

FCC Subsurface Site Investigations for Areas of Geological Uncertainty FCC Week 2024 San Francisco

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Overview

- 1.Recap of subsurface site investigations (SSI) objectives
- 2.Current understanding of geology in the FCC region
- 3.Original scope of FCC SSI put out to tender in 2023
- 4.Results of tender and strategy amendments
- 5.Provisional SSI programme and deliverables
- 6.Future site investigation campaigns
- 7.Additional studies
- 8.Conclusions

Recap of Subsurface Site Investigations (SSI)

ILF/GADZ 2020/21

- Definition of 'Areas of Geological Uncertainty' for the preferred alignment scenario

Université de Genève 2021-2024

- Geological data gathering and creation of geological model

Quantum (Egis/BG) 2022-2024

- Detailed analysis of 'Areas of Geological Uncertainty' for the amended alignment and updated geological models
- Optimization of the proposed SSI campaign scope of works
- Cost estimates and schedule for SSI
- Preparation of Technical Specifications for SSI Contractor MS and IT
- Analysis of bidder's tender returns, finalization of contractual documentation and technical input to permitting activities



Geology in the FCC Region

Main geological characteristics

Moraines (Quaternary Deposits)

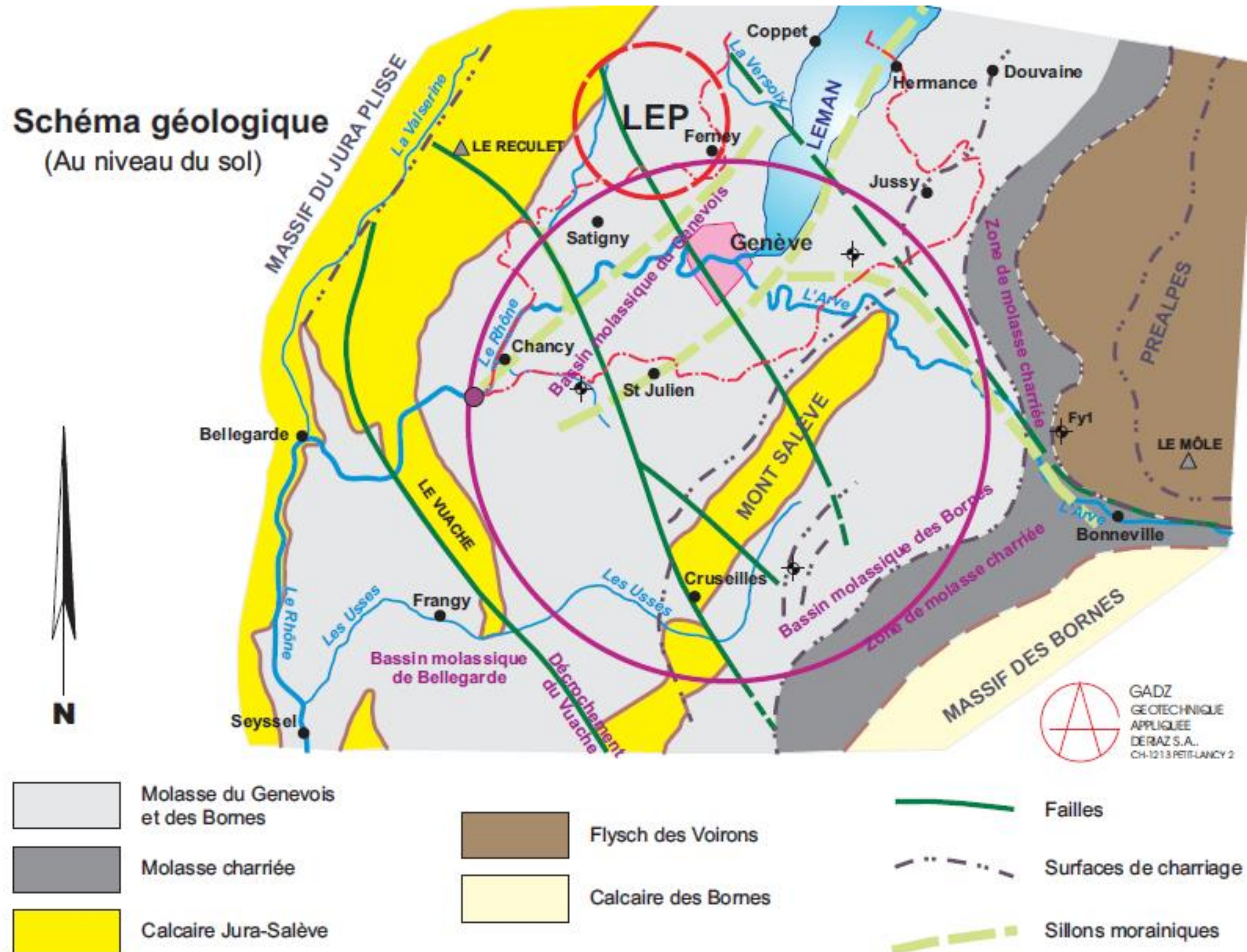
- Glacial deposits comprising gravel, sands, silt and clay
- Water bearing

Molasse

- Mixture of sandstones, marls and formations of intermediate composition
- Soft rock (Average compressive strength: 5.5-48 Mpa)
- Considered good excavation rock for a TBM
- Dry and stable

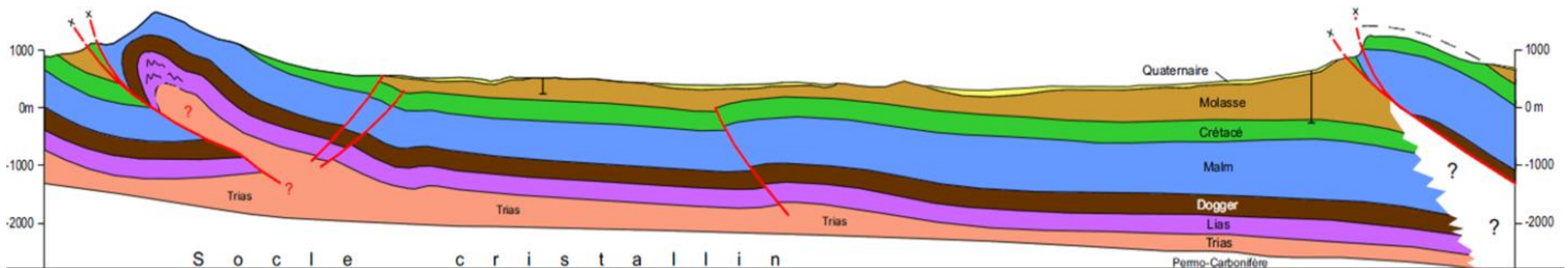
Limestone (Cretaceous)

- Hard rock
- In this region, fractures and karsts are likely present
- Risk of encountering artesian water flows
- Possible to excavate using TBM
- Could be excavated using drill & blast technique



Geology in the FCC Region

- Moraines vary in depth, generally 50-150m
- The molasse will host the majority of the infrastructure
- Karstic limestone is present in the southern and western extents of the alignment



West-East geological section of the Geneva region

Areas of Geological Uncertainty

- Good knowledge of the ground (e.g. information near to CERN from LEP/LHC projects)

Jura

- Limestone/molasse interface uncertain.
- Risk of karsts and high-water pressures

Le Rhône

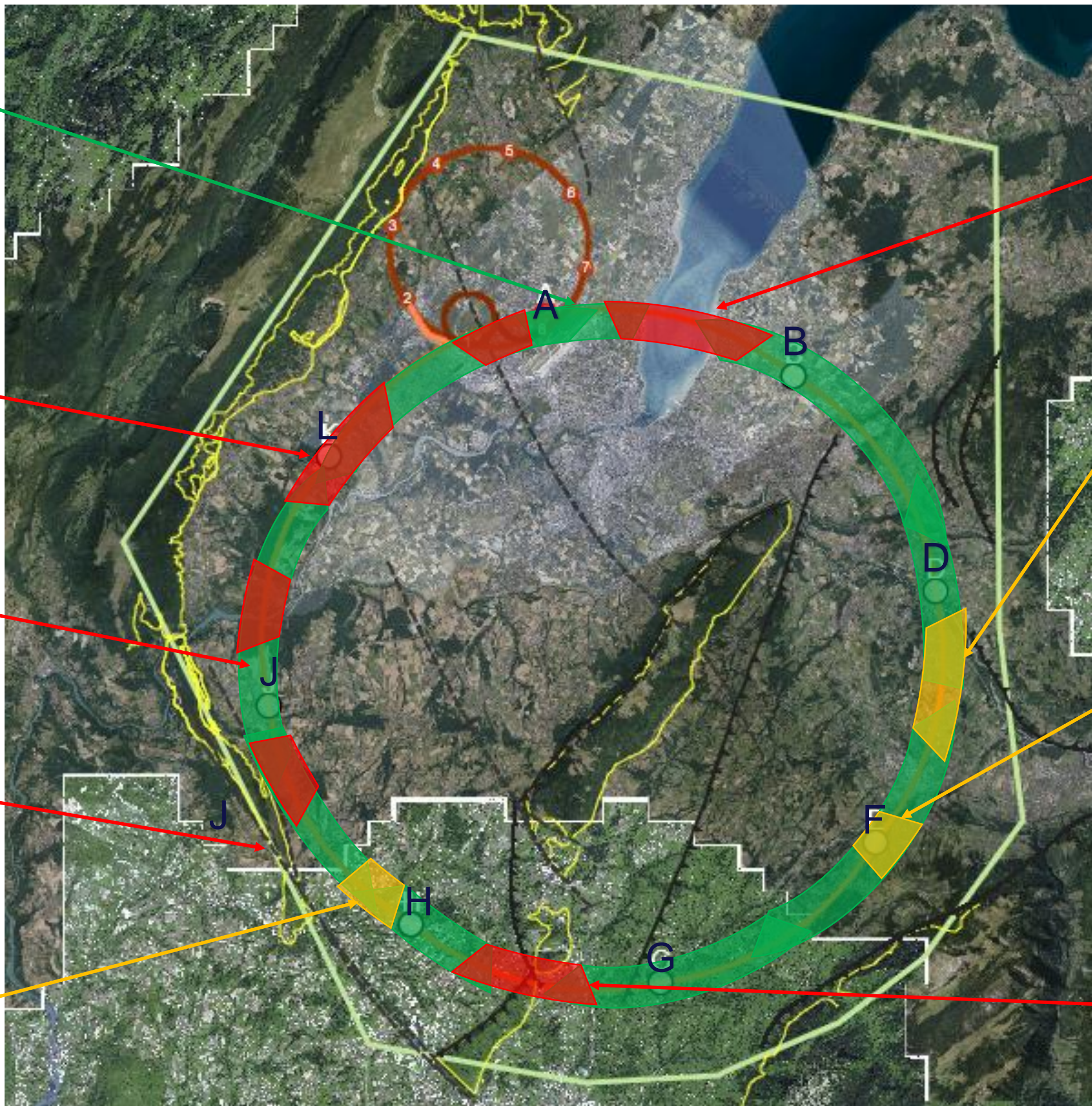
- Moraine/molasse interface uncertain.

Vuache

- Limestone/molasse interface not certain.
- Proximity to main active fault

Les Usses

- Moraine/molasse interface uncertain.
- Low tunnel rock cover



Lac Léman

- Moraine/molasse interface uncertain
- Soils and rock properties uncertain
- High uncertainty in the hydrogeological conditions

Vallée de l'Arve

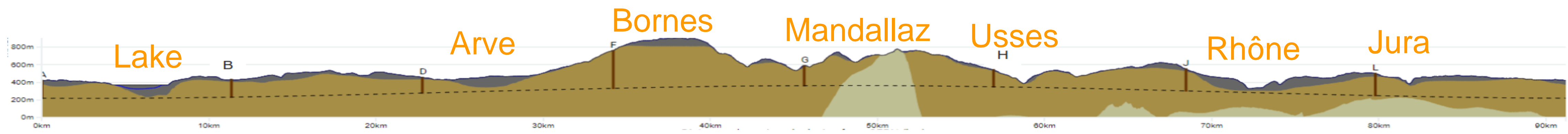
- Moraine/molasse interface uncertain.
- Lack of reliable borehole information

Bornes

- Insufficient deep borehole information
- Complex faulted region
- Quality of molasse is uncertain.

Mandallaz

- Fractured limestone formations, characteristics and locations of karsts unknown.
- High water pressures

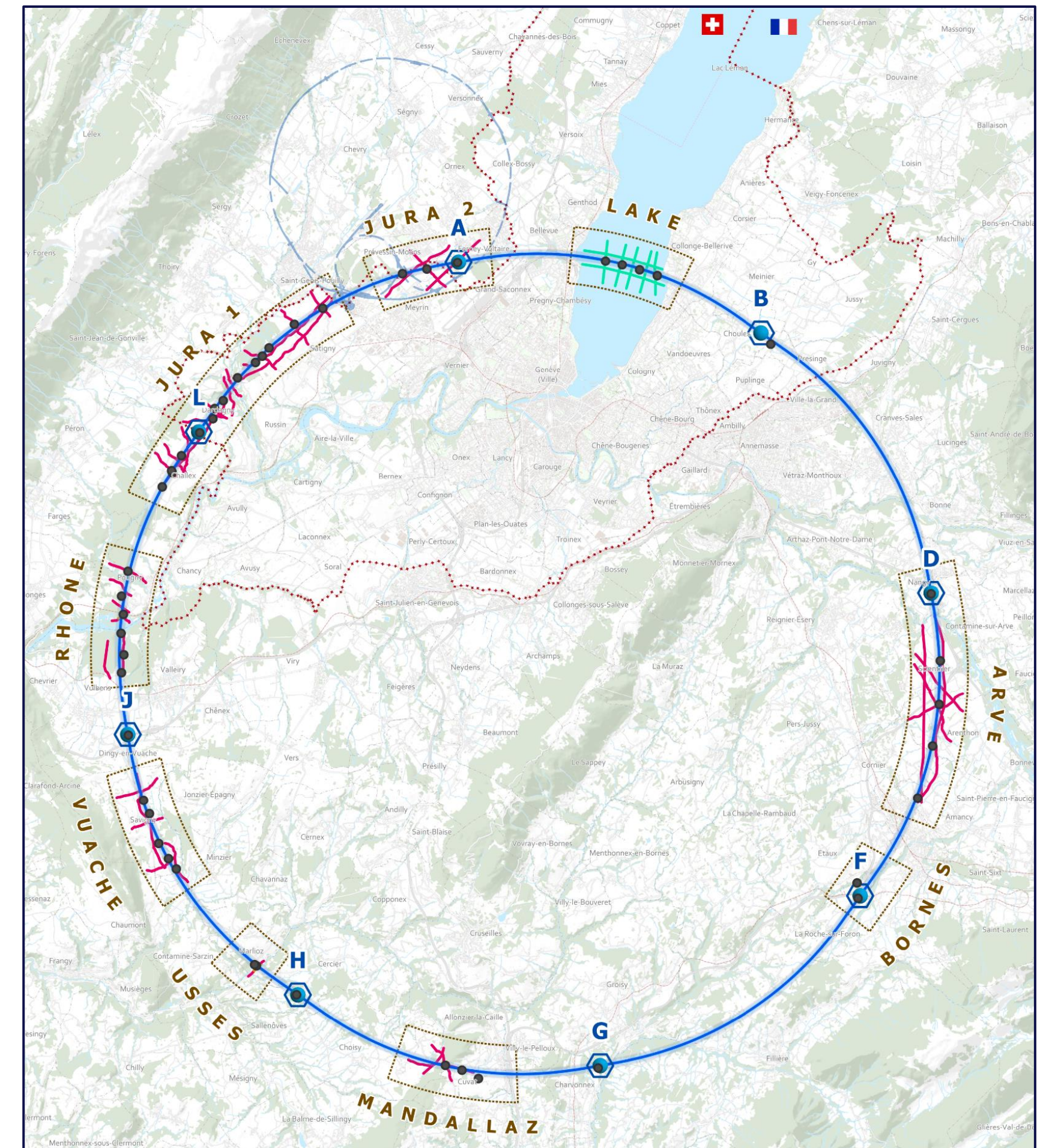
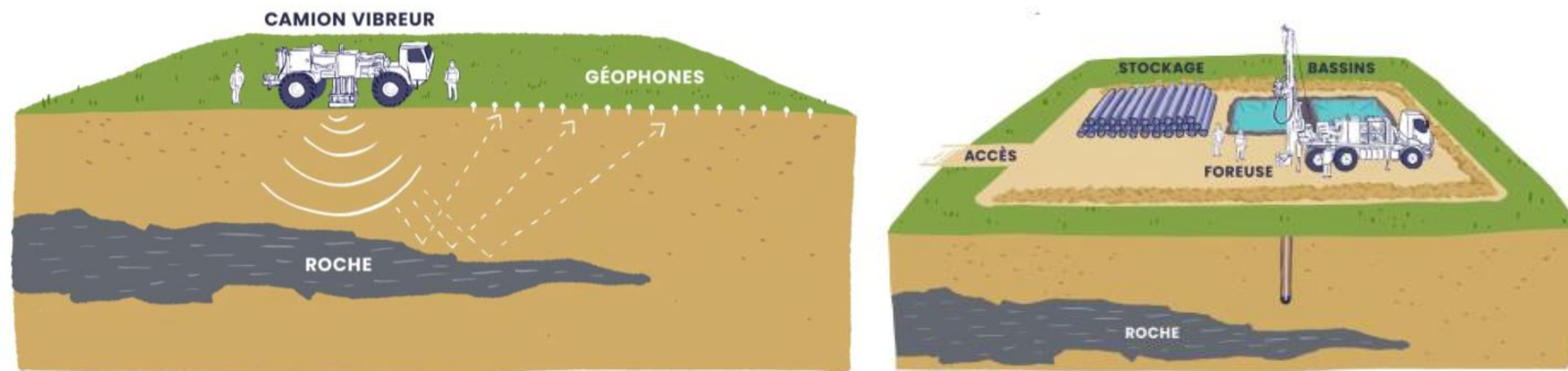


Original Scope of SSI Put Out to Tender in 2023

The scope put out to tender in October 2023 was envisaged as a single contract for the entirety of the works, with investigations both in France and in Switzerland

This was made up of:

- Over 80km of 2D seismic geophysics
- 48 boreholes both fully and partially cored



Layout of scope put out to tender in Oct 23

Results of Tender Oct 2023

- Three international consortia were admitted to the tender stage
- Bids from two consortia were technically compliant and extremely close in value

French/Swiss group
GEOTEC-ERG-ISR



UK/Italian group
SGS3



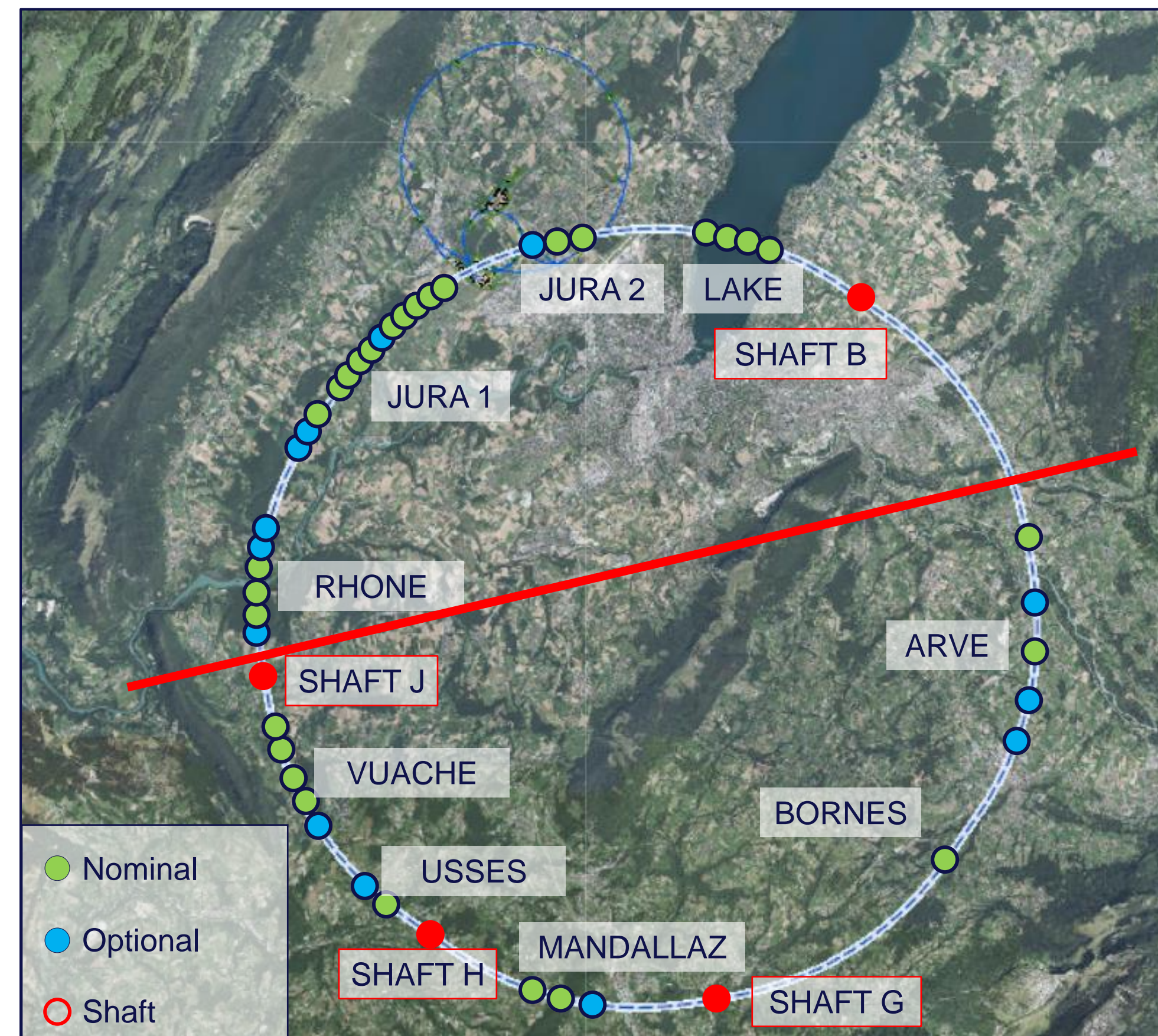
Strategy Amendments

With both bids being so close in value, the decision was made to split the full scope into two separate contracts. This has the following advantages:

- Returns contracts to 4 major member states (FR/CH/UK/IT) and gives CERN more flexibility to accelerate works
- Engages more industrial partners ahead of potentially bigger future SI campaigns

The following technical scope amendments were incorporated:

- 15 boreholes were set as optional pending geophysics results
- 4 Shaft boreholes not located in target areas were postponed to the future campaign
- Geophysics scope remained unchanged



Division of SSI scope

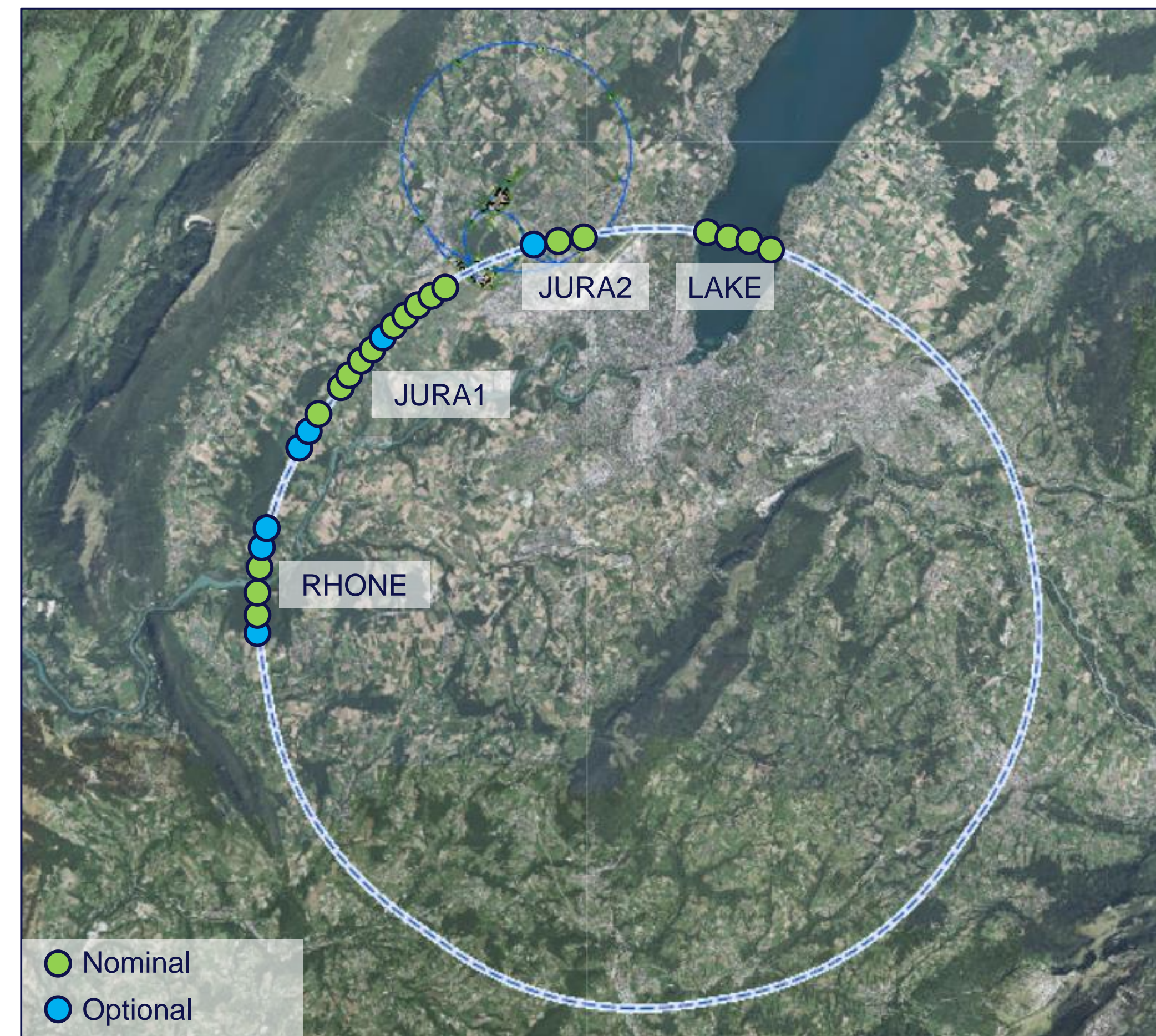
Strategy Amendments



GEOTEC-ERG-ISR were allotted northern-eastern works package

This includes 19 nominal boreholes and 50km of geophysics in sections:

- Rhone
- Jura 1
- Jura 2
- Lake



GEOTEC-ERG-ISR scope

Strategy amendments



SGS3 were allotted south-western package

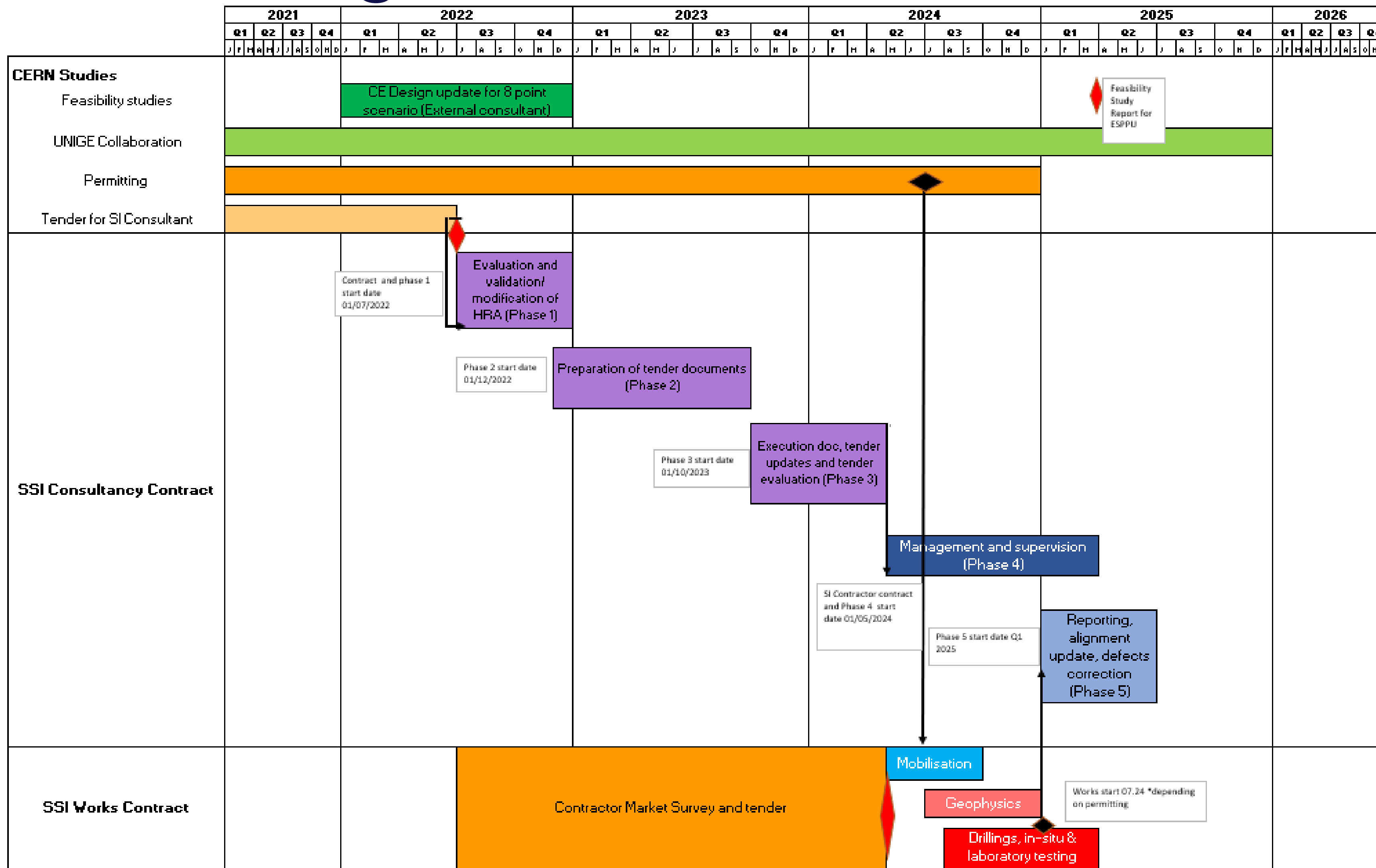
This includes 10 boreholes and 30km of geophysics in sections:

- Vuache
- Usses
- Mandallaz
- Bornes
- Arve



SGS3 scope

Provisional Programme

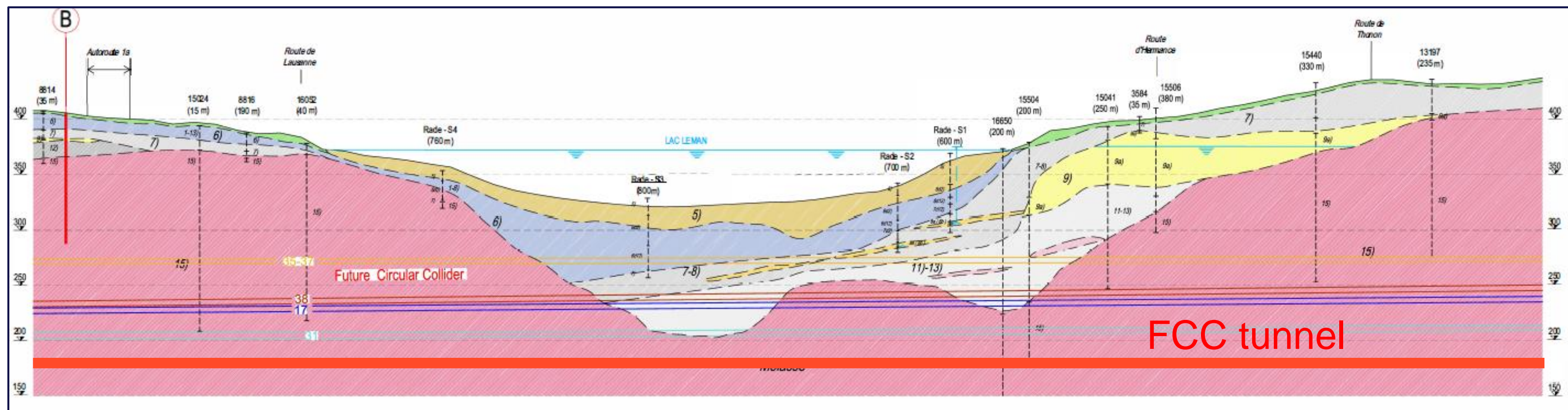


Outcomes Required from SSI

The main goals of the SSI campaign are:

Identification of the moraine-molasse interface under the Lake

- The baseline alignment is close to the predicted interface
- Our objective is to stay within impermeable molasse
- In all scenarios, the lake critically influences the depth of overall tunnel alignment



Geological profile below Lake Geneva



Drilling on Lake Geneva

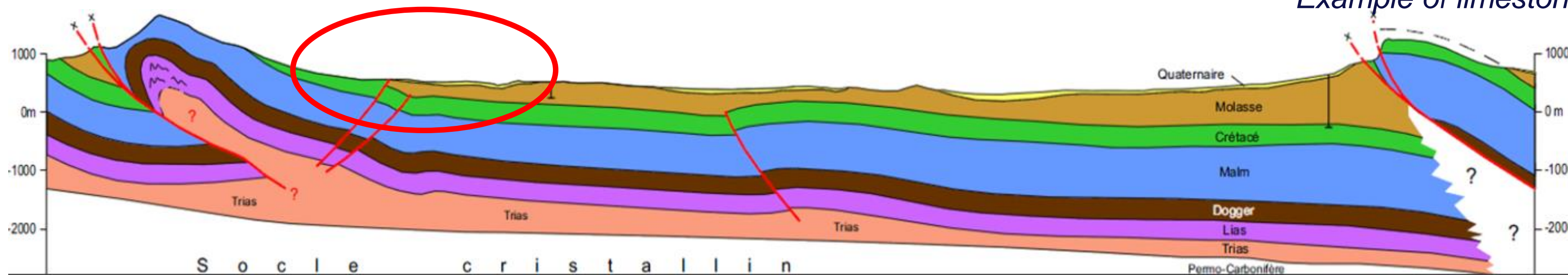
Outcomes Required from SSI

Identification of the molasse-limestone interface in the Jura

- The predicted depth of the limestone in the Jura is uncertain. Limestone in this region is known to be karstic and can be subject to considerable artesian water flows
- These need to be avoided during construction



Example of limestone Jura (le Reculet)



West-East geological section of the Geneva region

Outcomes Required from SSI

The identification of the moraine-molasse interface in the Rhone Valley

- The current alignment configuration is close to the surface at the Rhone Valley and water-bearing alluvial soils should be avoided if possible

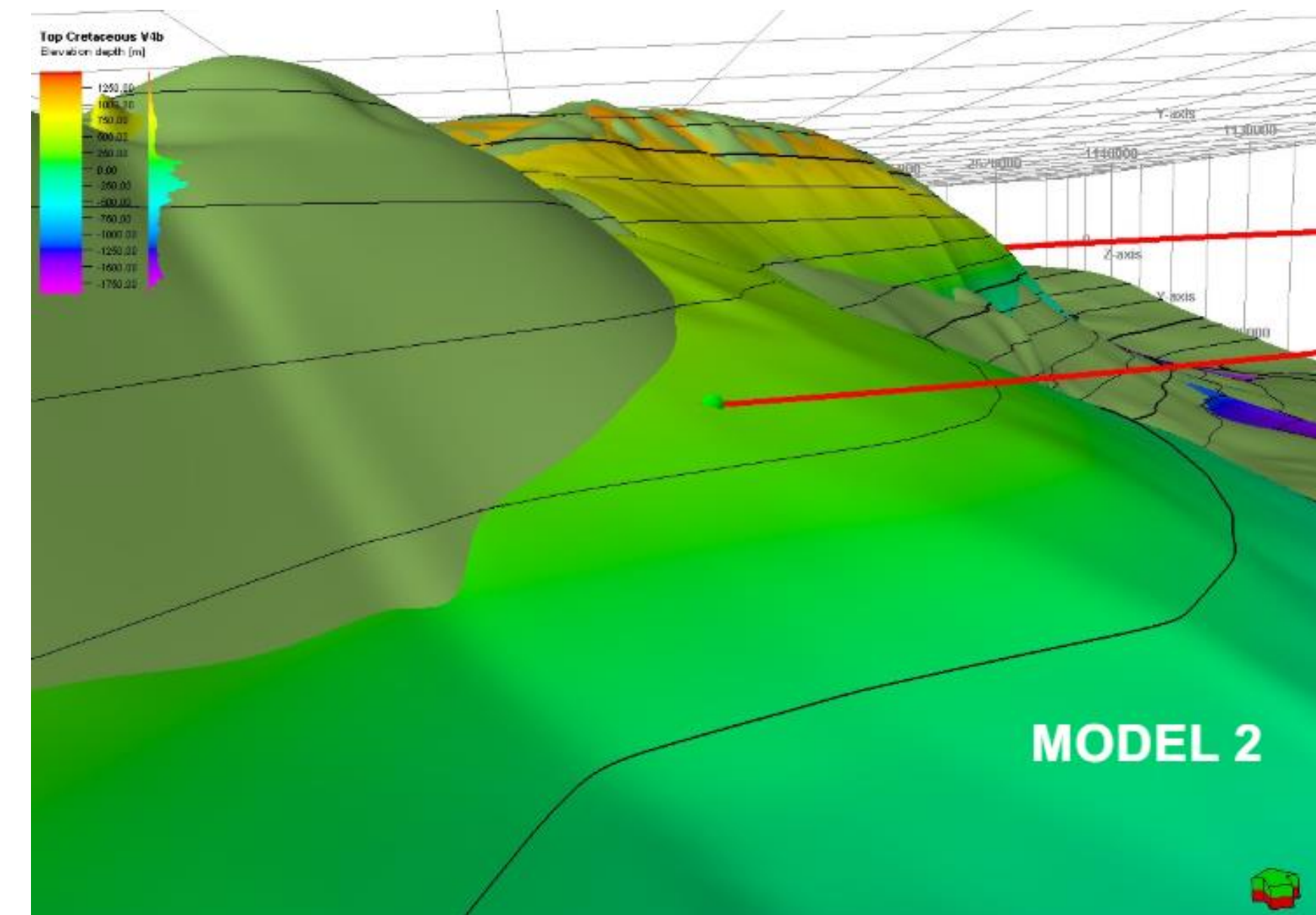
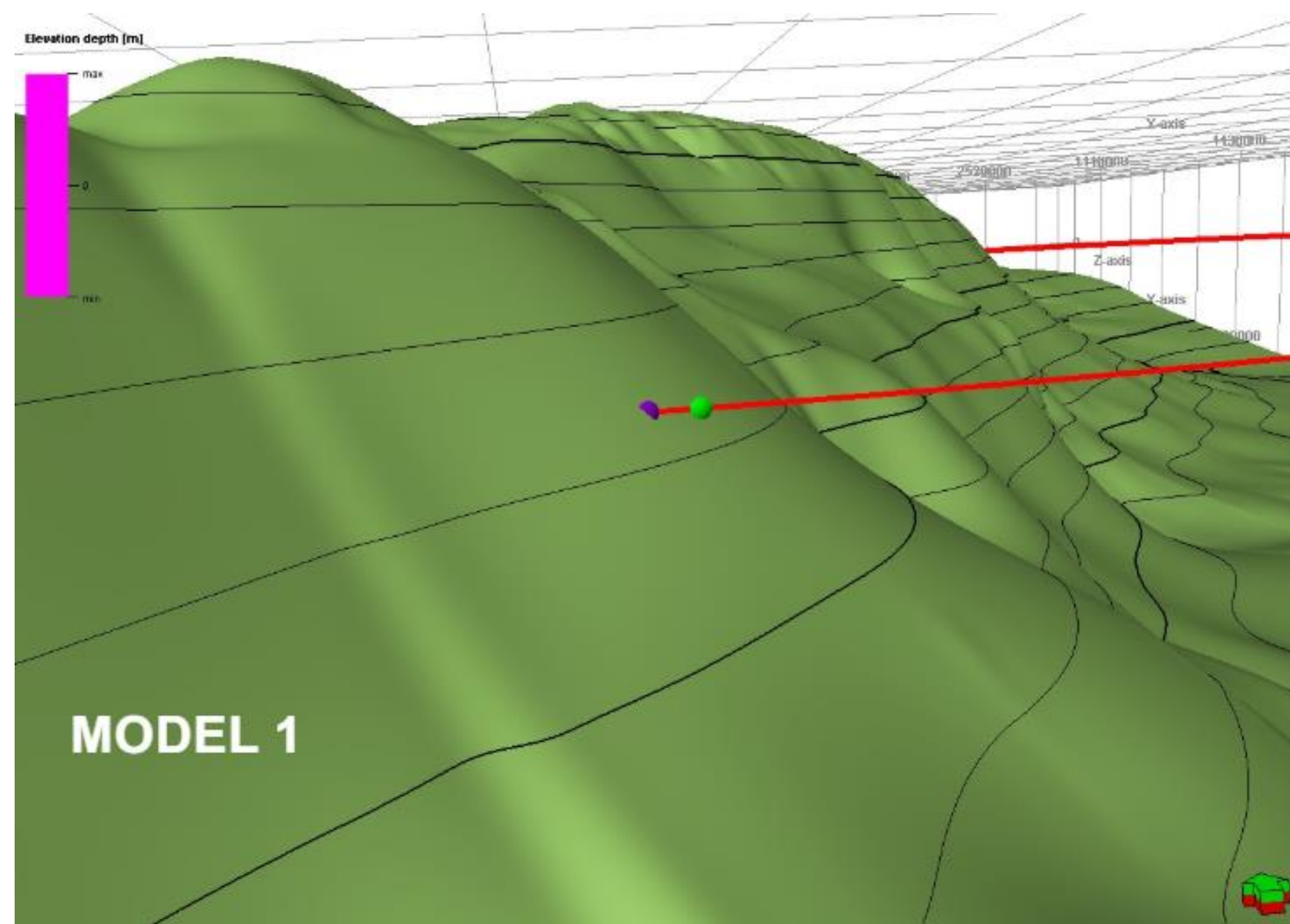


The Rhone River and le Marais de l'Etournal protected area

Outcomes Required from SSI

The identification of the extent of the limestone in Mandallaz

- This will help accurately map the width of the Mandallaz massive and identify potential hazardous geological features for tunnelling.
- The objective is to reduce the total length of tunnel in limestone



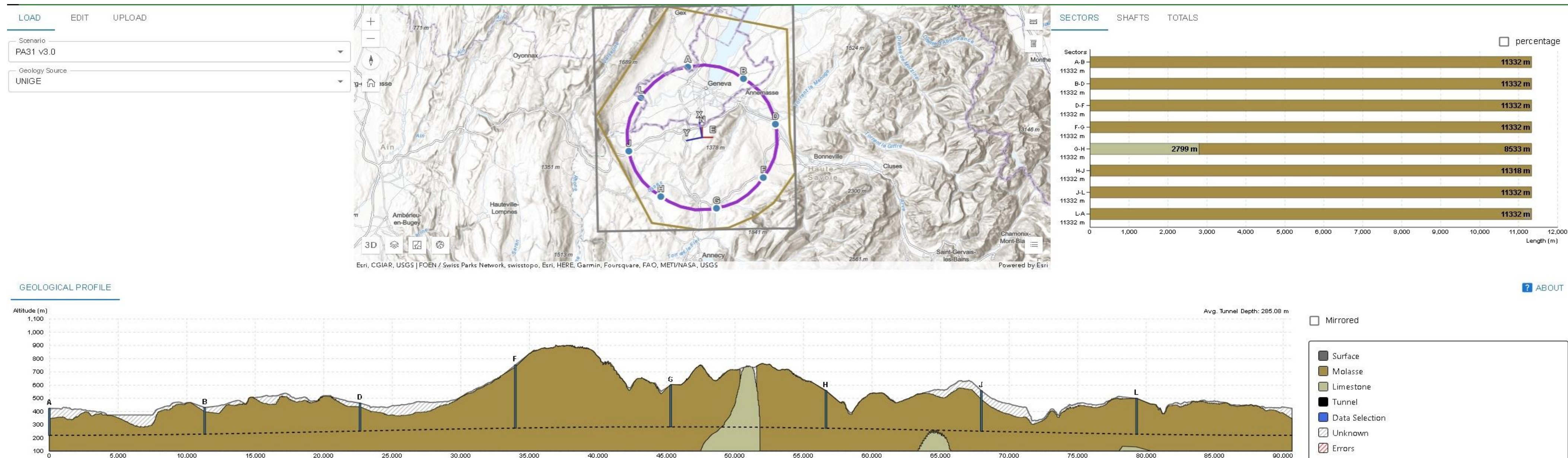
UNIGE models of the limestone in Mandallaz Massive

Modifications to the Tunnel Alignment

The alignment can be optimized using CERN in-house developed Geoprofiler tool

The Geoprofiler tool allows CERN to input multiple 3D geological models and;

- Change the tilt of the alignment in two axes
- Vary the depth of the overall alignment
- Automatically solve for the best alignment configuration based on multiple criteria



Future Site Investigation Campaigns

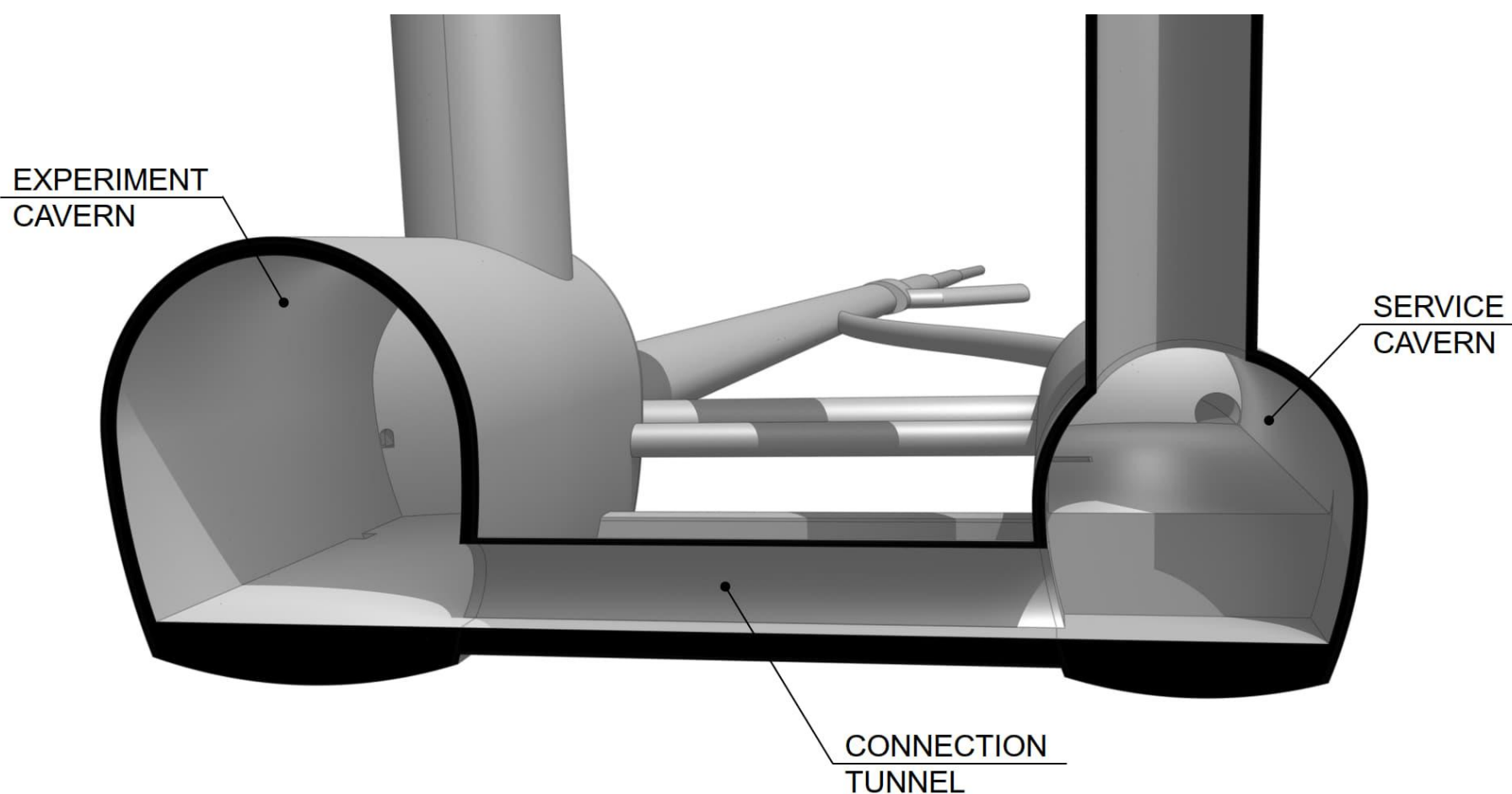
Following SSI works phase 1 further site investigation works are foreseen

Site investigation works phase 2

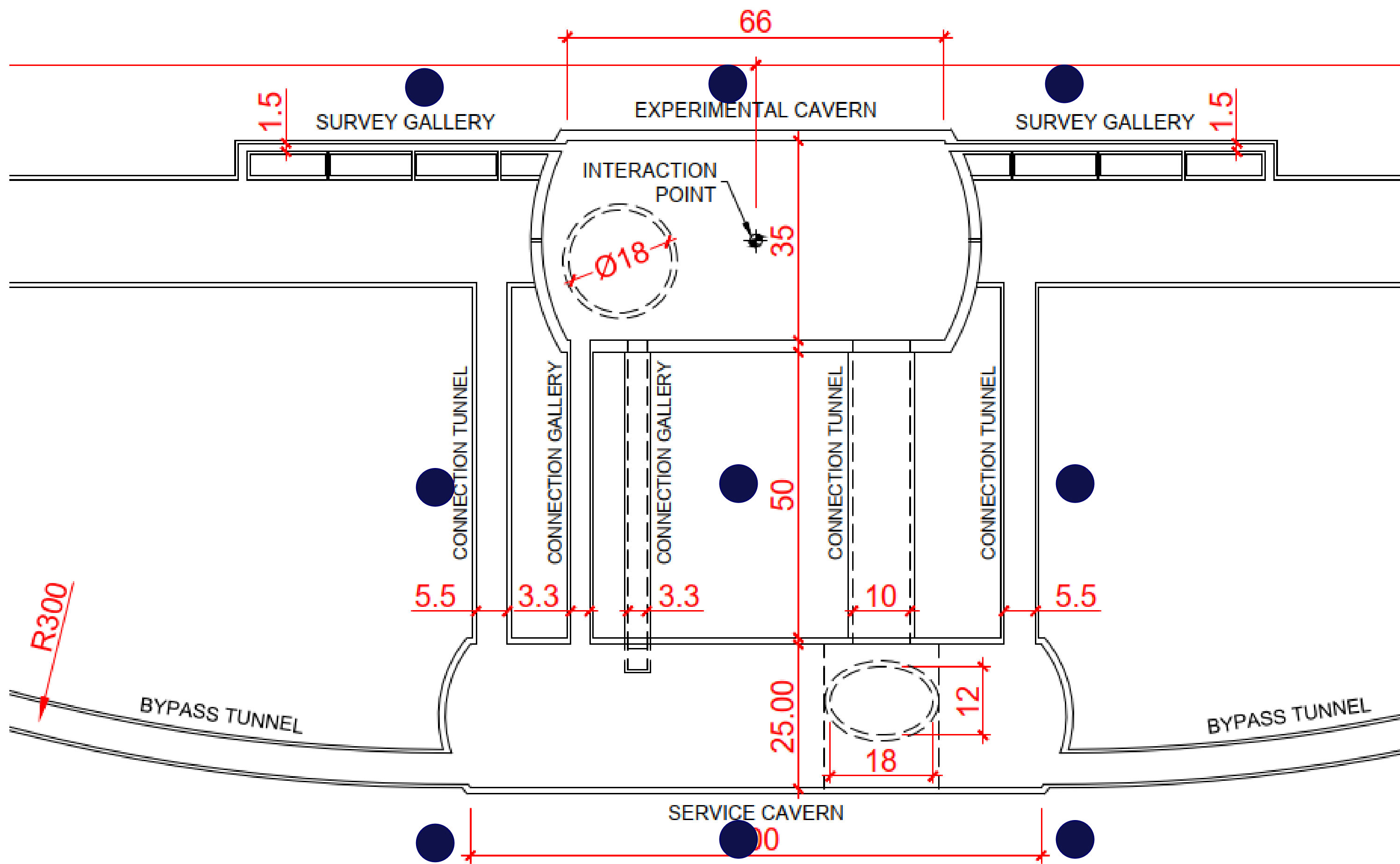
- Targeted additional investigations around key underground infrastructure such as caverns and shafts
- This campaign will give sufficient detail to allow for the tender of construction works packages.
- Planned from 2027-2028

Example of Targeted Boreholes

- A 3x3 layout of targeted boreholes will allow a detailed 3d model of the cavern complexes to be created



Schematic of FCC IP cavern complex



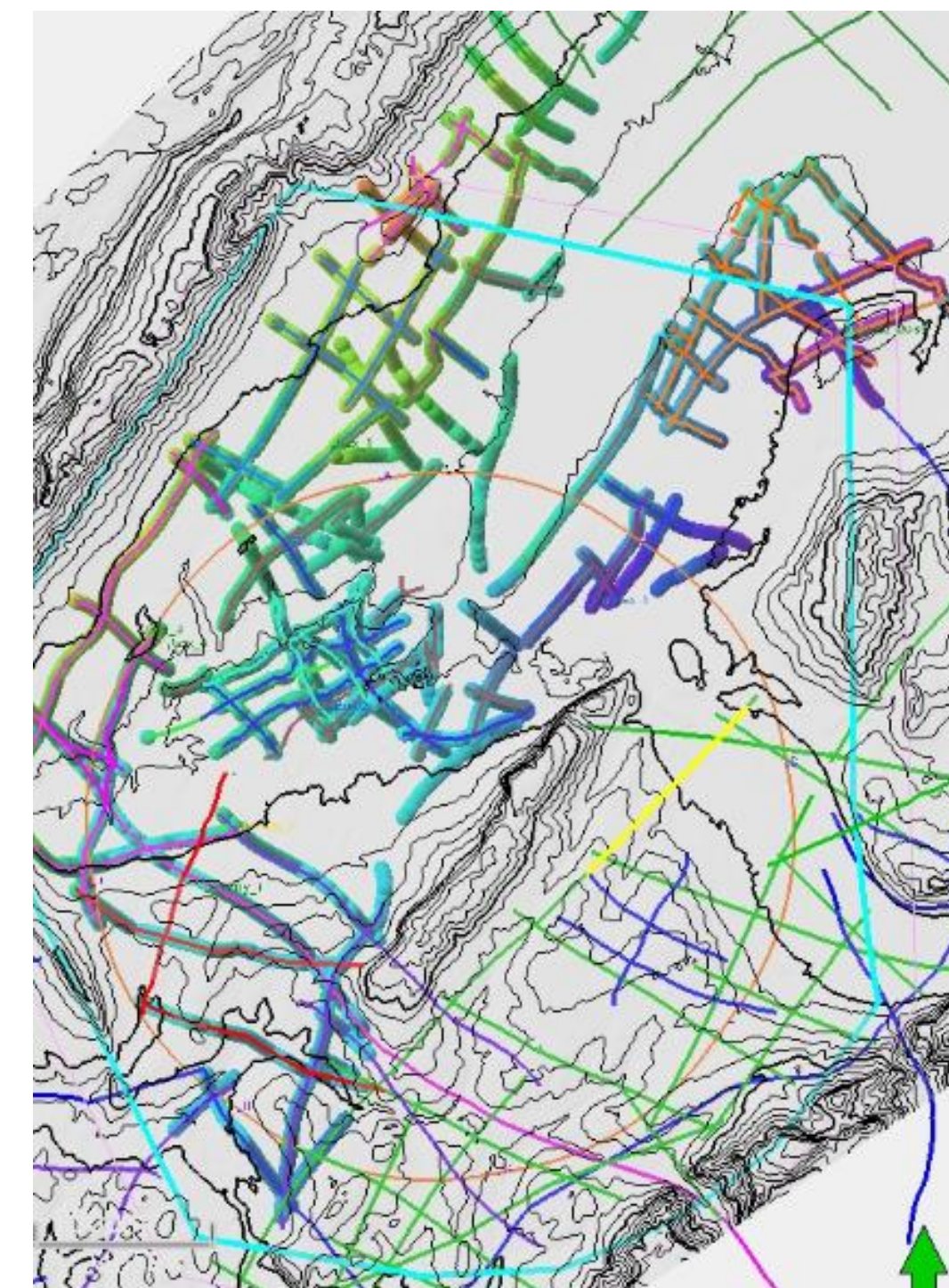
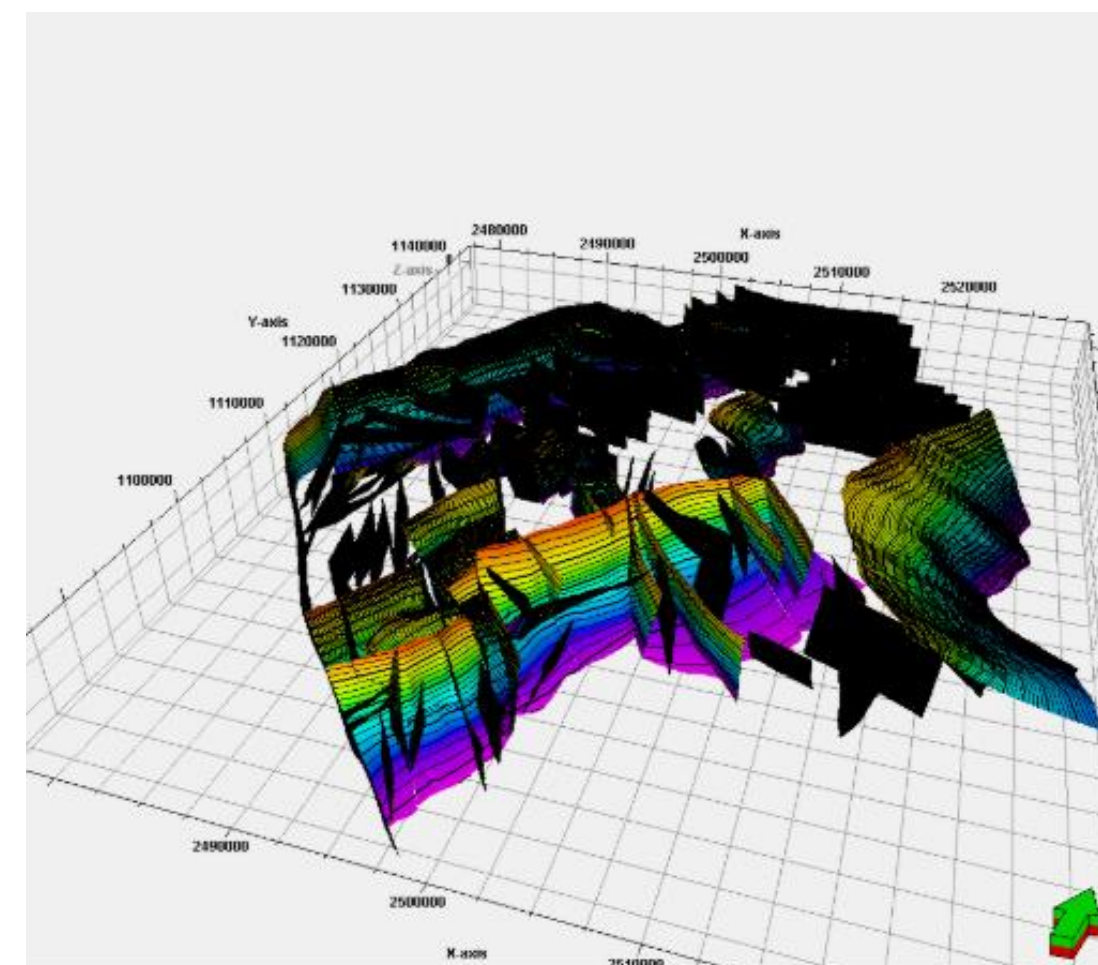
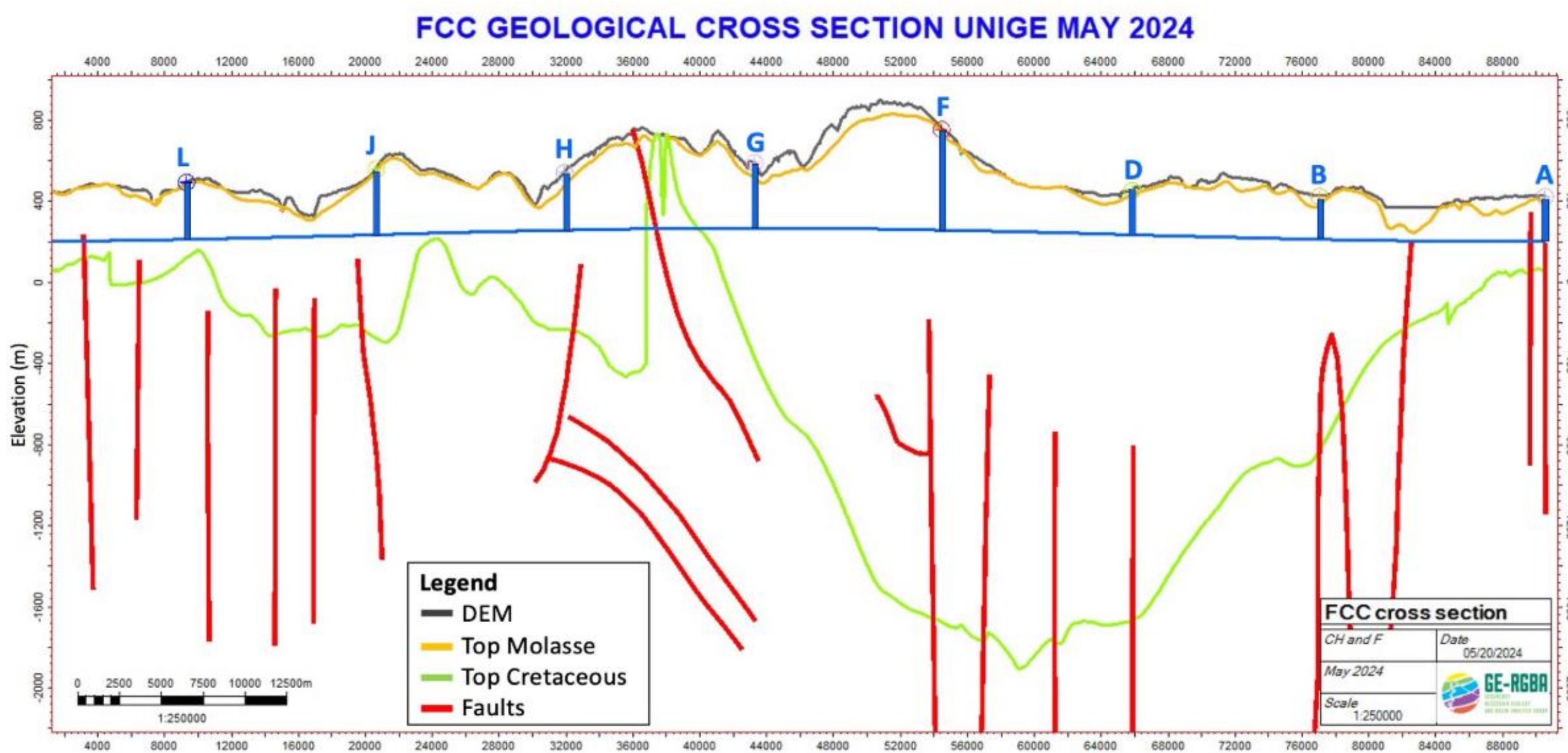
Future Site Investigation Campaigns

Site investigation works phase 3

- Additional supplementary investigations in areas where gaps still exist that will be identified by the design consultant
- These will allow the engineer to design the full scope of construction works
- Planned from 2028-2030

Additional Studies

- Detailed mapping of the faulting along the FCC alignment in collaboration UNIGE
- Understanding the potential effects of this faulting on the tunnel and construction process



Conclusions

- SSI campaign targeting areas of most uncertainty and will help reduce risk in the geological model
- The campaign is due to start imminently and will be executed by two separate international groups
- Data acquired from SSI campaign will be used to update the model in the Mid-term Report and reduce uncertainty for the Feasibility Report
- Future campaigns to follow this SSI campaign are already being designed
- Collaborations with industrial and academic partners continue to reduce global uncertainty in the geological model, in turn reducing uncertainty in the cost and schedule estimate

Thanks to all collaborators

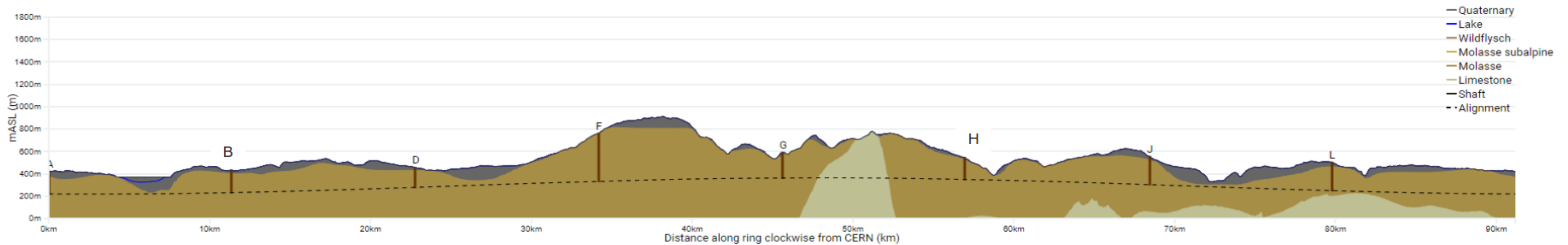
SCE-SAM-FS
SCE-SAM-TG
QUANTUM
ILF
UNIGE
GADZ



Back-up slides

Placement Considerations

- Keep the tunnel and caverns in molasse wherever feasible
- Footprint of alignment fixed due to surface constraints
- Maintain a tilt of the alignment plane at around 0.5%
- Avoid water bearing moraines
- Avoid potentially karstic limestone wherever possible
- Keep overall depth of shafts as low as possible

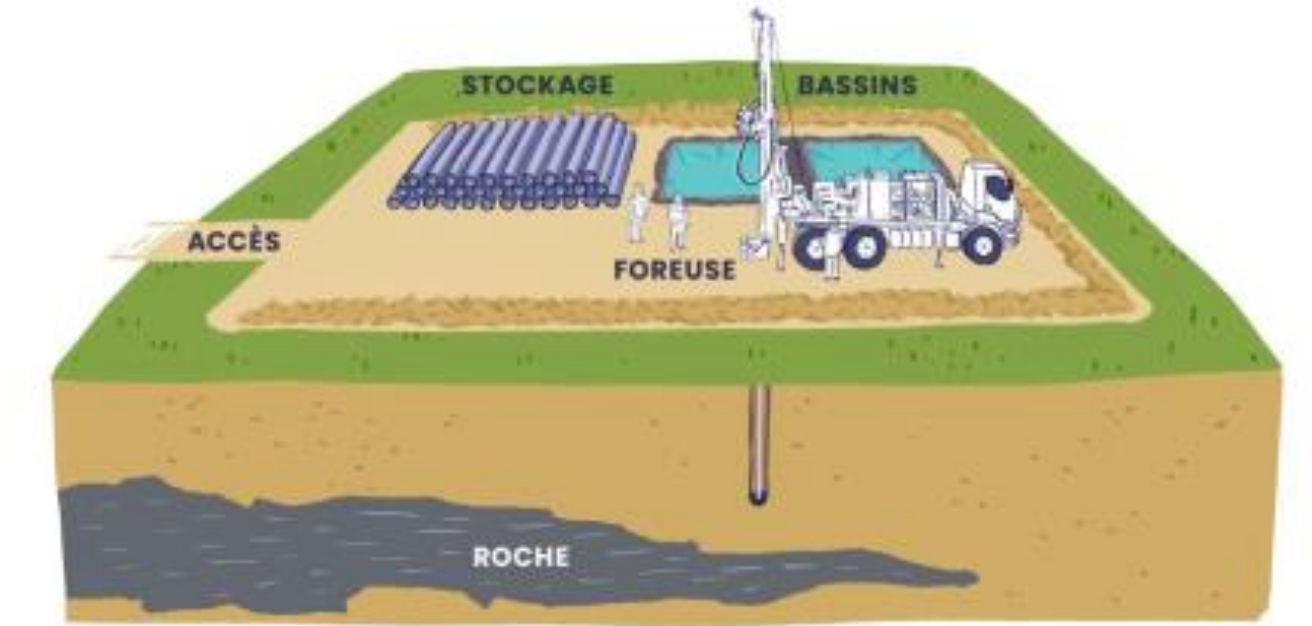


Types of Site Investigation: Boreholes

Geotechnical borehole drillings

- 48 boreholes (including 4 on Lake Geneva)
- Certain boreholes to be equipped with piezometers

Sector	Quantity	Depths (m)
Jura 1	13	230-275
Jura 2	3	240-250
Lake	4	130-185
Arve	5	185-210
Mandallaz	3	360-510
Usses	2	70-75
Vuache	5	210-295
Rhône	7	75-190



Drilling at Prevezin, CERN 2020



Drilling on Lake Geneva

Credit: www.swissdrilling.ch

Subsurface Investigation– Lake Geneva

Aims

- Confirm the depth of the fluvio-glacial alluvial deposits
- Precise location of the molasse/moraine interface
- 4 boreholes
- 8 seismic lines

