EXCAVATED MATERIALS MANAGEMENT STRATEGY

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Strategy developed in collaboration with:

Centre for Tunnel Studies, France

Centre for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning, France

Technical University of Leoben, Austria

Technical support by the GESDEC (Canton of Geneva's department of geology, soil and waste)

Collaborations with external experts:

- *Regulatory framework:* University of Lyon 3,
- *3D subsurface modelling:* University of Geneva, University of Grenoble, University "La Sorbonne" (Paris)

Support by external consultants:

- Inventory of regional opportunities: SETEC/Lerm, WSP
- Feasibility study for railroad connection: EGIS-rail

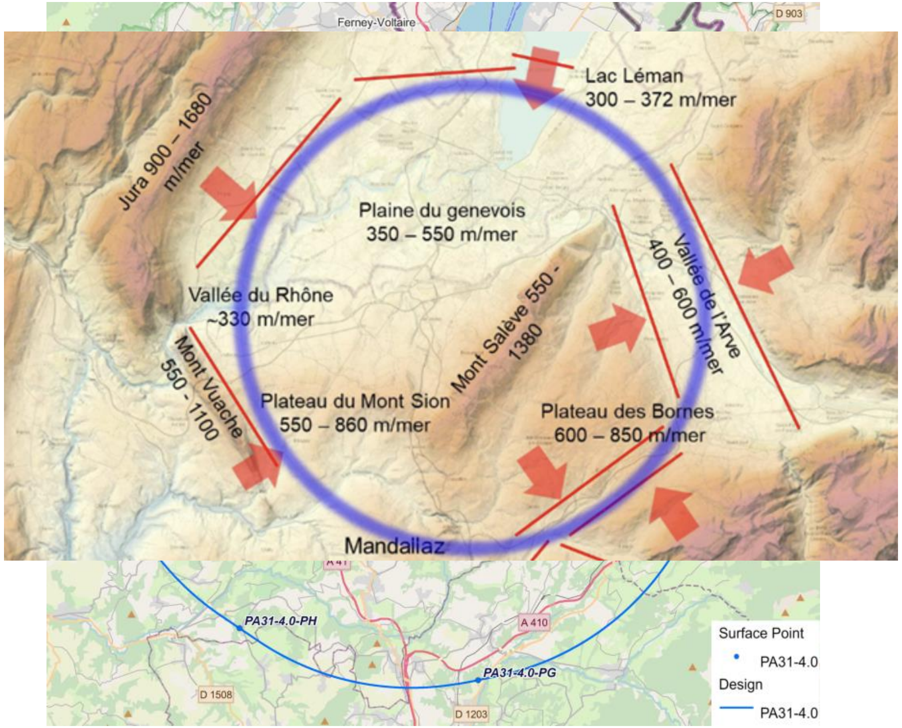
Management of excavated materials: rationale

Excavated Materials (MATEX):
6.3 Mm^3 material (in-situ)- about 16.4 Mt

95% heterogeneous sedimentary **molasse**, 3% limestone, 2% moraine

Type of material	Quantity (in-situ)
Limestone	141 200 m^3
Quaternary deposits	179 800 m^3
Molasse	5 971 900 m^3
Total	**6 292 900 m^3**

Average composition of Molasse
- 30 to 50% clay
- 10 to 15% silt
- 10 to 15% sand, with a grain size of between 63 µm and 4 mm
- 15 to 20% sandstone particles larger than 4 mm.



Schematic view of the location of the FCC infrastructures

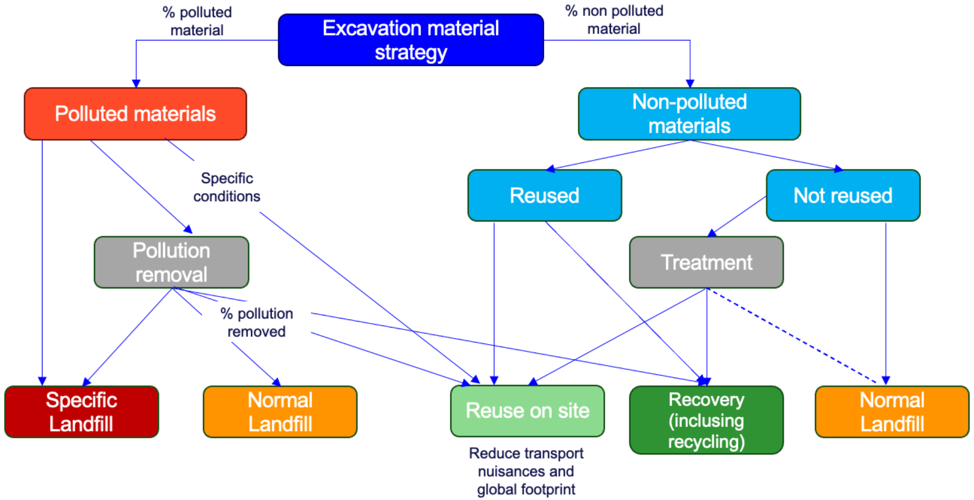
Today **no known industrial-scale re-use** for the molasse

Excavated materials management strategy

Objectives

- To demonstrate the **FCC feasibility** from the perspective of excavated materials' management.
- To anticipate and describe the **main aspects** to be considered by the future project owner (technical, regulatory, timing, etc.).

Excavated materials management strategy ≠ operational management plan



"The way forward is clear."

Main principles of the MATEX strategy

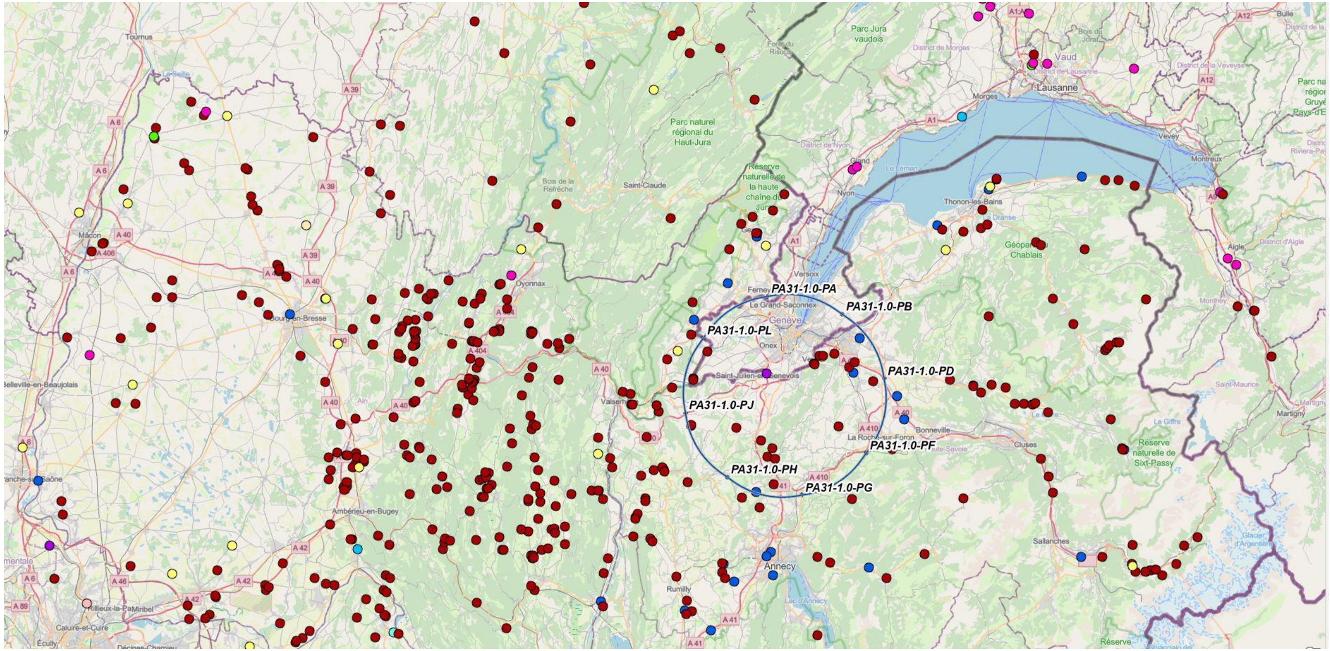
….well, not so straightforward!

Main principles underlying the definition of the owner's strategy

- Identify the **applicable regulations and planning documents: transnational situation.**
- **Anticipate and apply risk management** to MATEX.
- **Identify possible reuse cases** on the basis of geological considerations (incl. potential pollution) and the impact of tunnelling methods.
- Analyse the **economic aspects**, the **MATEX production schedule**, the **project's material needs, those of the local territory** and the requirements for **technical facilities and logistics** (incl. transport).

Ultimately, landfilling should be the last option when no reuse or recovery is possible…

Regional opportunities

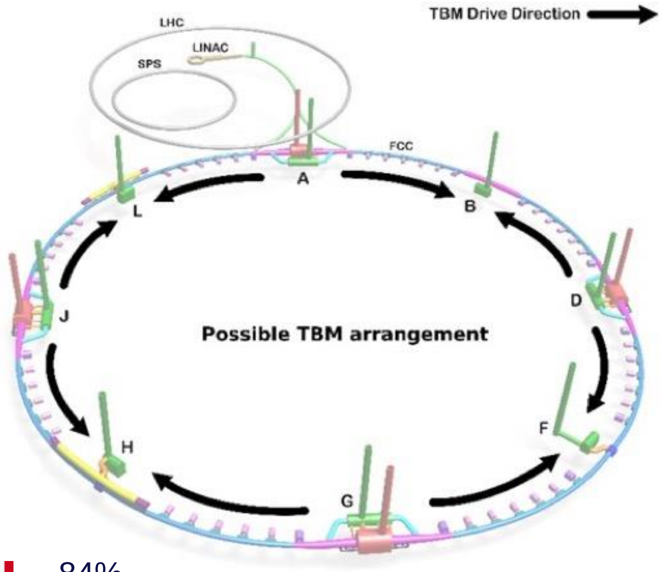


Data collected per site:

- Acceptance criteria
- Authorization of exploitation (beyond 2033)
- Backfilling potential capacity for quarries and mines

Provisional reference scenario for the Tunnel Boring Machines (TBM)

“Fair-share” principle: **each state manages the equivalent mass of MATEX excavated on its territory,** based on the vertical projection of the border FR/CH



Material excavated in France and Switzerland, based on vertical projection of border, including bulk factor[1].

	Vol. All Material (m^3)	Weight. All Material (m^3)	Moraines (t)	Molasse (t)	Limestone (t)
Total	8 180 819	16 361 637	467 501	15 527 081	367 055
Total FR	6 871 888	13 743 775	392 701	13 042 748	367 055
Total CH	1 308 931	2 617 862	74 800	2 484 333	-

FR 84%
CH 16%

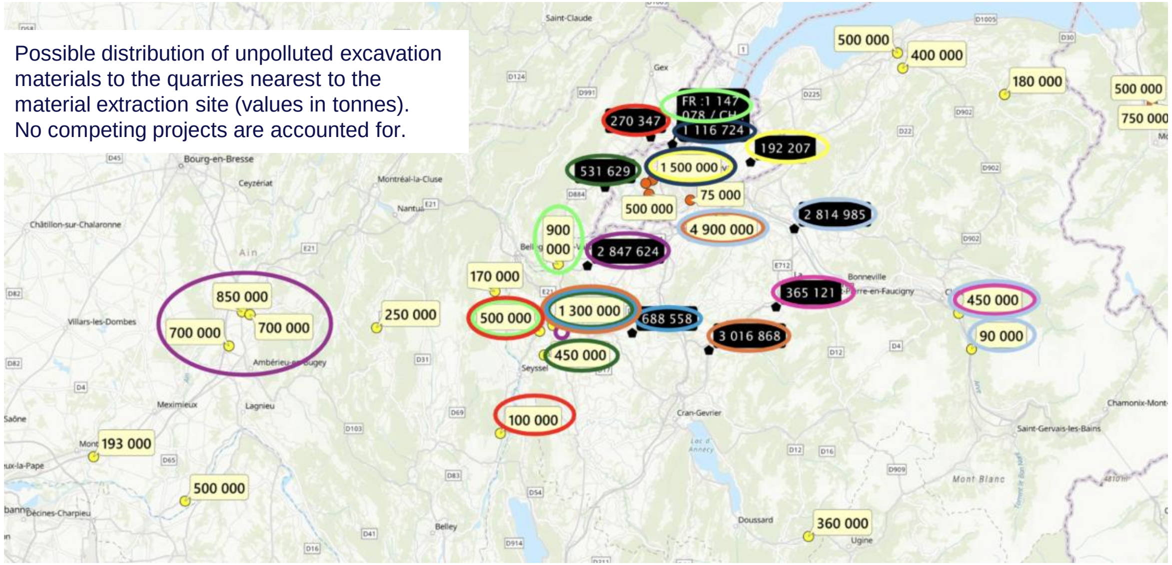
The starting point of each TBM is also the exit point of the excavated materials

Experimental sites (PA, PD, PG, PJ) will probably host:

- Excavated material temporary storage (capacity for a few weeks, depending on the excavation rate).
- Local first treatment to allow for safe transport to the reuse facility.
- Installations to identify and sort the materials according to the pollution and reuse potential.

[1]*Bulk factor: 1.3*

Example of possible distribution of unpolluted excavated materials for the Feasibility Study



- **Regional quarries have sufficient capacity to receive the excavated materials.**
- The inventory of the **potential recipients** was carried out with the only aim of identifying potential showstoppers for the FCC feasibility and evaluating the financial envelope.
- It is just a **first step** for the later application of the “avoid, reduce, compensate” principle.
- It is not possible at this stage to identify the **specific recipients** without engaging in contractual agreements.

Excavated material shall be seen as a “resource” rather than waste ➔ focus on REUSE!

Focus on reuse

The **negative impacts created by landfilling** include degradation of the countryside, potential impacts on nature and potential degrade of the quality of life of surrounding residents.

According to the current regulation in France **excavated material is classified as waste** as soon as it exits the project site. This is why it is important that FCC is considered an **undividable, single project in a transnational context**. Discussion with the authorities of the Host States.

The five-step "waste hierarchy", established in the EU Waste Framework Directive is applied. It establishes an order of preference for managing and disposing of waste.

The focus on finding reuse opportunities addresses the following aims:
- Reduce pressure on existing suitable deposits.
- Reduce the need for long transport (lowering the local nuisances and carbon emissions).
- Reduce the overall project costs.
- Contribute to the socio-economic benefits, beyond the project itself, by proposing innovative reuses.

The reuse of excavated materials

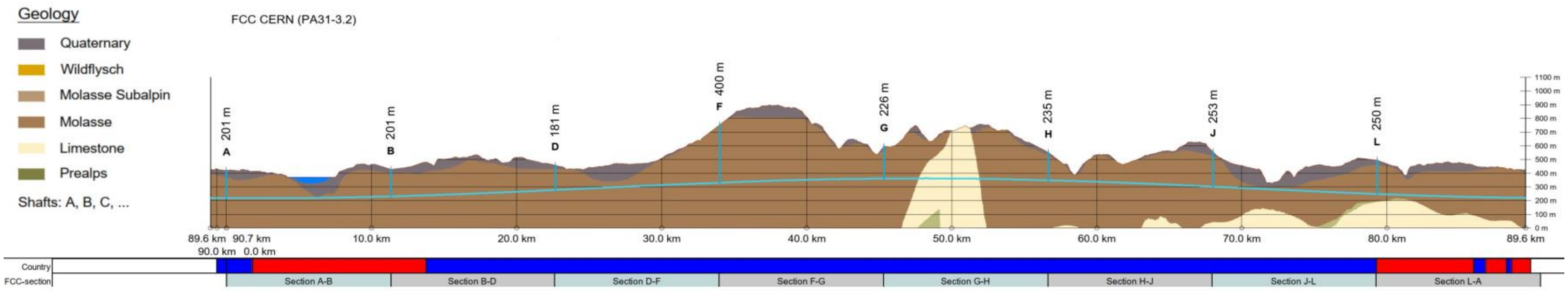
The degree of actual reuse depends largely on the **geochemical, mineralogical and geotechnical properties** of the excavated materials.

The **choice of the tunnelling method** is of particular importance. It influences the **particle size** distribution and on **anthropogenic contamination**.

Possible presence of **geogenic anomalies** (hydrocarbons and heavy metals) also impacts the re-use possibilities.

Risk management: **subsurface investigations at regular intervals** along the tunnel path and with increased frequency at geotechnically unknown regions **are compulsory.**

To **avoid the creation of temporary surface storage**, the results of geochemical, mineralogical and geotechnical analysis should be available as soon as possible - **preferably via online-analyses in the underground during tunneling.**



MATEX composition scenarios

Based on previous CERN projects (LHC and, more recently, HL-LHC)

	Optimistic Scenario	Realistic Scenario	Pessimistic Scenario	Destination
Polluted material Geogenic pollution: Treatment and partial reuse or landfilling	30%	30%	30%	• *Special landfilling* • *Standard landfilling after depollution* • *Reuse after depollution*
Non-polluted material / Used reuse (with or without treatment) on site or offsite and/or recovery	60%	35%	10%	• *Reuse* • *Recovery*
Non-polluted material / Not Used Material not suited for reuse because of lack of adapted treatment or regional opportunities	10%	35%	60%	*Standard landfilling*

Regulatory and legal framework

Transboundary situation: application of the regulatory framework of France and Switzerland

Regulatory aspects	France	Switzerland
Codification of waste	The Swiss definition of “unpolluted excavated materials” (heading 17 05 06) corresponds to a part of heading 17 05 04 “Soil and stone other than that mentioned in heading 17 05 03”, without the soil. Swiss classification makes a distinction between soil and other types of material that can be extracted.	
Hierarchy of waste treatment methods	In France and in Switzerland, the same priorities are given to the various streams: reuse on the worksite, recycling, backfilling of quarries/gravel pits, disposal.	
Waste management prevention and recovery objectives	General national target of 70% material recovery	Cantonal objectives but no national objectives
Possibility of end-of-waste status	Possible via the end-of-waste procedure	/
Responsibility for management	Waste producer	Waste holder
Transboundary movement	Regulation (EC) No. 1013/2006: Article 43 authorises imports into a European country of waste destined for recovery from countries which are parties to the Basel Convention. Article 41 authorising disposal cannot be activated as France has not received a duly reasoned request from Switzerland.	Transboundary movements of waste are governed by Article 23 of the Swiss Ordinance on the Movement of Waste (VeVA 814.610, 2005). FOEN gives permission to import after examining seven criteria, including one indicating that the waste is not being imported to be stored permanently in a landfill.
	Implementation of the Basel Convention signed by France and Switzerland on 31 January 1990.	

Reuse cases

Traditional methods

- Use for **development requirements within the project** (e.g. FCC worksite tracks, landscaping purposes, etc.)
- **Use in earthwork** (backfilling of quarries and mines and rewilding) and development projects
- Use of the **limestone fraction** in concrete production and stabilisation of structures
- Use of the **sand fraction** in concrete production

Innovative methods

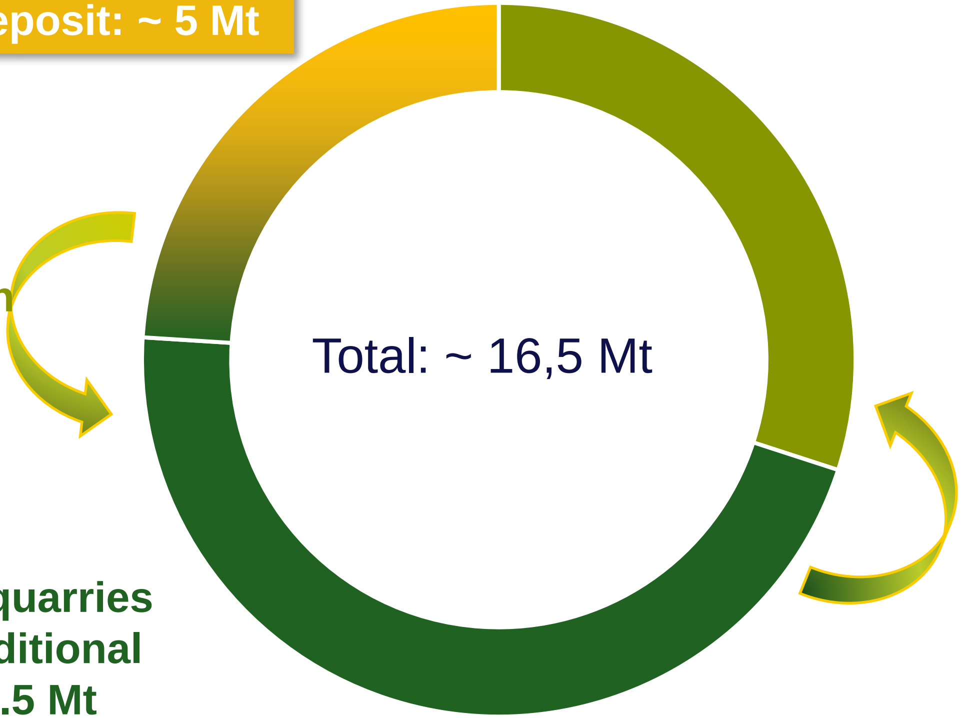
- Transformation of the molasse into **functional (fertile) soil**: development of brownfield sites, urban recreational areas and forest areas, improvement of acidified land and/or as technical areas along the verges of roads and motorways
- Use as **technical materials**: trench cover (e.g., roads), acoustic screens, farm tracks, forest paths etc.
- Development of **building components by compression** (bricks or compressed earth using `sandwich' technology)

Reuse cases

25% reconstituted soil: ~ 4 Mt

30% Deposit: ~ 5 Mt

Innovative characterisation and treatment methods

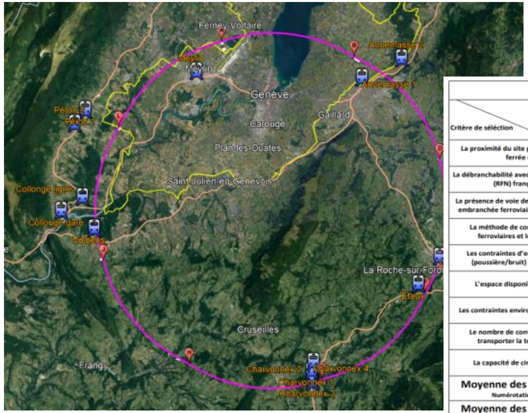


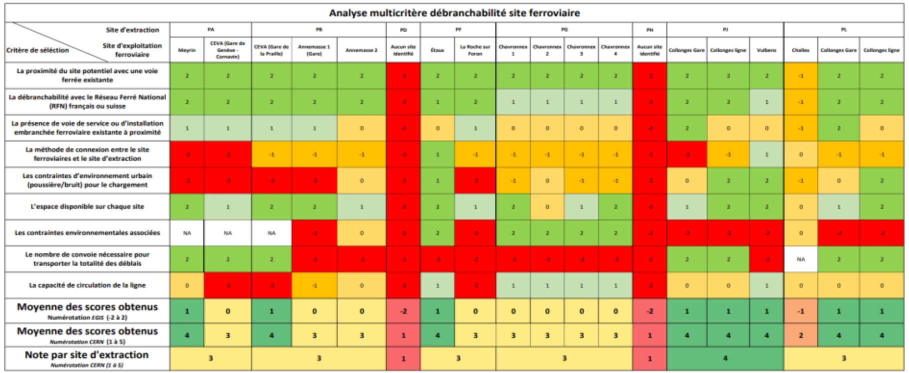
Innovative reuse methods:
Bricks, isolation elements, acoustic screens, etc.

45% re-fill of quarries and other traditional reuses :~ 7.5 Mt

Studies performed for the FCC feasibility study

Feasibility study for railroad connections

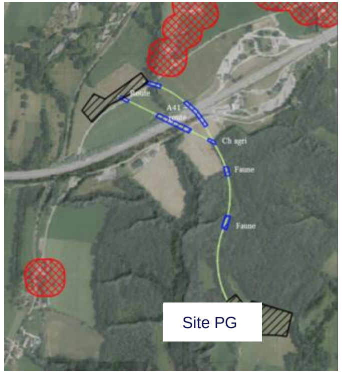




Analyse multicritère débranchabilité site ferroviaire

Critère de séléction \ Site d'extraction / Site d'exploitation ferroviaire	PA		PB			PD	PF		PG				PH	PJ			PL		
	Meyrin	CEVA (Gare de Genève - Cornavin)	CEVA (Gare de la Praille)	Annemasse 1 (Gare)	Annemasse 2	Aucun site identifié	Étaux	La Roche sur Foron	Chavronnex 1	Chavronnex 2	Chavronnex 3	Chavronnex 4	Aucun site identifié	Collonges Gare	Collonges ligne	Vulbens	Challex	Collonges Gare	Collonges ligne
La proximité du site potentiel avec une voie ferrée existante	2	2	2	2	2	-2	2	2	2	2	2	2	-2	2	2	2	-1	2	2
La débranchabilité avec le Réseau Ferré National (RFN) français ou suisse	2	2	2	2	2	-2	1	2	1	1	1	1	-2	2	2	1	-1	2	2
La présence de voie de service ou d'installation embranchée ferroviaire existante à proximité	1	1	1	1	0	-2	0	1	0	0	0	0	-2	2	0	0	-1	2	0
La méthode de connexion entre le site ferroviaires et le site d'extraction	-2	-2	-1	-1	-1	-2	1	-1	-1	-1	-1	-1	-2	-2	-1	1	0	-1	-1
Les contraintes d'environnement urbain (poussière/bruit) pour le chargement	-2	-2	-2	-2	0	-2	1	-2	-1	0	-1	-1	-2	0	2	2	-1	0	2
L'espace disponible sur chaque site	2	1	2	2	1	-2	2	1	2	0	1	2	-2	1	2	2	0	1	2
Les contraintes environnementales associées	NA	NA	NA	-2	0	-2	2	-2	2	2	2	2	-2	-2	-2	-2	0	-2	-2
Le nombre de convoie nécessaire pour transporter la totalité des déblais	2	2	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	2	2	-2	NA	2	2
La capacité de circulation de la ligne	0	-2	-2	-1	0	-2	1	-2	1	1	1	1	-2	0	0	1	0	0	0
Moyenne des scores obtenus Numérotation *EGIS* (-2 à 2)	1	0	1	0	0	-2	1	0	0	0	0	0	-2	1	1	1	-1	1	1
Moyenne des scores obtenus *Numérotation CERN* (1 à 5)	4	3	4	3	3	1	4	3	3	3	3	3	1	4	4	4	2	4	4
Note par site d'extraction *Numérotation CERN (1 à 5)*	3		3			1	3		3				1	4			3		

Feasibility study for connection by conveyor belts to selected railroad connections



Example of a conveyor belt study

Example of a conveyor belt

Innovative ideas for the reuse of excavated materials from FCC: **from waste to functional soil**

International competition “ Mining the Future” launched in 2022 with the support of the EU Horizon 2020 grant agreement 951754

Purpose: Find innovative solutions for the excavated materials (molasse) reuse. «From waste to opportunity »

http://miningthefuture.web.cern.ch/

https://home.cern/news/news/engineering/winner-mining-future-competition-announced

Proposed innovative ideas:

- separation of materials in view of increasing the re-use potential,
- reuse via soil engineering for agriculture, renaturation and forestry
- reuse for construction components (bricks, concrete)

Real-scale innovation project: OpenSkyLab

The priority for FCC is to propose a **large-scale re-use of excavated materials as reconstructed functional soil** for many applications

See the presentation «OpenSkyLab» C. Pueyo and Ch. Staudinger, Tuesday 20th May.

Reuse of excavated materials: OpenSkyLab project

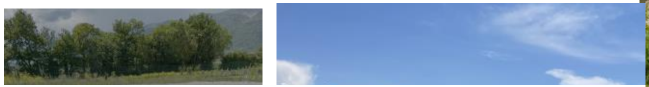
Goal: Develop quality-managed processes to transform excavated materials into functional soil

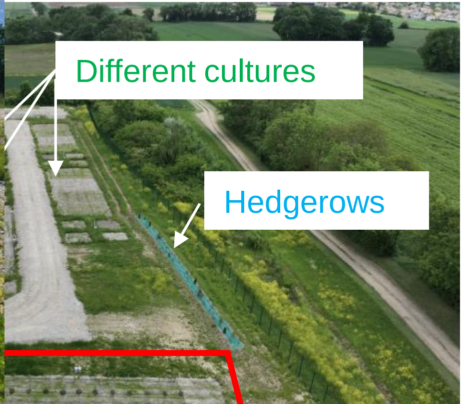
Collaboration with academy and industry

Location: 1 ha field in Cessy (France)

Duration: 5 years, longer if FCC approved

https://openskylab.web.cern.ch/





All modalities so far exhibit positive results regarding plant growth (30 days after seeding)

hepia Haute école du paysage, d'ingénierie et d'architecture de Genève
brgm Géosciences pour une Terre durable
EDAPHOS ENGINEERING
BOKU UNIVERSITY
microhumus
MONTAN UNIVERSITÄT LEOBEN
BECC
wsp

Conclusions

"The way forward is clear."

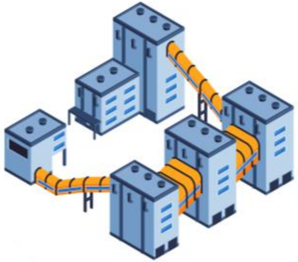
Strategy for FCC excavation materials is published
https://doi.org/10.5281/zenodo.14923266

The **territory and regional regulations are evolving continuously**: agreement with regional and local authorities for a joint effort in making the innovative local reuse a valid and cost-effective solution.

Evaluation of the **socio-economical impact** of the consequences on the local market due to the development of innovative MATEX reuses.

Two key areas of development:
- **processes** (logistics, characterisation, treatment, traceability, etc.) : this will allow to develop an iterative «**Excavation Material Management PLAN»**
- **regulatory framework** : fair share principle yields an amount of materials on Swiss territory that is larger than the volume excavated on this territory(4%). A solution for either the repatriation of excavated materials from France to Switzerland or a form of compensation needs to be developed before the excavation process can start.

Future roadmap


- Confirmation of the characteristics of the excavated material (subsurface investigations)
- Correlation between the material properties and the acceptance criteria of the potential receivers.

- Technical methods for the real-time analysis of the materials and their sorting.
- Regularly update of the regional treatment and disposal opportunities (e.g., quarries, final deposits, treatment facilities);

- Definition of the regulatory framework for the management of the excavated materials with the host States

- Study on the excavation material logistics (traceability, fluxes, conveyors etc.), including the evaluation of environmental and societal impacts and the potential limitations.

- Developing processes for using excavated materials including an evaluation of the environmental, economic and societal impact
  - reuse as construction or isolation materials.
  - Continuation of the OpenSkyLab for landscaping and forestry purposes

Thank you for your attention.

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Technical and socio-economical challenges

Technical

- Estimate the nature, quantities and main features of MATEX (including potential pollution), account for the impacts of the construction methods. Draw on feedback from past projects and gather all available information.
- Identify and develop potential uses, especially in the case of molasse, which is predominant.
- If necessary, plan a suitable treatment to fulfil the technical specifications required for a given use
- Ensure the availability of the technical facilities required for successful management (transport, storage areas, etc.).
- Apply risk management to MATEX.

Socio-economical

- Anticipate and involve all stakeholders. A specific agreement between the owner and the Host States will be necessary.
- Ensure a clear communication and strengthen the social acceptability of the project by reducing nuisances.
- Support the local population and innovation (employment, economic activity, education, etc.).
- Perform LCA analyses.

❑ Future Circular Collider quantities compared to EU/FR/CH

In total, 16,4 million tons of excavated material, and 3,3 million tons per year over a 5 years period

In France, 13,7 million tons of excavated material, and 2,7 million tons per year

In Switzerland, 2,6 million tons of excavated material, and 520 000 tons per year

	France	Switzerland	Europe
	National	National	All
Excavated material per year (million tons)	144	40-60	520
FCC proportion	1,90%	0,90%	0,60%