, Verkehr, Energie und Kommunikation UVEK

Bundesamt für Energie BFE
Sektion Entsorgung radioaktive Abfälle

17. Februar 2011

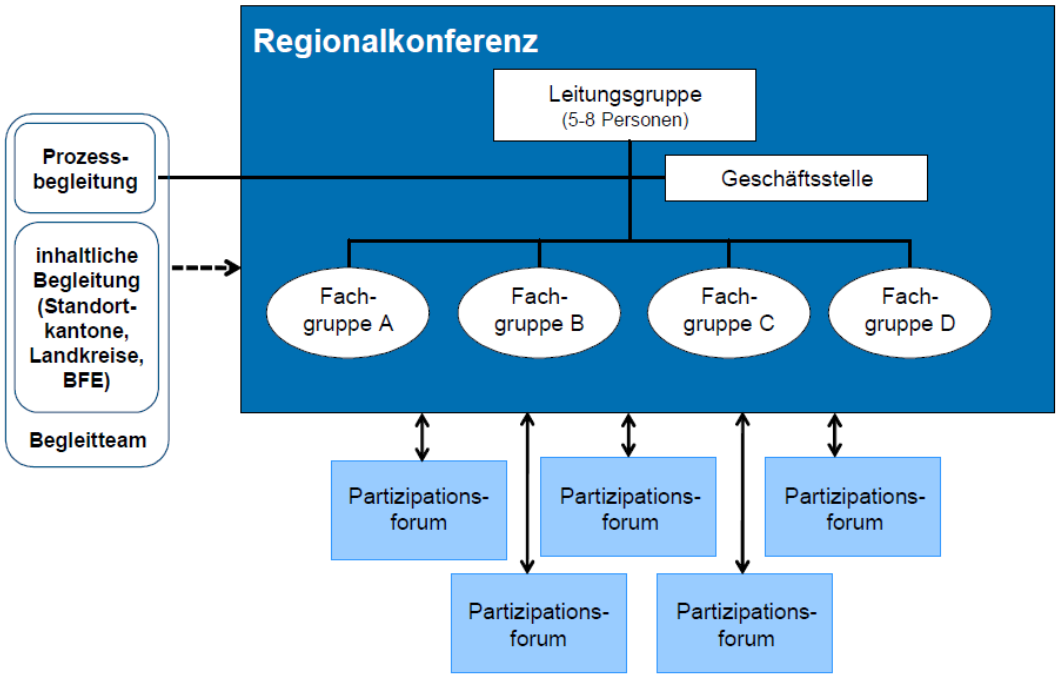
Sachplan geologische Tiefenlager

Konzept regionale Partizipation:
Grundlagen und Umsetzung in Etappe 1 und 2

Organisation of regional conferences

… 50 to 150 members

- management group (5 to 9 members)
- office
- specialist groups
  - safety
  - surface infrastructure
  - regional development
  - ….
- general support
- process support (initial phase)



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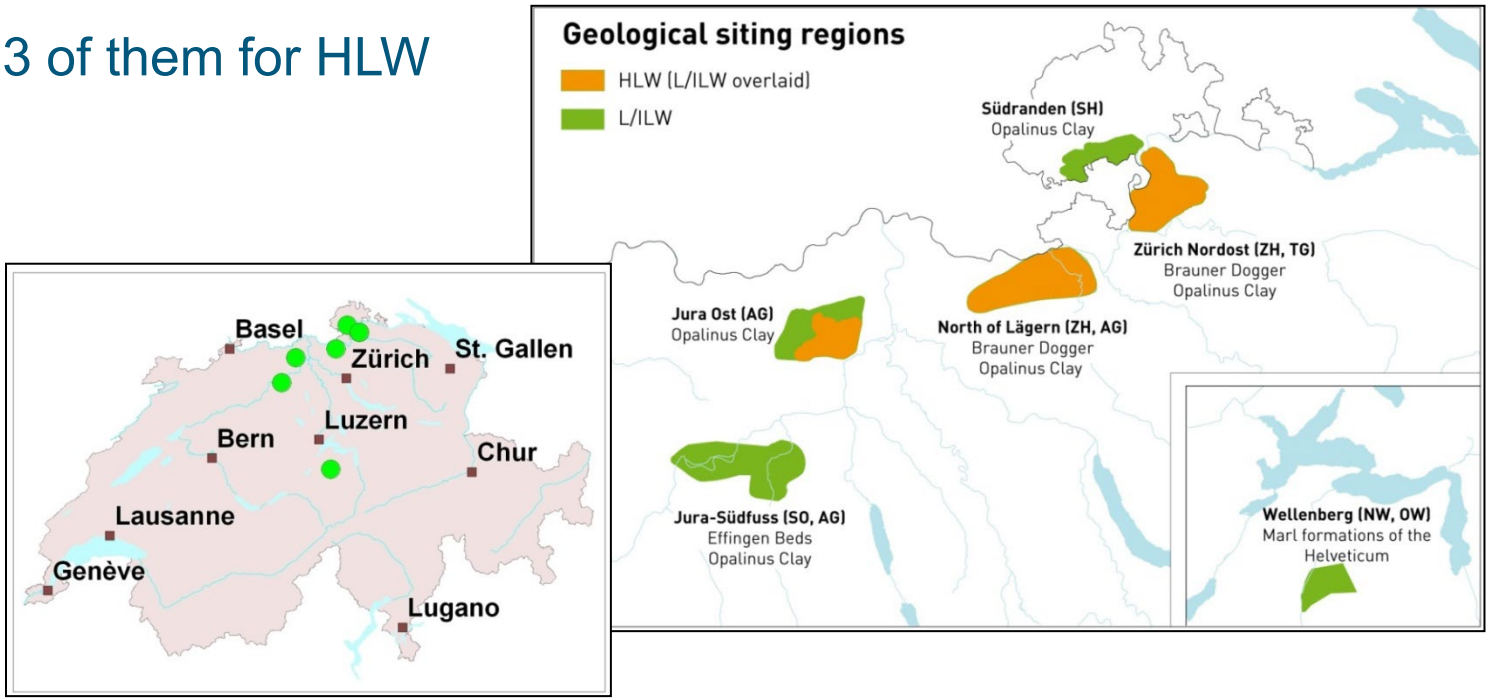
- Rules to involve region in structured manner (jointly developed) are important, to be enabled through information and support (own studies, etc.)

First screening of Switzerland: Six siting regions …

with 3 of them for HLW



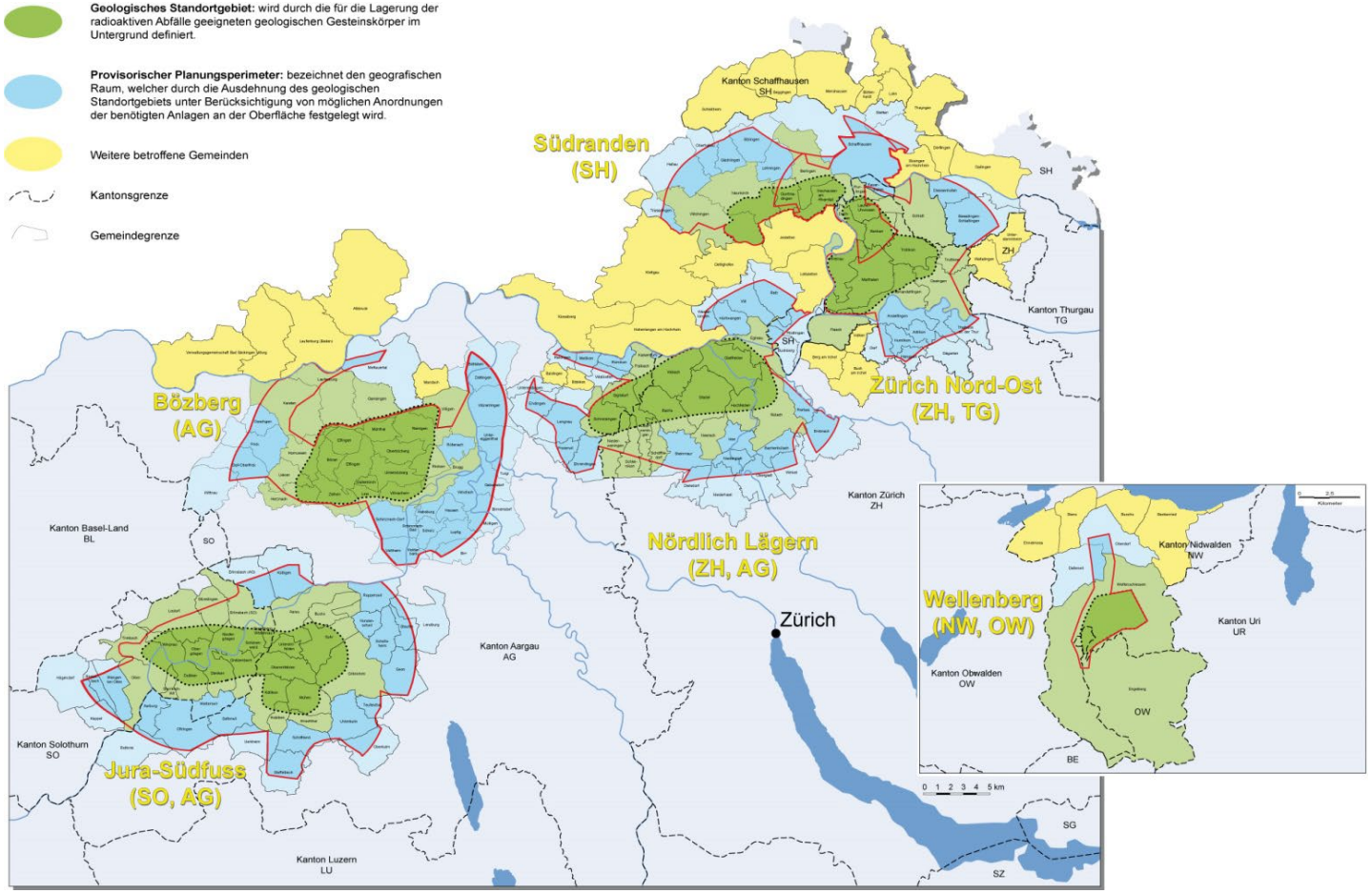
… developed in a systematic stepwise narrowing down process based on the safety-related requirements of sectoral plan

… accepted by Federal Government (Nov 2011), based on thorough review by safety authorities and broad consultation

… are basis for future stages in site selection process and active involvement of affected communities and regions

Starting point: … participation formally organized

Identification of communities to be formally involved
(through regional conferences & working groups)



Regional conference at work

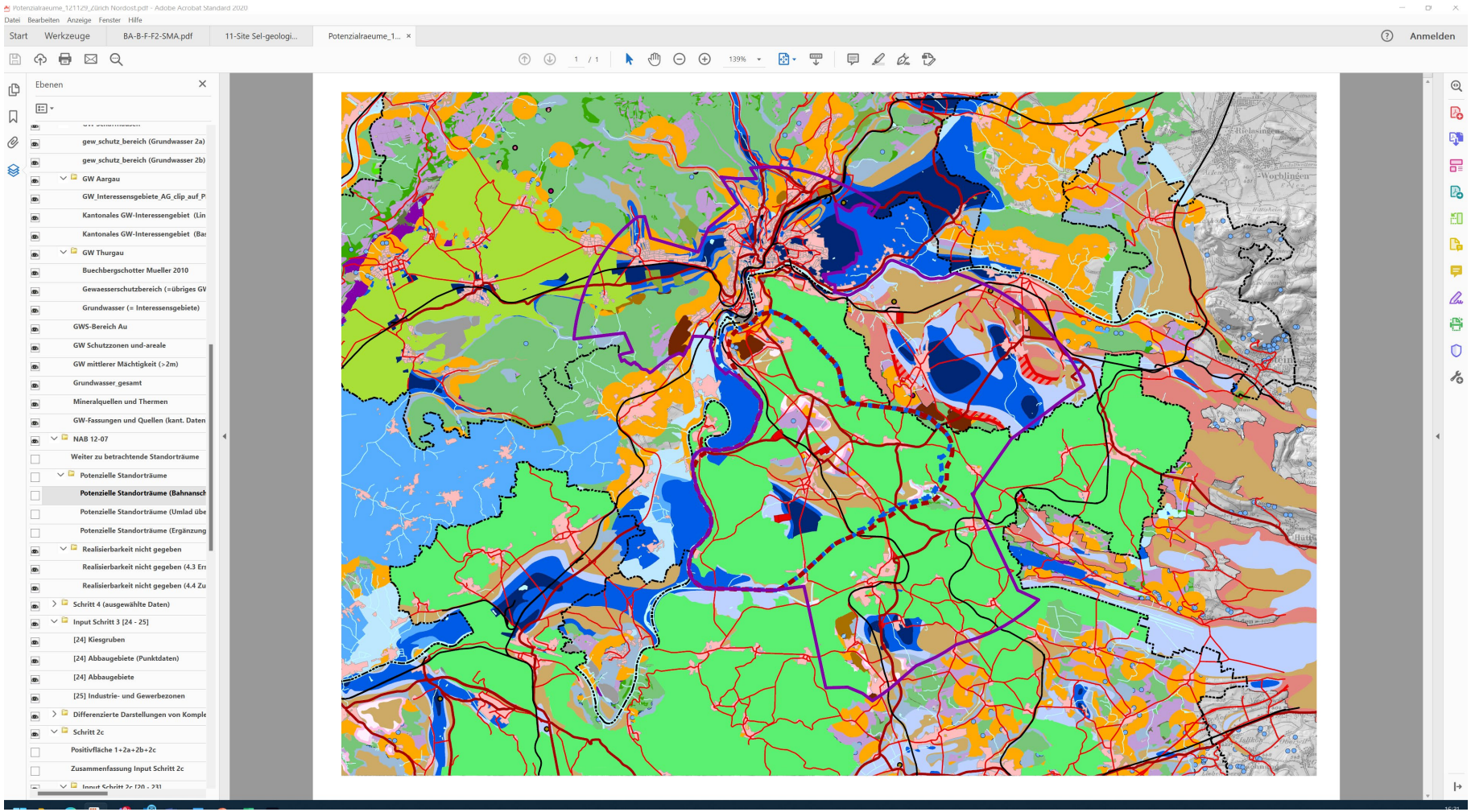
Discussions

Visit at potential surface site

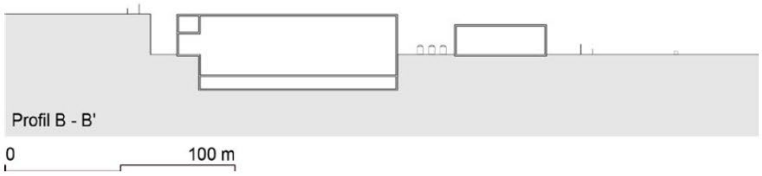
Land use planning: What? Where? Why?

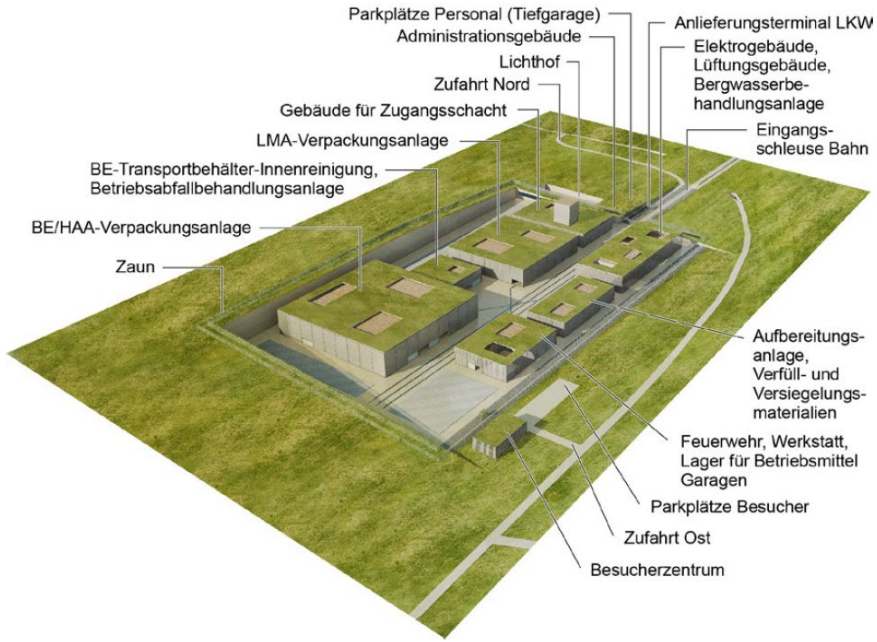
Everywhere, there are some conflicts (but: differences in severity)

… an instrument to play around and form your own opinion



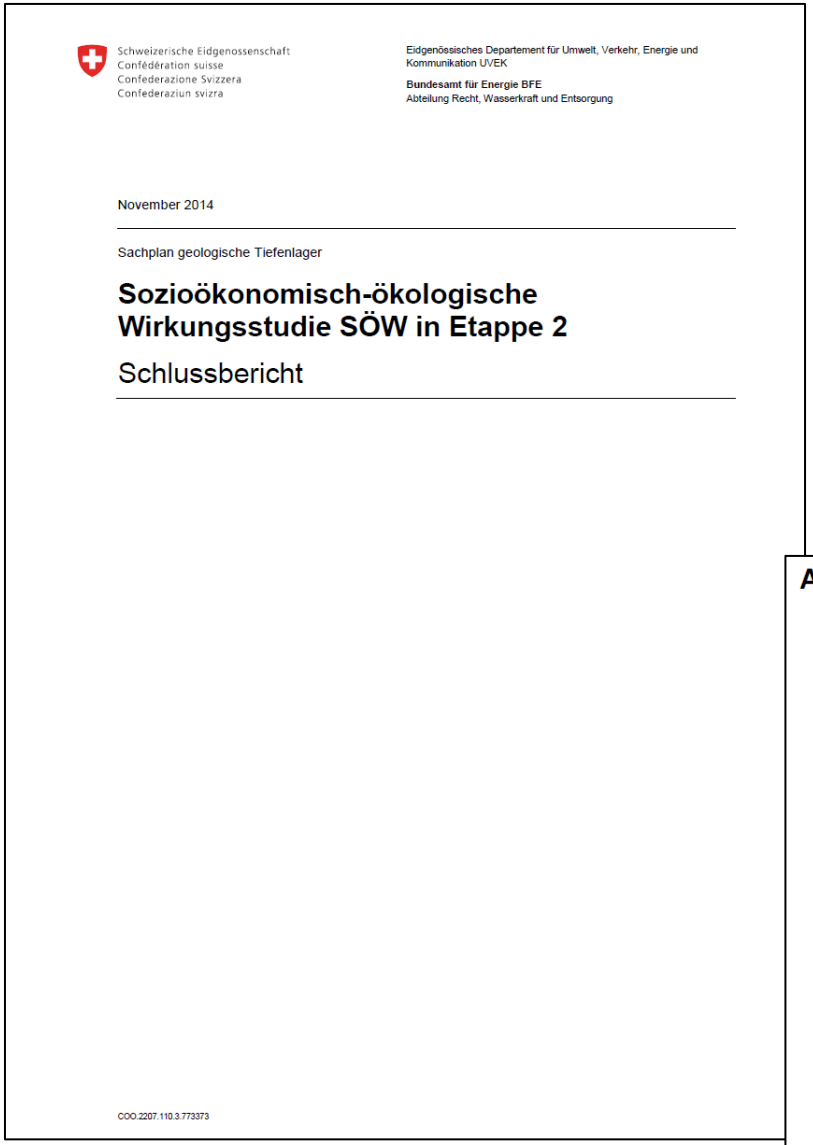
'Planning studies': allows regions to form an opinion





- Switzerland

Socio-economic-ecologic impact studies ('SÖW')



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Abteilung Recht, Wasserkraft und Entsorgung

November 2014

Sachplan geologische Tiefenlager

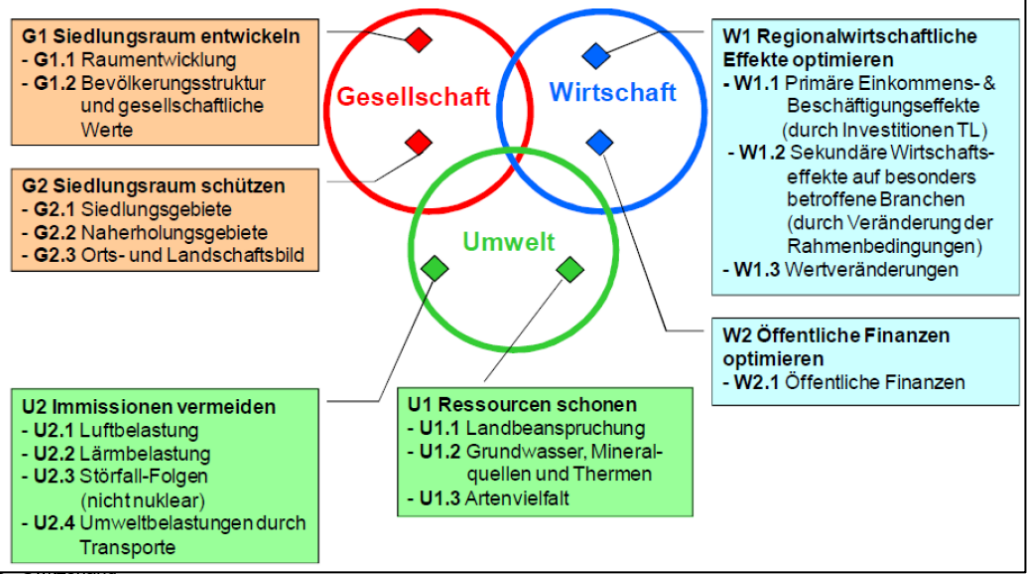
Sozioökonomisch-ökologische Wirkungsstudie SÖW in Etappe 2

Schlussbericht

COO.2207.110.3.773373

- 'Mapping' of current structural characteristics of regions
- Future evolution ('impact')
  - Economy
  - Environment
  - Society
  - Overall results (based on indicators)
- Overall findings: limited impact achievable (in comparison with other activities)

Abbildung 1: Zielsystem SÖW auf Stufe Teilziele



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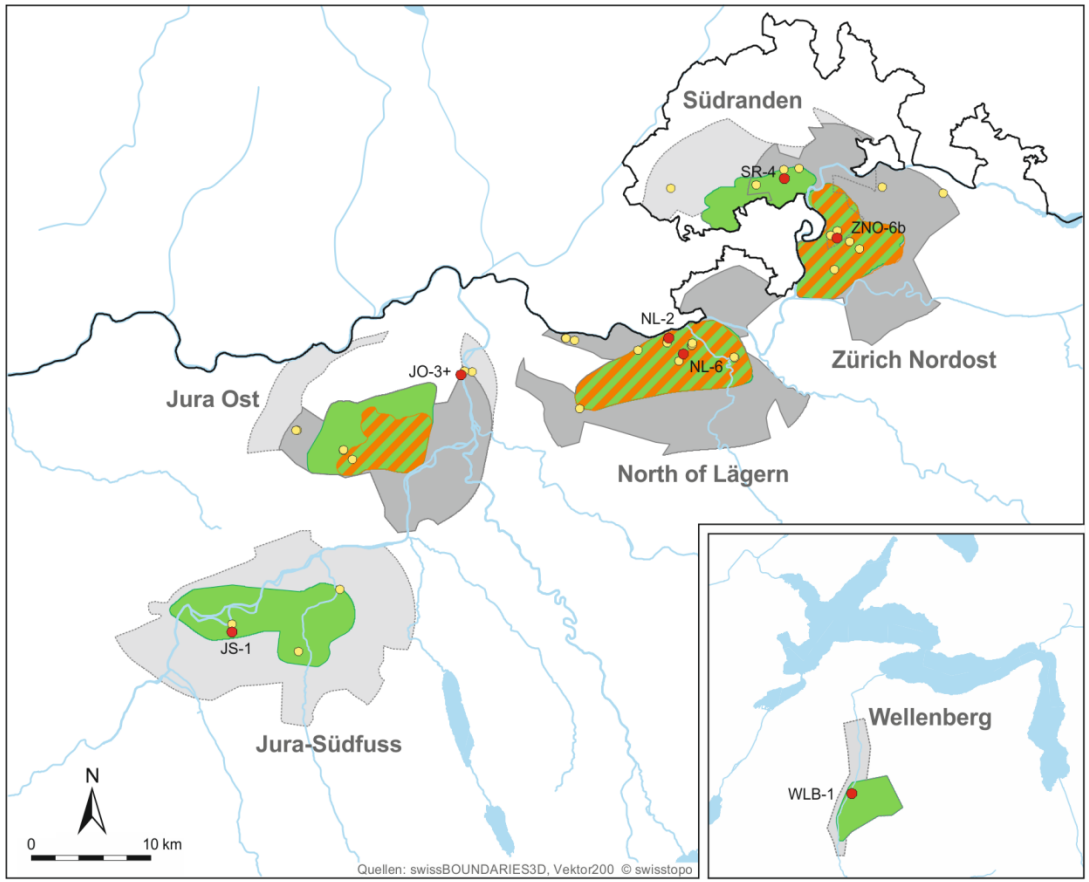
- Interaction of stakeholders with public with clearly defined roles
- Rules to involve region in structured manner (jointly developed)
- Evaluation of socio-economic-ecological impact – be realistic & transparent with long-term (economic) benefits & drawbacks (Switzerland)

Surface facilities: Proposed sites (within siting regions)

20 siting areas proposed in 6 siting regions (January 2012; NTB 11-01)



… with 13 additional proposals (developed in co-operation between siting regions, siting cantons & Nagra)

… and all siting regions having made their choice

… 'taken over' by Nagra

P.S.: strong interest of regions in operational phase

- Geological siting regions HLW repository
- Geological siting regions L/ILW repository
- Planning perimeter HLW and L/ILW
- Planning perimeter L/ILW
- Sites with planning studies submitted
- Sites analysed
- Swiss border

The societal process …

… is often like a meandering river: it not always takes the direct path, it may go more slowly than expected

… but as long as it stays within certain bounds (the basic rules are observed), this is acceptable

Experiences made …

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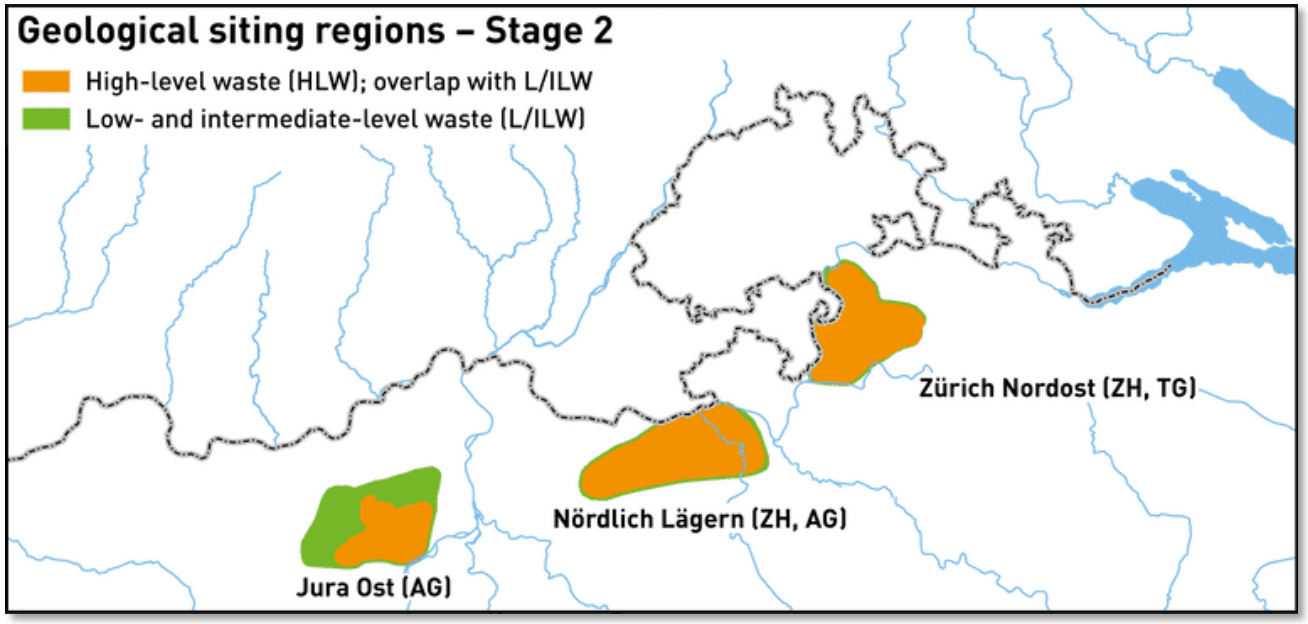
- Interaction of stakeholders with public with clearly defined roles
- Rules to involve region in structured manner (jointly developed)
- Evaluation of socio-economic-ecological impact – be realistic from start
- Working successfully together with siting region is possible – some support to enable siting region to develop its own ideas can be useful, but: it took more time (incl. interaction with 'officials') than originally anticipated

Endpoint of stage 2: regions for further investigation

… in parallel – looking at geology



… based on additional field data

… and thorough analysis (rating, comparisons, dose-calculations)
→ clarity on the *'why these and not those'*

… final decision by federal government at end 2018 after broad public consultation: 3 sites to be further investigated

Seismics: field work

Borehole Bülach

Information at borehole site

'face-to-face'

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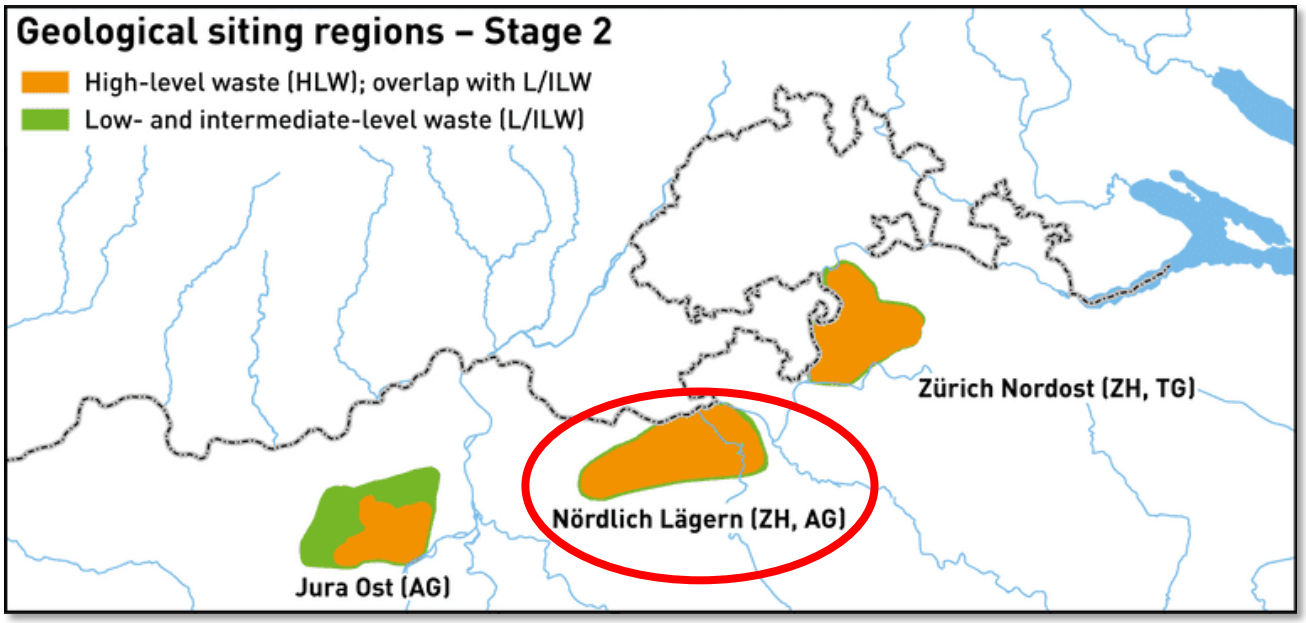
- Working successfully together with siting region is possible, but takes time
- Field work is an excellent opportunity to make personal contacts

Endpoint: site selected (for combined repository)



… based on all the results available

choice of Nördlich Lägern as site for implementing a combined repository (announcement Nagra in September 2022)

next step: General Licence Application (Site Licence) in 2024

… again: convincing arguments for *'why here and not there'*

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- 'Concept' for site selection process developed, involving all stakeholders
- 'Concept': geology defines site, develop surface infrastructure with region
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- Interaction of stakeholders with public with clearly defined roles
- Rules to involve region in structured manner (jointly developed with regions)
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- Field work is an excellent opportunity to make personal contacts
- Importance of convincing geological arguments on *'why here and not there'*

The overall programme

- Demonstration of disposal feasibility (L/ILW: 1988, HLW: 1988/2006), requiring the development of an adequate scientific basis
- Site selection ('Sectoral Plan')
  - Development of rules (2008)
  - Stage 1: selection of siting regions (2011)
  - Stage 2: selection of siting areas for surface facility within siting regions, narrowing down of siting regions to at least 2 for each repository type (2018)
  - Stage 3: selection of a site for each repository type & preparation of general license application (2024)
- General license (~2030)
- Construction license
- License for closure

years: endpoints (high-level decision taken)

Summary: the most important issues in Switzerland

- National commitment to progress with disposal of radioactive waste
- Clarity in stepwise process (defined before start of site selection)
  - roles & responsibilities to reach sustainable decisions at the highest level
  - phases & milestones with adequate objectives (stepwise refinement of options)
  - suitable criteria to develop & evaluate the options with *'first priority to safety'*
- Correct & professional behaviour of all stakeholders ensured through a neutral capable & strong process owner (government agency)
- Projects of high technical quality (developed by competent implementer & reviewed by credible & independent regulator), considering the needs of local society
- Socio-economic-ecological impact on region evaluated, not dominating
- Provide the time & information needed for society to become an informed partner in the project and to understand the *'why here and not there'*
- Interaction with the public 'at equal level' (incl. listening), understandable for public to become familiar with organisation & to be able to contribute to project

thank you
for your attention

piet.zuidema@zuidema-consult.ch