



FCC-he Civil Engineering

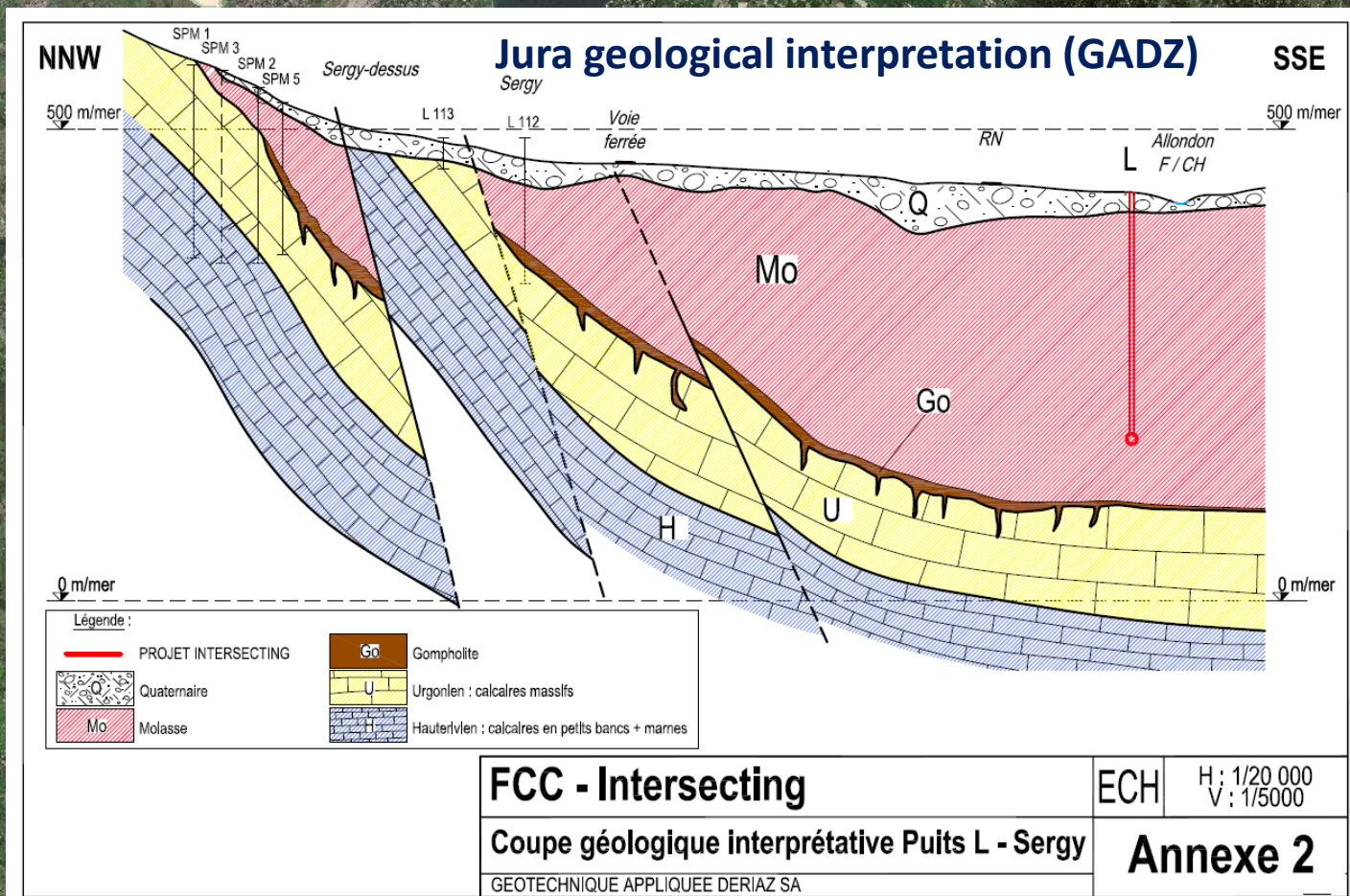
FCC Week
Rome, 2016

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Outline

1. LHeC potential solutions
2. FCC-he potential solutions
3. LHeC/FCC-he potential solutions

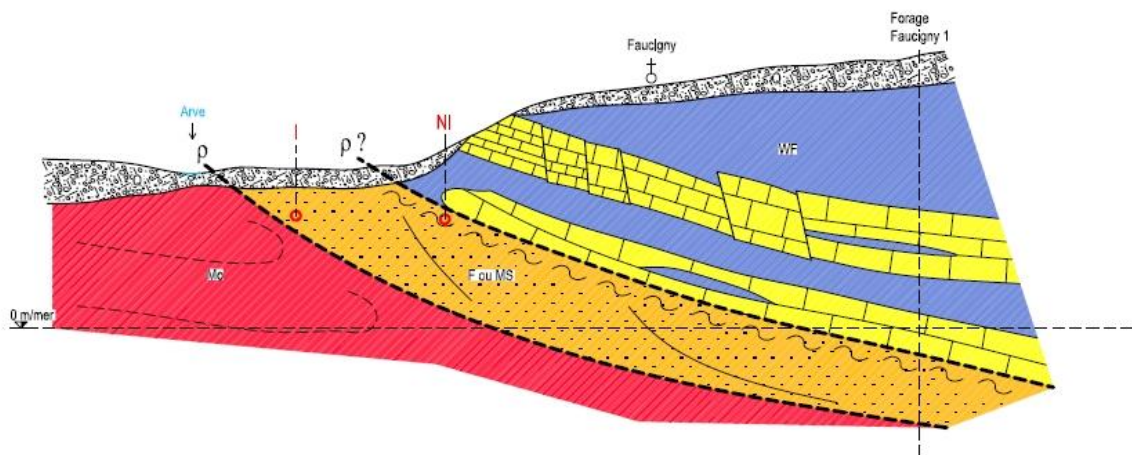
Geology, positioning and civil engineering challenges for each



W

E

Voiron - Faucigny geological interpretation (GADZ)



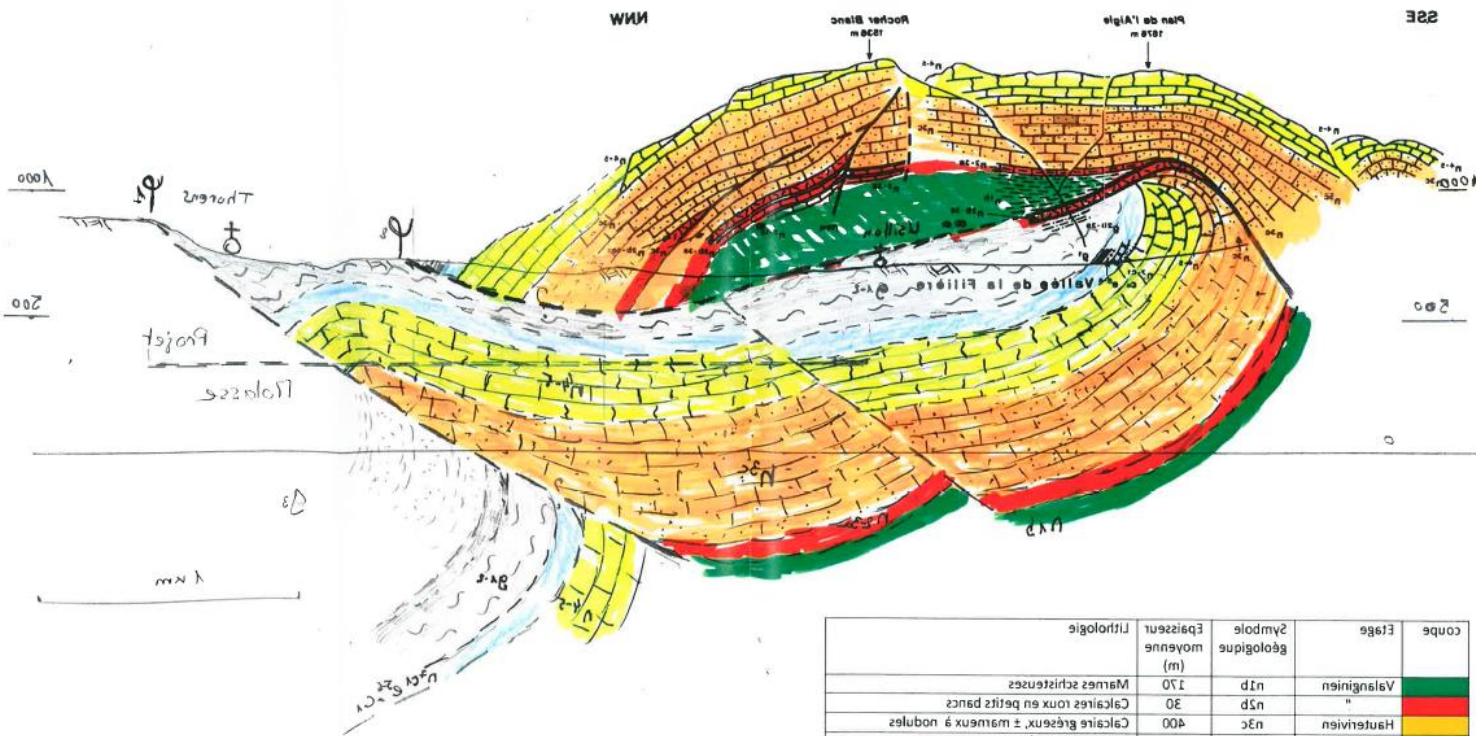
Légende :

	Q : Quaternaire (Moraines, Ebouils)		F-MS : Grès et Silt argileux (Flysch ou molasse subalpine ?)
	Mc : Molasse Rouge		WF : Wildflysch (Grès, marnes, calcaires)
	NI ○	FCC position approximative des variantes Intersecting et Non Intersecting	

FCC - 100 km - Secteur Volrons - Faucigny ECH 1:10 000
Coupe géologique 3
 GEOTECHNIQUE APPLIQUEE DERIAZ SA



Prealps geological interpretation (GADZ)



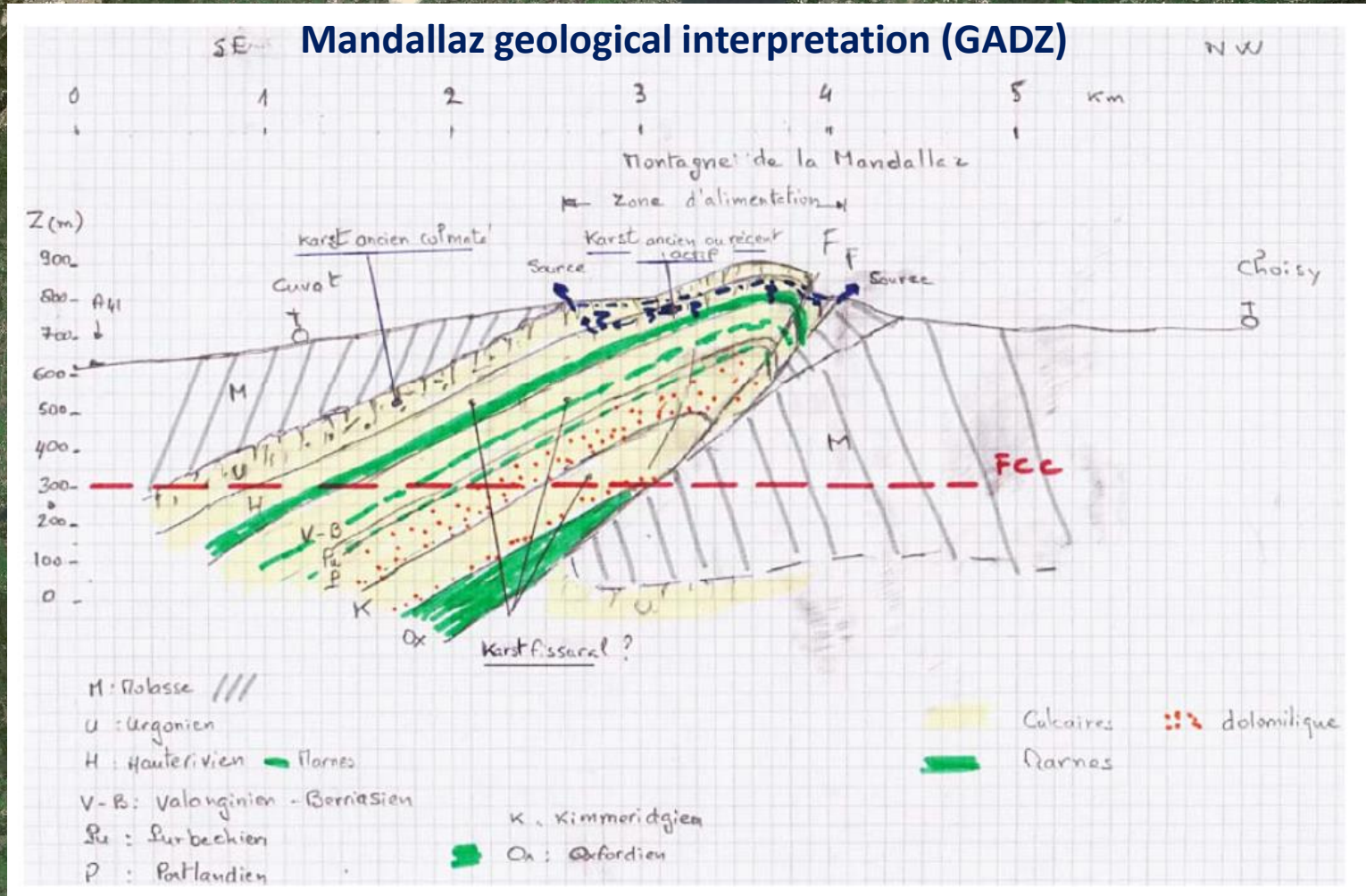
Extrapolation en biotopogent
 Versant lève gauche interprétation 1. Chistolais

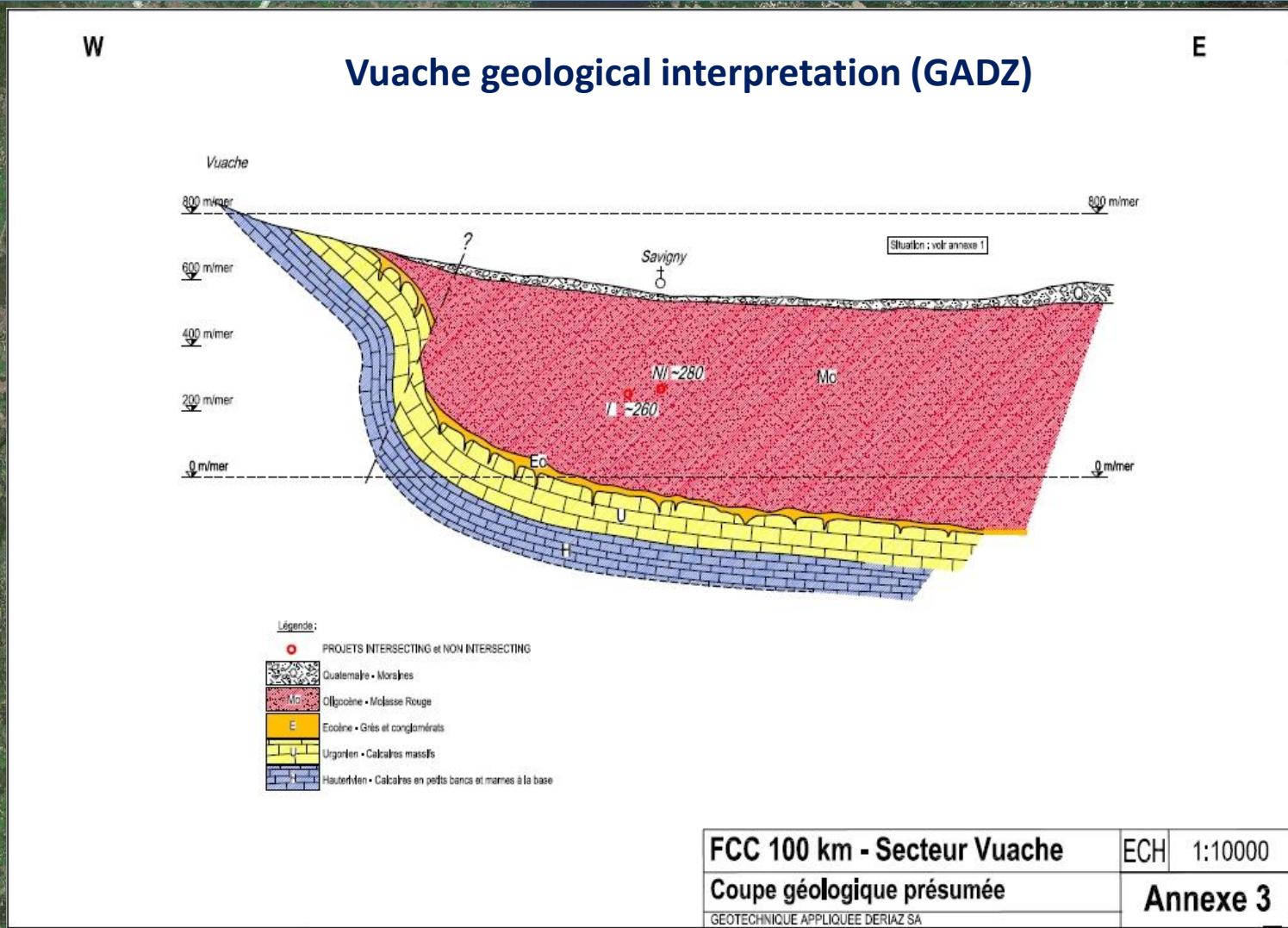
coude	Etage	symbole géologique	Épaisseur moyenne (m)	Lithologie
g3	"	"	>1000	Molasse
B3	"	"	200-250	Flysch (Grès, marnes siliceuses et schistes)
R1	Oligocène	R1	30	Marnes
Écône	"	Éc-É	30	Grès ferrugineux
"	"	C2	20	Calcaire
"	"	n3 C1	20	Grès glauconieux
"	"	n4-2	240	Calcaires massifs
"	"	n3c	400	Calcaires gréseux ± marnes à nodules
"	"	n3p	30	Calcaires lous en petits bancs
"	"	n1p	170	Marnes schisteuses

FCC - Option 100km - Variante préalpes (non intersecting) 1:12000

Annexe 3

Coupe géologique 1



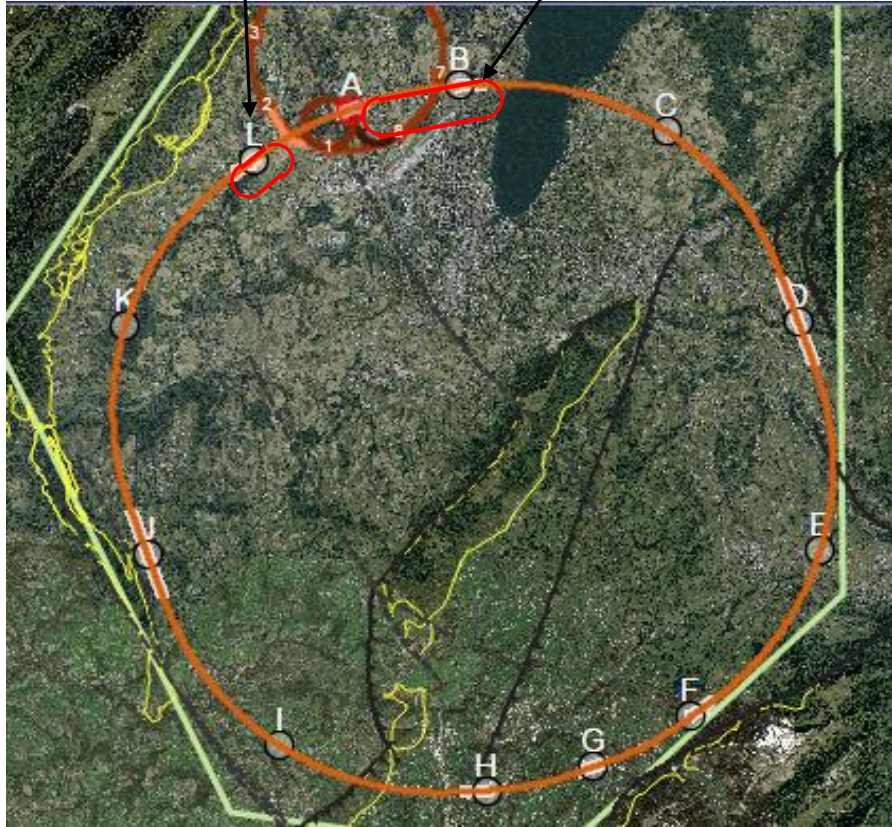
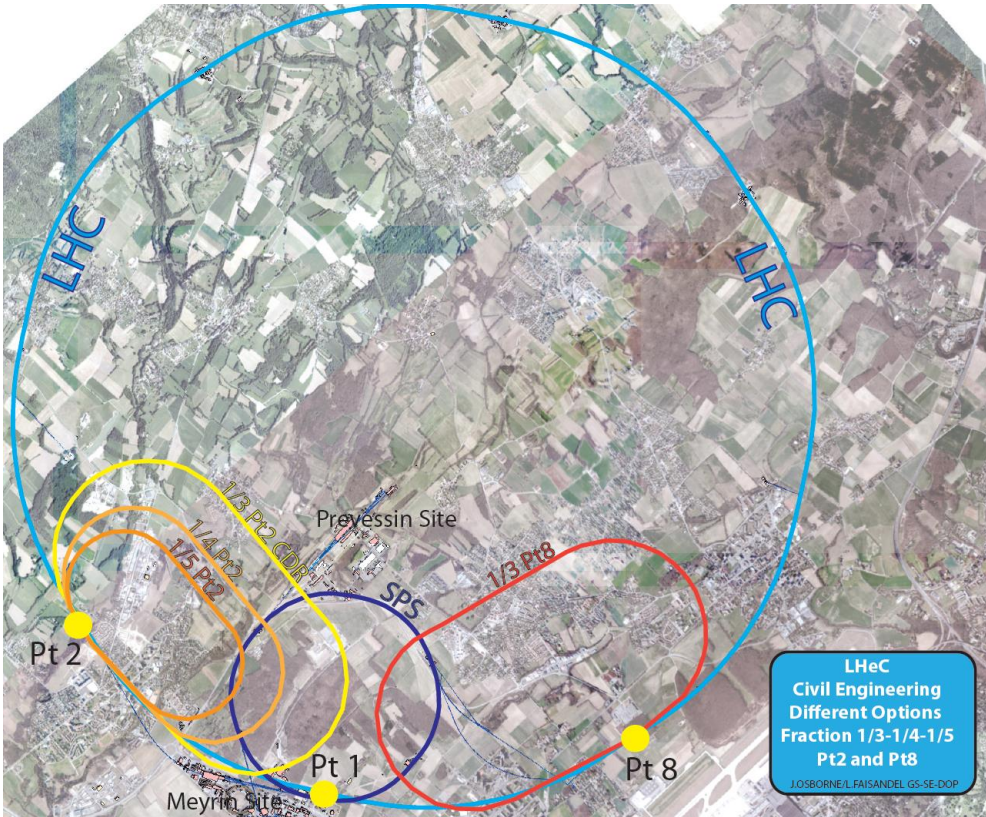


LHeC and FCC-he

LHeC Machine

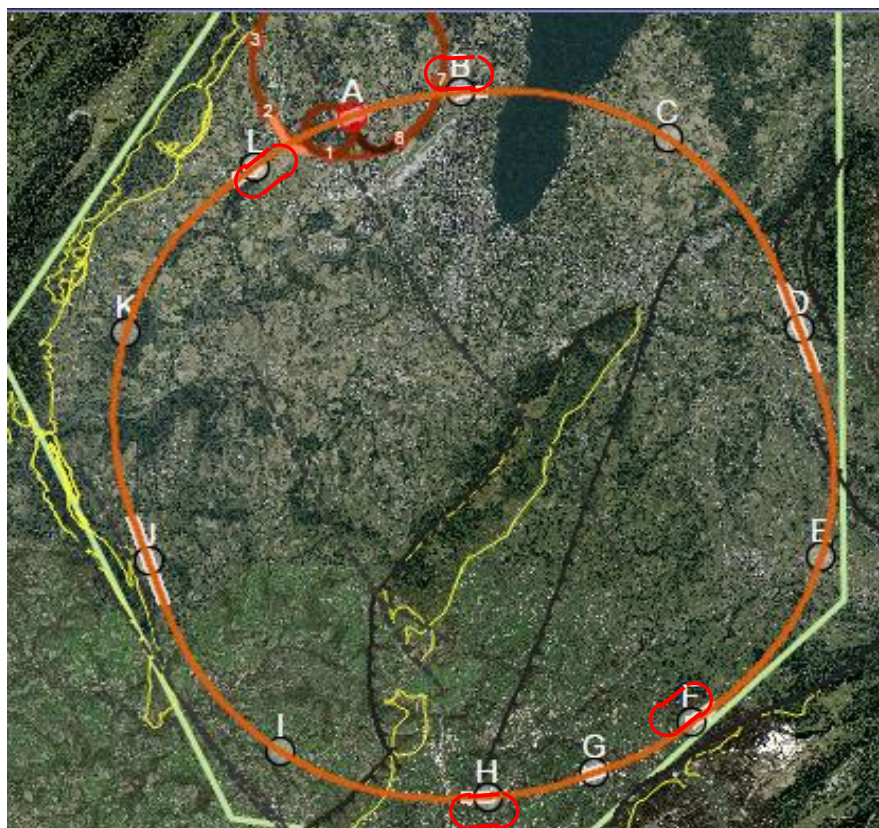
Independent FCC-he Point L, F, H or B

LHeC / FCC-he LHC P8 & FCC PB



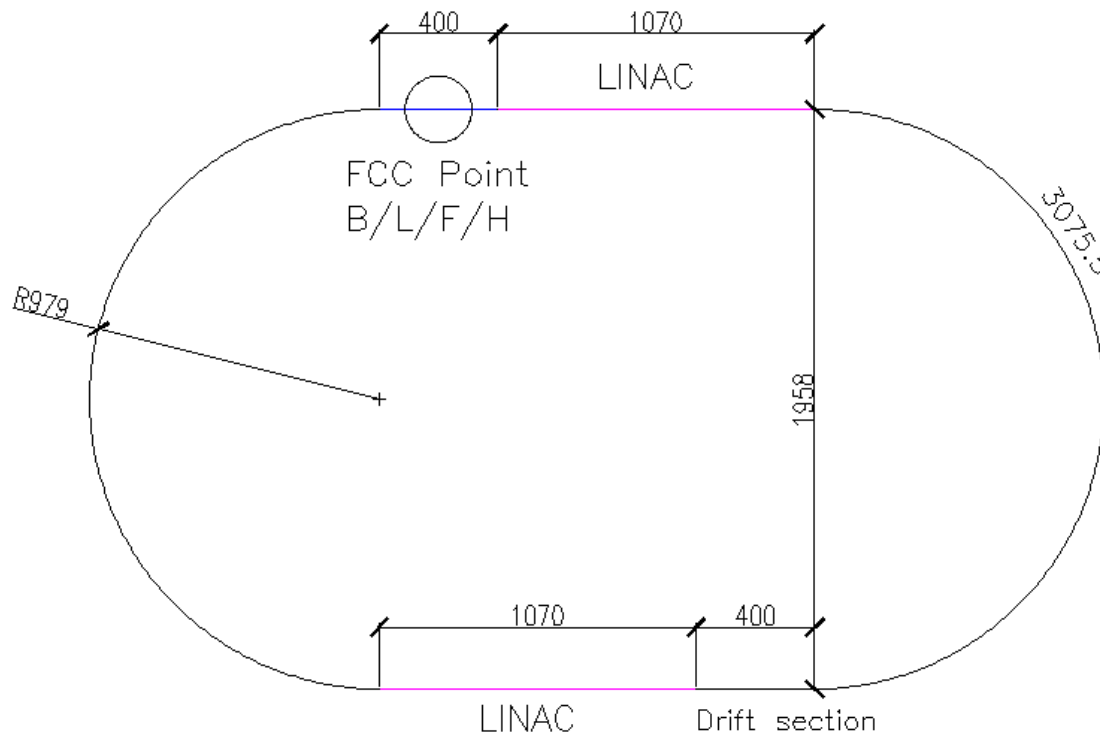
FCC-he

Independent FCC-he
Point B, L, F or H
(FCC straight sections)



FCC-he

- Connection to FCC straight section at point B, F, H, or L
- 1070m ERLs - 400m BDS – 979m radius arcs - 400m beam transfer
- 9091m total length, $\frac{1}{11}$ of FCC



FCC-he Point L

FCC Long Straight Section L

Tunnel Geology

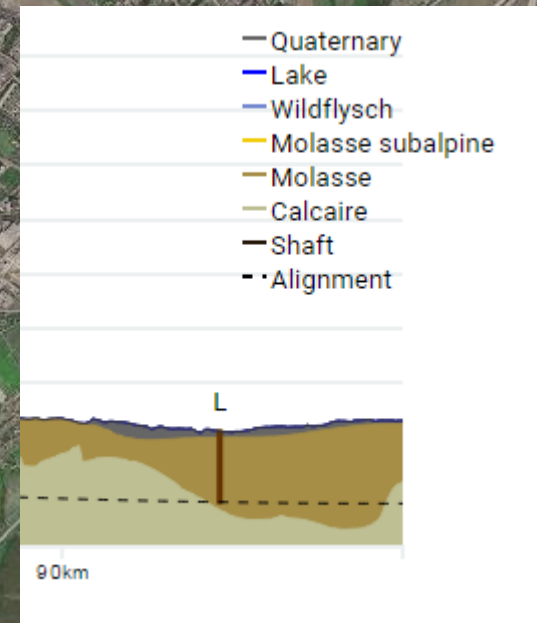
- Molasse rock (sandstone)
- High risk of hitting (hazardous) Jura limestone

Construction

- Tunnel Boring Machine (TBM) in straight sections
- Roadheader in arcs

Civil Engineering challenges

- High geological risk of travelling through karstic limestone
- Not feasibility issue but special probing measures could be required (increase costs)



FCC-he Point B

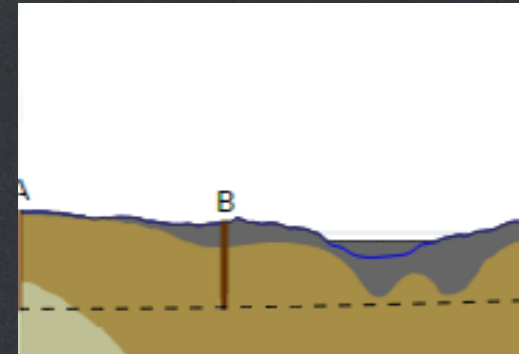
FCC Long Straight Section B

Tunnel Geology

- Molasse rock (sandstone)

Construction

- Tunnel Boring Machine (TBM) in straight sections
- Roadheader in arcs



Civil Engineering challenges

- Biggest challenge is avoiding interaction with main FCC tunnel(s) (junction caverns, sloped FCC-he)
- Geological hazards are low if in molasse

FCC-he Point F

FCC Long Straight Section F

Tunnel Geology

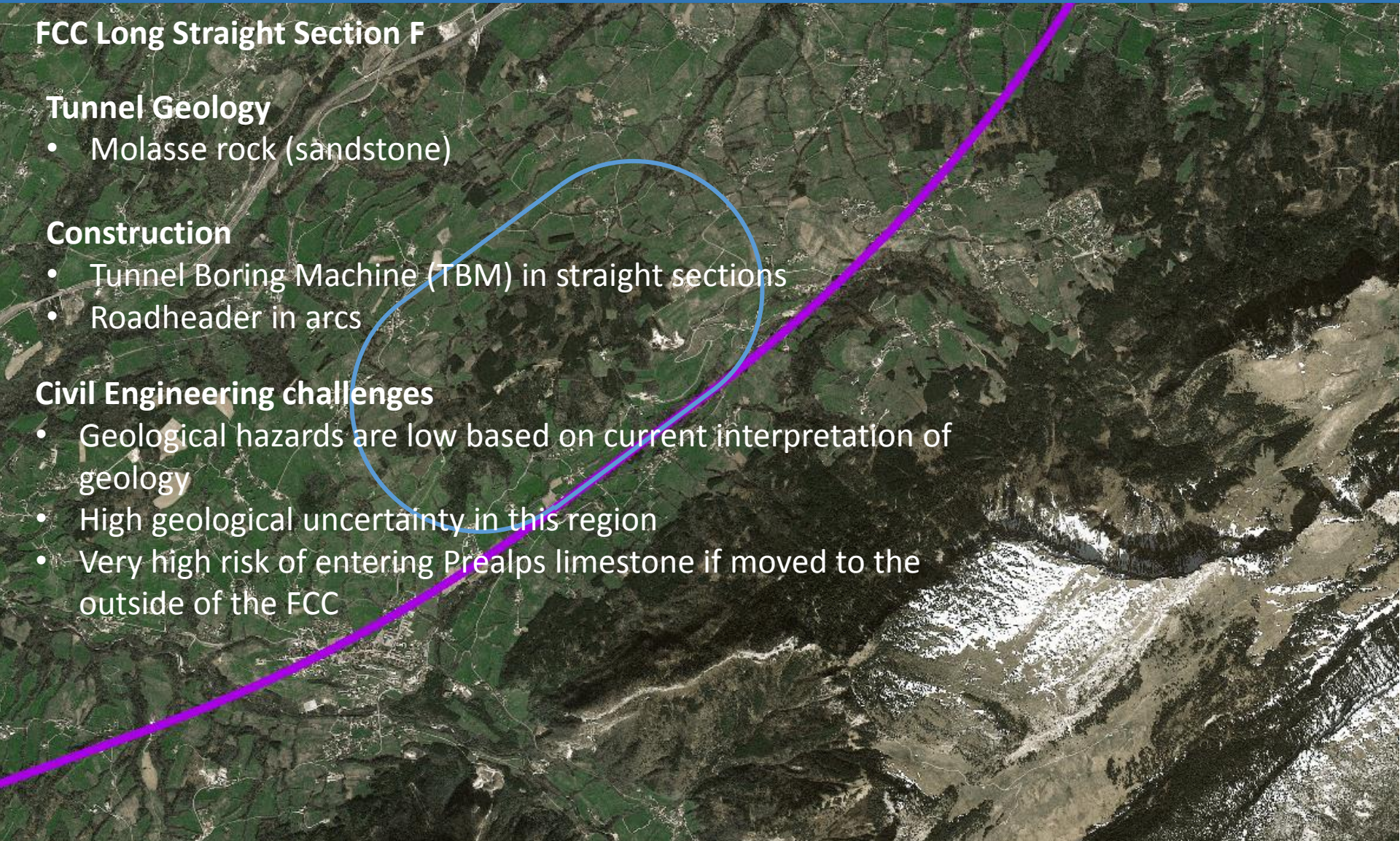
- Molasse rock (sandstone)

Construction

- Tunnel Boring Machine (TBM) in straight sections
- Roadheader in arcs

Civil Engineering challenges

- Geological hazards are low based on current interpretation of geology
- High geological uncertainty in this region
- Very high risk of entering Prealps limestone if moved to the outside of the FCC



FCC-he Point H

FCC Long Straight Section H

Tunnel Geology

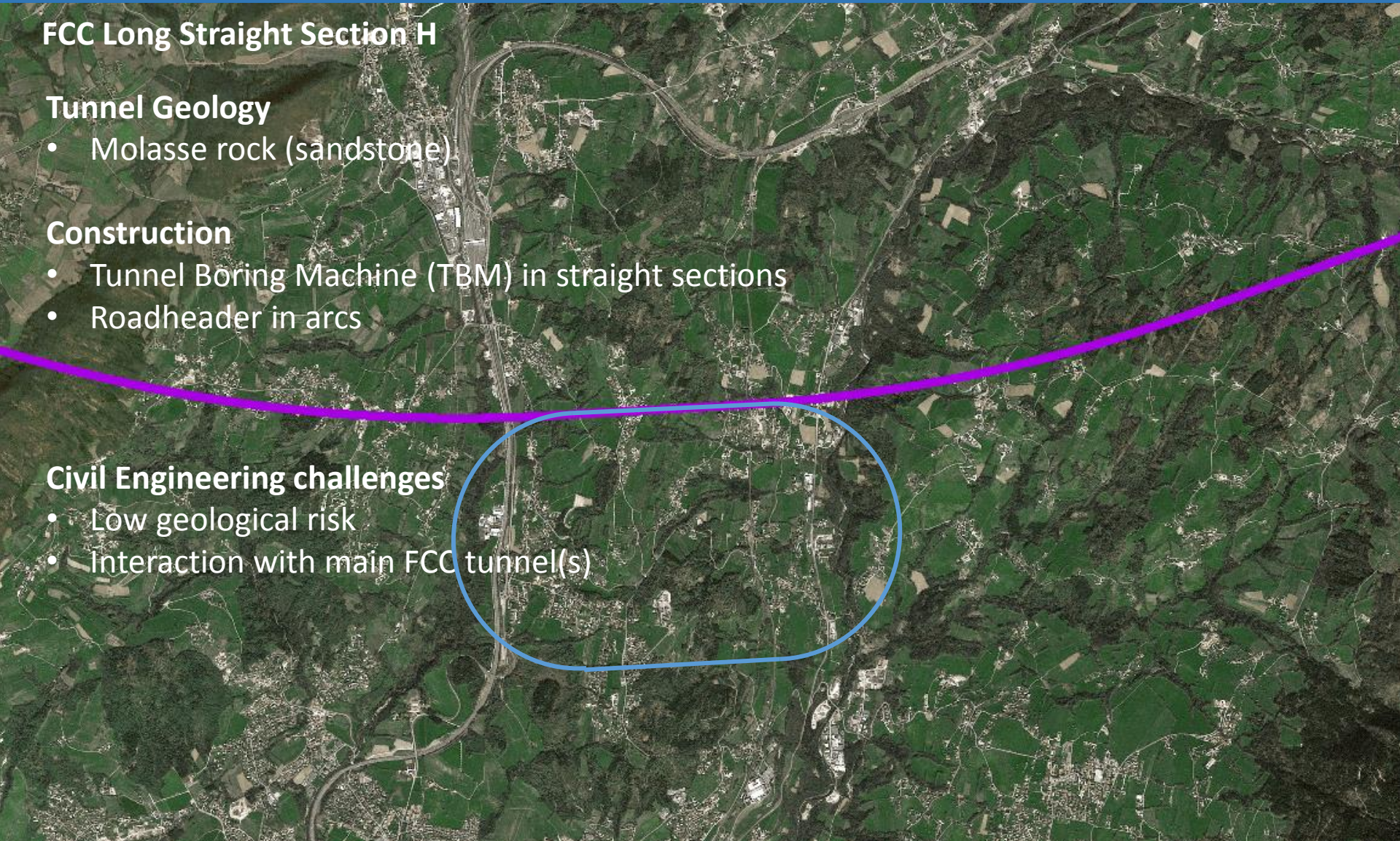
- Molasse rock (sandstone)

Construction

- Tunnel Boring Machine (TBM) in straight sections
- Roadheader in arcs

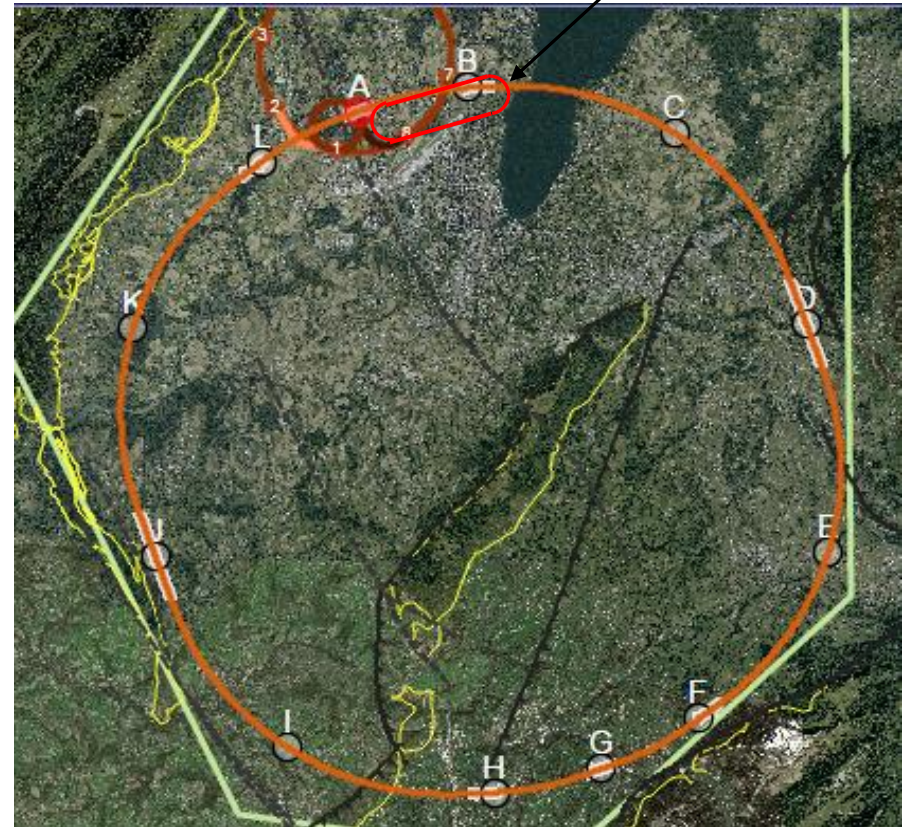
Civil Engineering challenges

- Low geological risk
- Interaction with main FCC tunnel(s)



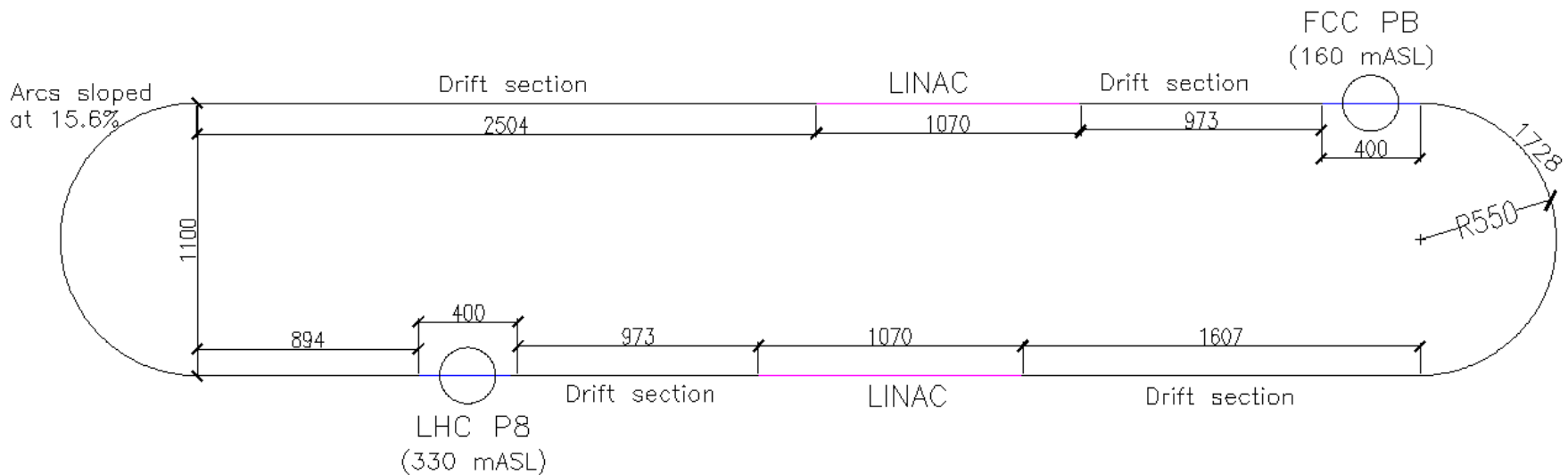
- LHeC/FCC-he machine with experiments on both the LHC and FCC ring
- Connection at LHC P8 and FCC PB – only feasible location
- 170m vertical distance
- Traverse vertical with arcs

LHeC / FCC-he
LHC P8 & FCC PB



LHeC/FCC-he Civil Engineering

- LINACS at different levels (160 mASL FCC and 330 mASL LHC)
- 550m radius arcs sloped at 15.6% to traverse the 170m vertical and 2km horizontal
- Drift sections added to reach 0.5LHC total length. Added to west of P8 to avoid Lake Geneva
- 1070m LINACS - 400m BDS – 555m radius arcs - ~7000m drift (total)
- 13.35km total length... $\frac{1}{2}$ of LHC



LHeC/FCC-he Civil Engineering

LHC Point 8 & FCC Long Straight Section L

Tunnel Geology

- Molasse rock (sandstone)
- Limestone in west at FCC level
- Risk of travelling through (water bearing) moraines near the Lake

Construction

- Tunnel Boring Machine (TBM) in straight sections
- Roadheader in arcs

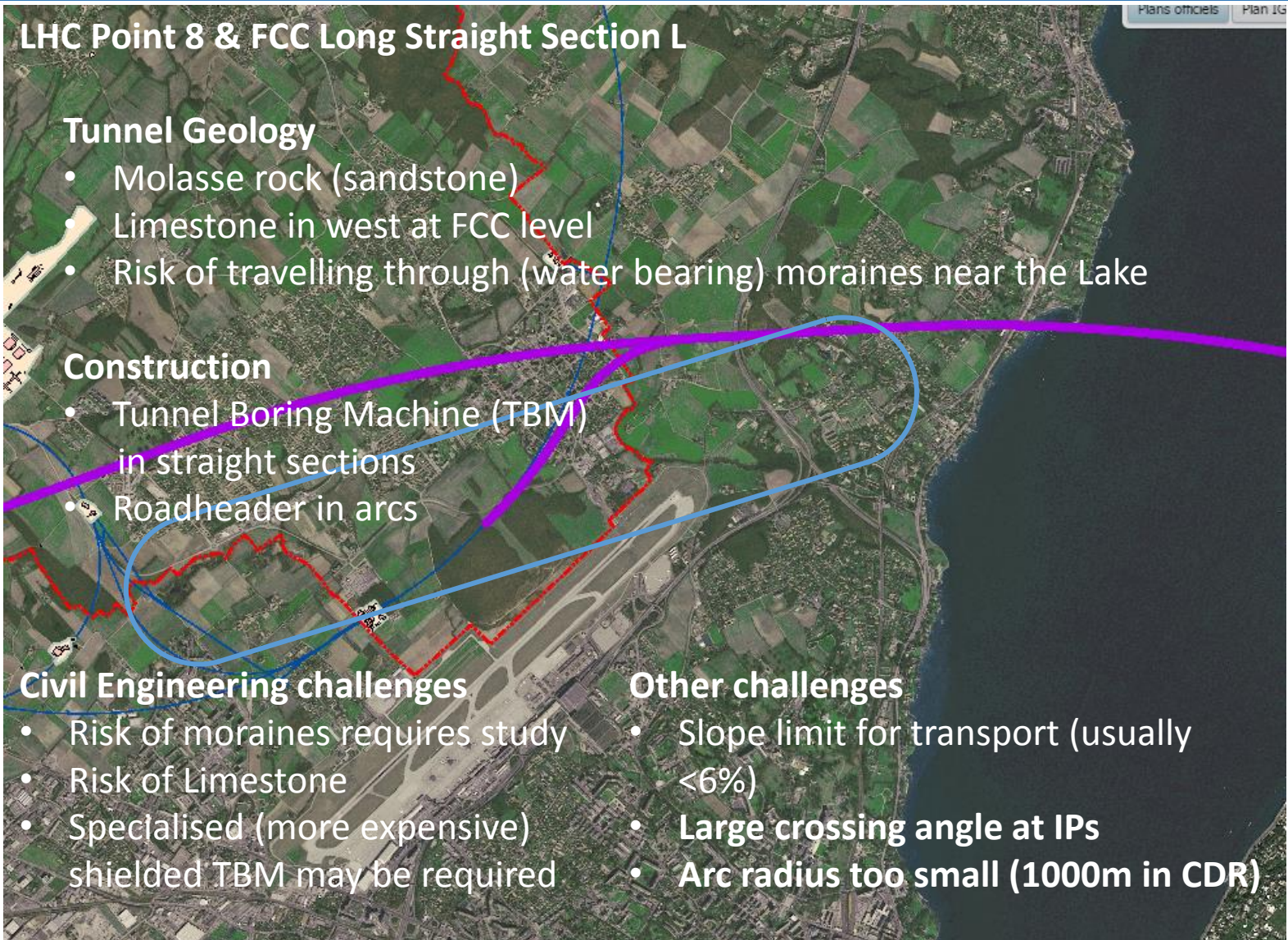
Civil Engineering challenges

- Risk of moraines requires study
- Risk of Limestone
- Specialised (more expensive) shielded TBM may be required

Other challenges

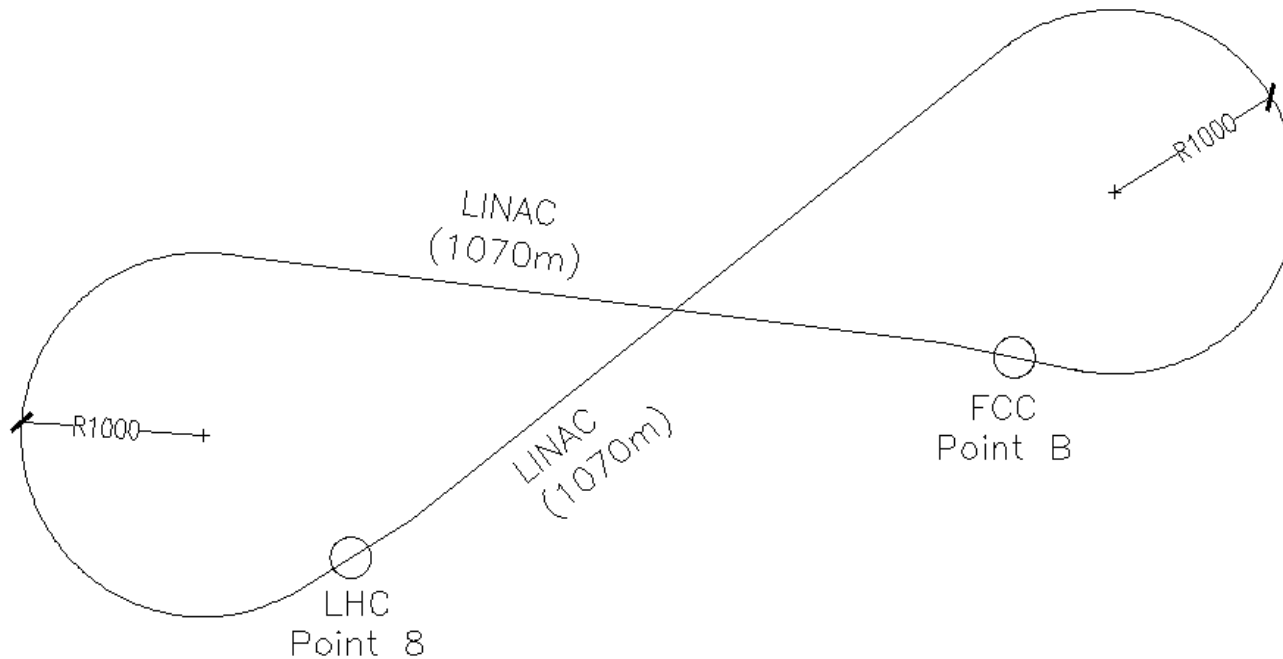
- Slope limit for transport (usually <6%)
- **Large crossing angle at IPs**
- **Arc radius too small (1000m in CDR)**

Plans officiels Plan IG



Further Study

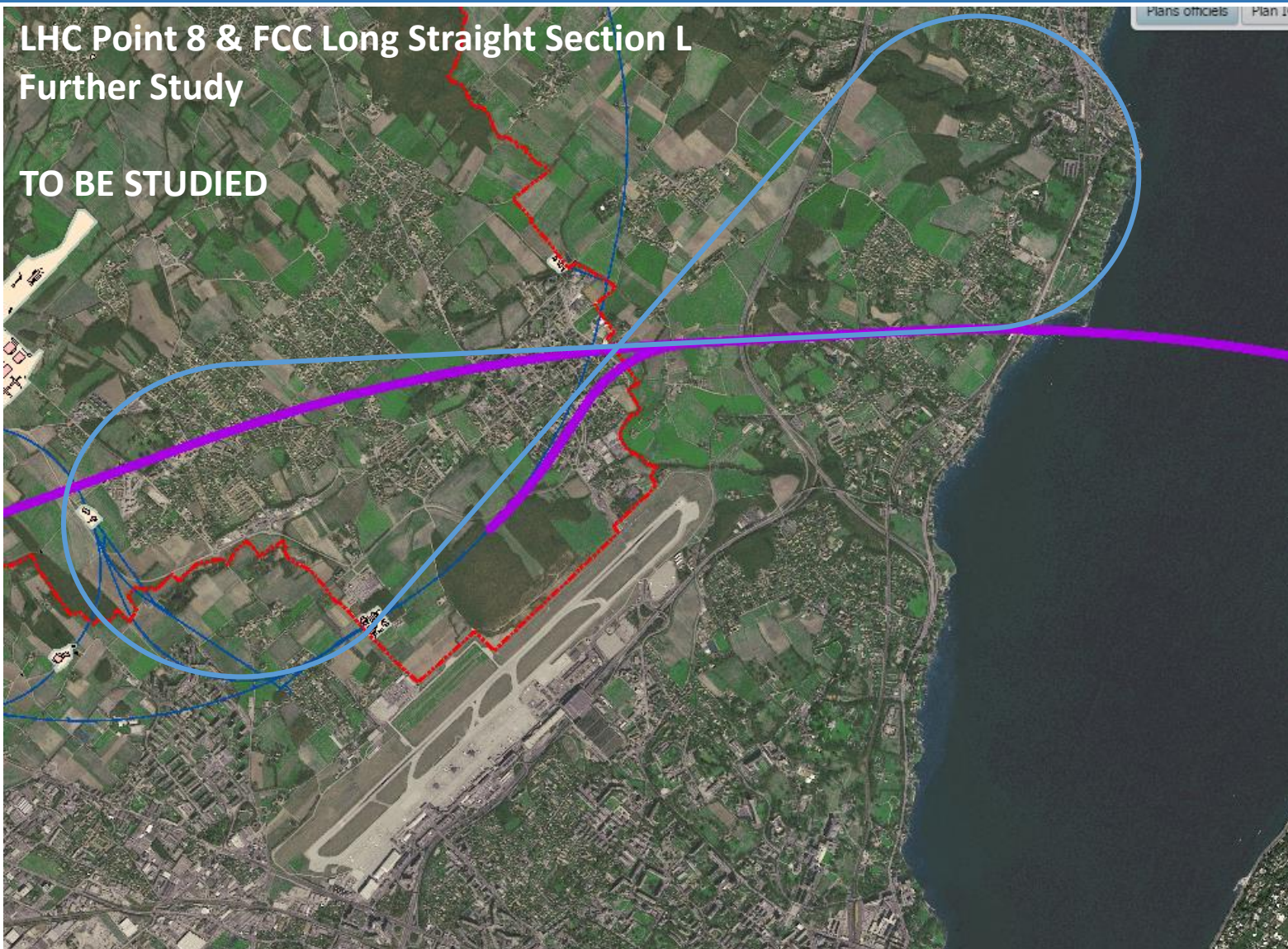
- Study new concepts with:
 - ~900m-1000m radius arcs
 - Much smaller crossing angles and P8 and PB
 - Smaller gradients to traverse 170m vertical



LHeC/FCC-he Civil Engineering

LHC Point 8 & FCC Long Straight Section L
Further Study

TO BE STUDIED



Future Steps

Future Steps

- Continue civil engineering study into feasibility of FCC-he options and LHeC/FCC-he option:
 - Geological profiles for options
 - Interaction of FCC-he tunnel & LHC/FCC main tunnels
 - Optimising LHeC/FCC-he design
- Drawings
 - 3D
 - Layout sketches
- Project cost estimates
 - Scale from previous estimates (AMBERG CDR)



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