



TBMs for the new water supply tunnel

Fredrikke Syversen

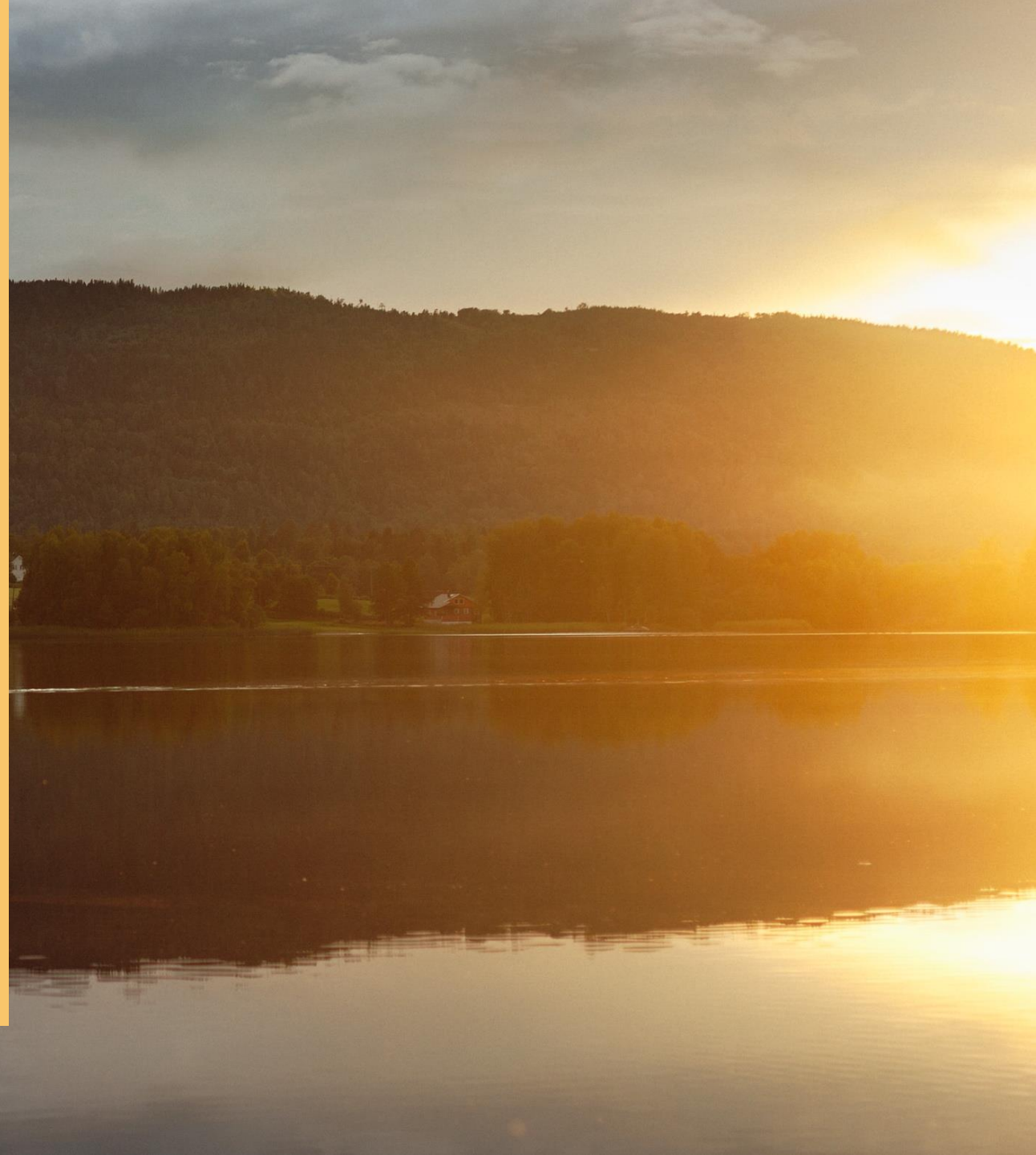
*The Municipality of Oslo
Agency of Water and Sewage
4.11.2019*





Agenda:

- Project introduction
- Decision making: excavation method and tunnel concept
- The results







Oset water treatment facility

Lake Maridalsvannet



Oslo

*The Norwegian Food Safety Authority's
instruction to the City of Oslo (the 3rd of April
2017)*

**The Norwegian Food Safety Authority
instructs the City of Oslo to establish a
satisfactory reserve water supply by
1st of January 2028.**



Oslo



Hole
kommune

SØRKEDALEN

Maridalsvannet

Water Supply Tunnel ~19.2km

SOLLIHØGDA

BÆRUMS VERK

Bærum
kommune

GREFSEN

GRORUD

Holsfjorden

Sentrum

ALNABRU

Lier
kommune

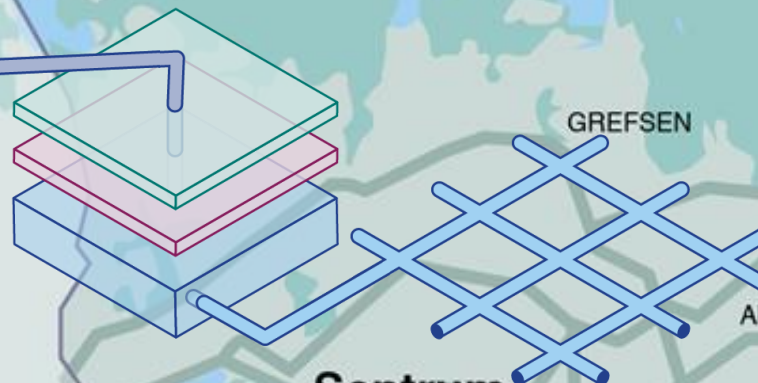
FORNEBU

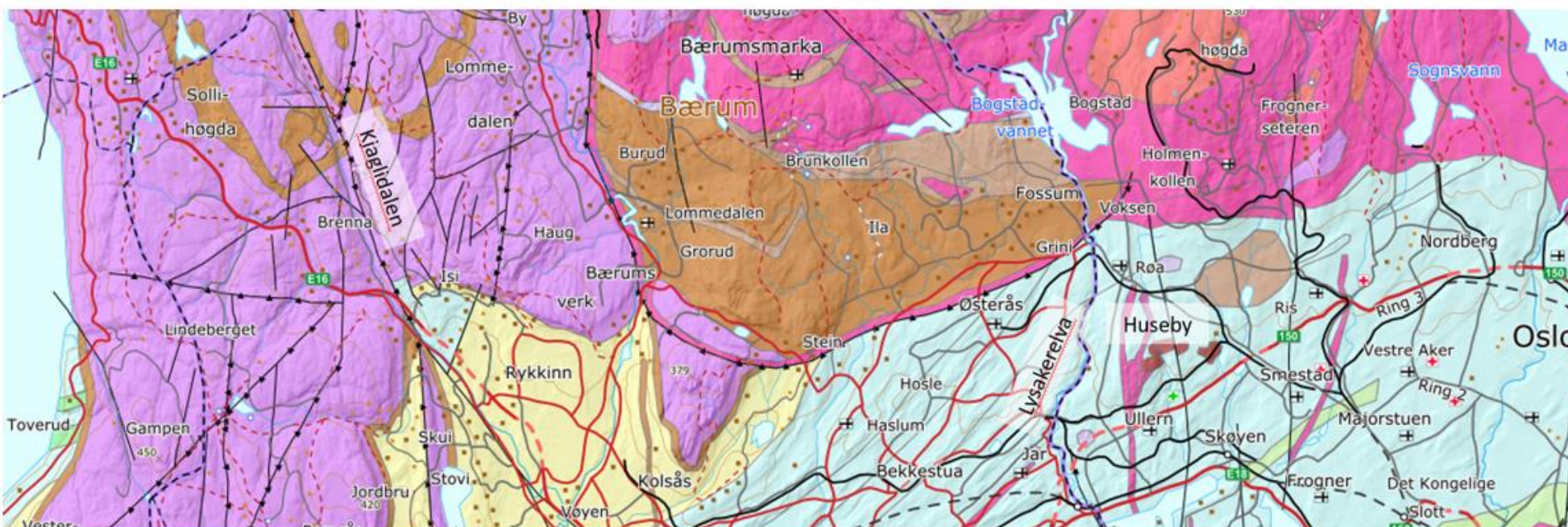
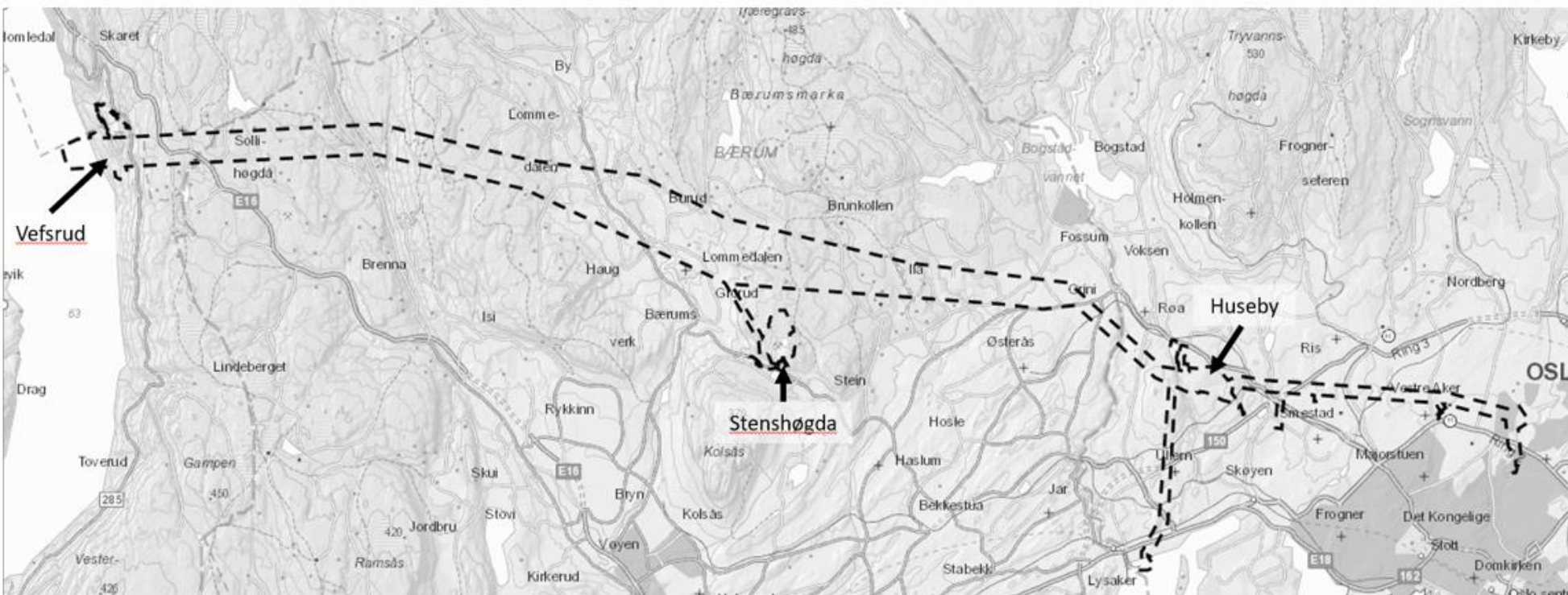
SANDVIKA

LAMBERTSETER

Asker
kommune

HOLMLIA





Bergarter fra karbon-, perm- og triastiden

Dyp- og gangbergarter

- 16 Gabbro, dioritt, camptonitt
- Sedimentære bergarter**
- 17 Leirstein, sandstein, konglomerat
- Vulkanske bergarter**
- 18 Breksje, tuff, ignimbritt
- 19 Ignimbritt
- 20 Ryolitt, ryodacitt, dacitt
- 21 Latitt (rombeporfyr)
- 22 Trakytt, porfyrisk
- 23 Basalt

Askergruppen

- 24 Leirstein, sandstein, konglomerat

Oslofjordovergruppen

- 26 Sandstein
- 27 Kalkstein, leirstein og sandstein
- 28 Leirskifer, mergelskifer og kalkstein
- 29 Alunskifer, sandstein, konglomerate og kalkstein

RAPPORT: 10-G-RAP-061

Oslo kommune, vann- og avløpsetaten

Forprosjekt Ny vannforsyning Oslo

Vurdering av TBM-boring i søndre trasé



Fakultet for ingeniørvitenskap
Institutt for bygg- og miljøteknikk



SINTEF Byggeforsk
Anlegg og infrastruktur



Skjeggedal Const.
Services AS

Dato
6.12.2018

Referanse

1 av 22

Notat

Til: Oslo kommune, vann- og avløpsetaten

Kopi til:

Fra: Eivind Grøv, Amund Bruland og Thor Skjeggedal

Signatur: *A. Bruland*

Forprosjektet Ny vannforsyning Oslo - «Vurdering av traséer og drivemetoder for råvannstunnel»

Versjon 1 med 4 alternativer, juni 2018

Tilleggsutredning med 5 alternativer desember 2018

Notatet starter med tilleggsutredningen og resultatene av den. Deretter følger Versjon 1 med en mer omfattende beskrivelse av geologi og andre forutsetninger. Vi har valgt denne rekkefølgen siden tilleggsutredningen representerer mer modne alternativer enn versjon 1. Mye av grunnlaget for Versjon 1 gjelder også i tilleggsutredningen.

Konklusjon tilleggsutredning

Tabell 1 Kostnadsestimater ved hjelp av Anslagsmetoden. P50 er kostnaden som med 50 % sannsynlighet vil overskrides (median), P85 er den kostnad som med 15 % sannsynlighet vil overskrides. For detaljer henvises til Håndbok 764 fra Statens vegvesen.

Alternativ	Lengde, m		P50 mill. kr	Differanse mot alt. 1 mill. kr	Standardavvik %	P85 mill. kr
	TBM	BS				
1 - Nord, 2 x TBM fra Vefsrud og Huseby	19670	0	1424		23,9	1817
2 - Nord, 1 x TBM fra Huseby + 1 x BS fra Vefsrud	14500	5100	1485	+61	27,3	1966
3 - Sør, 2 x BS Vefsrud-Isi, 1 x TBM Isi-Huseby	12900	7060	1693	+269	24,8	2185
4 - Sør, 3 x BS Vefsrud-Isi og Huseby-Dølli + 1 x TBM Isi-Dølli	10000	9060	1645	+221	24,4	2119

RAPPORT: 10-O-RAP-108

Oslo kommune, vann- og avløpsetaten

Forprosjekt Ny vannforsyning Oslo

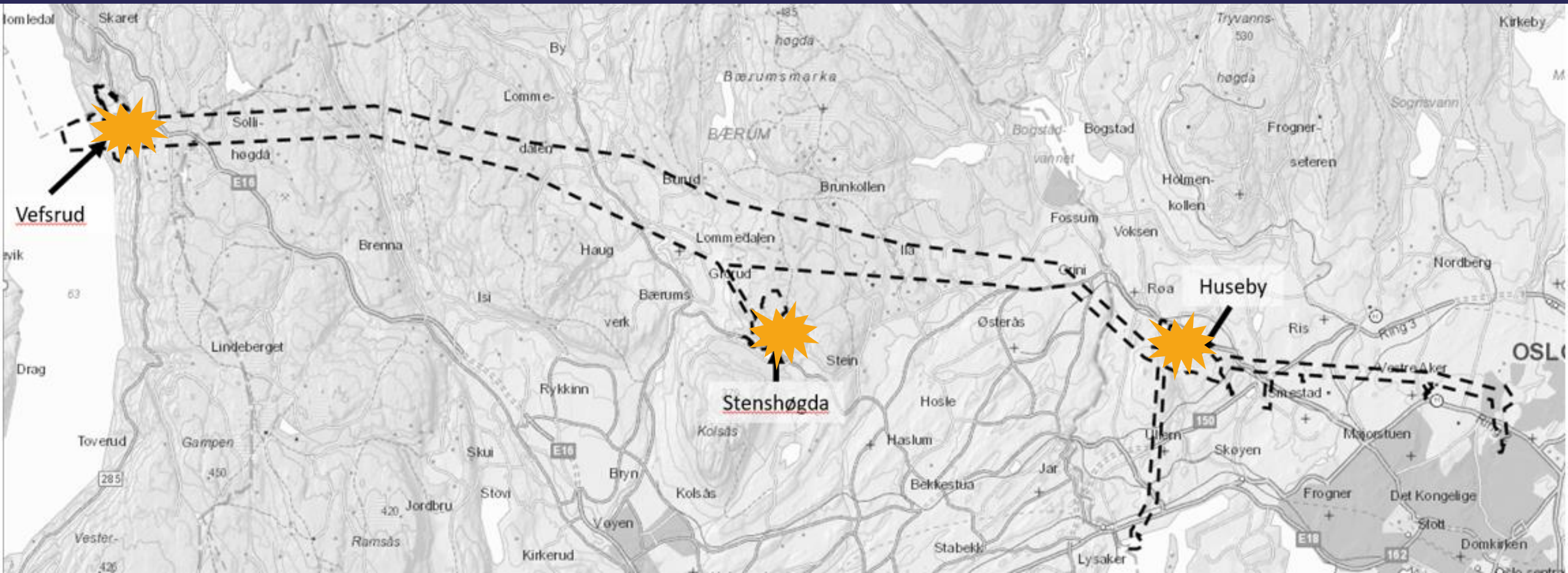
Vurdering av drivemetode for råvannstunneler



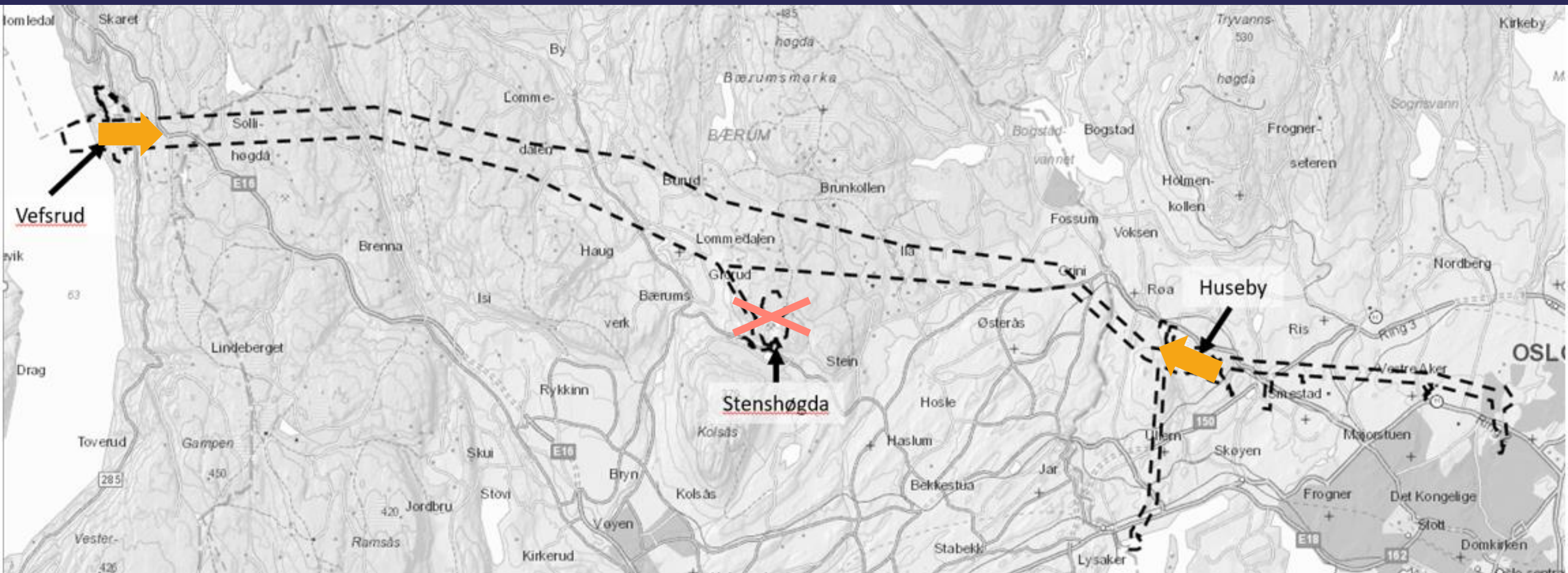
Anleggsteknikk/ingeniørgeologi

result

D&B – concept



TBM – concept



D&B

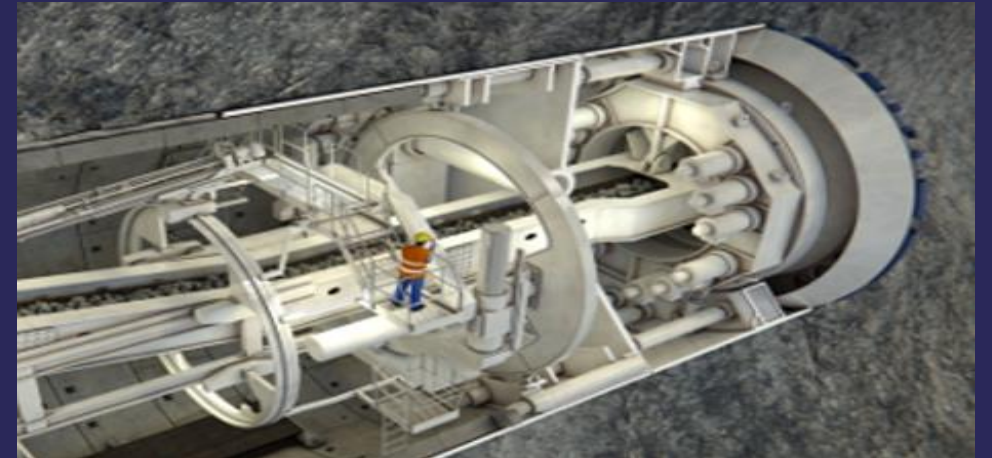
vs

TBM

- ◆ 3 access points
- ◆ 3 km Stenshøgda tunnel
- ◆ Cross section: min 32 m²

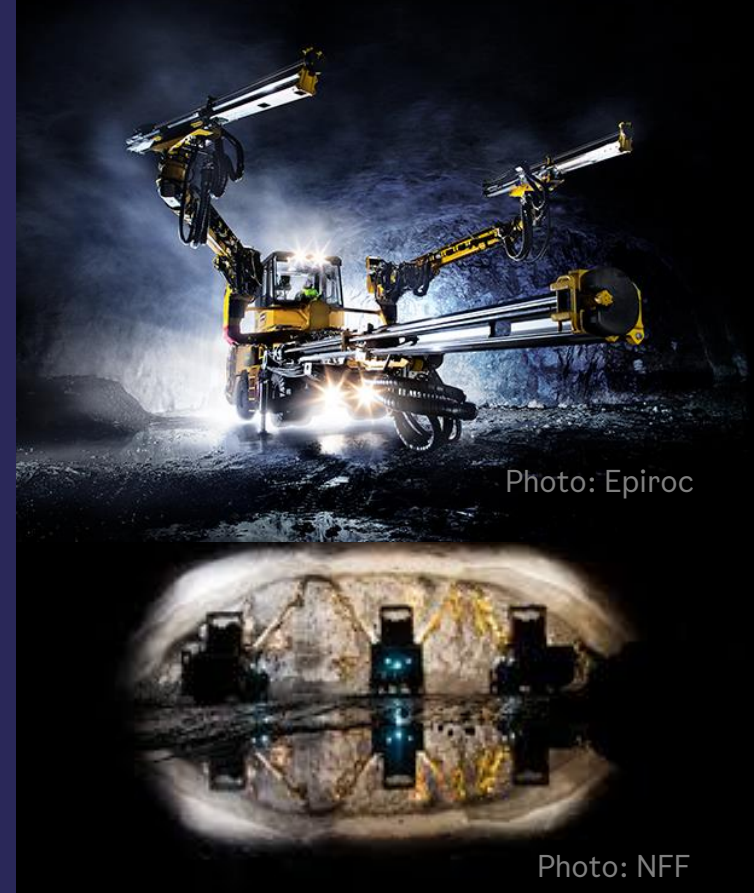


- ◆ 2 access points
- ◆ No Stenshøgda tunnel
- ◆ Cross section: 16 m²



Important factors considered:

1. Machines and equipment
2. Pre-grouting and rock support
3. OH&S
4. Need for access points
5. Environmental impact
6. Operational phase



D&B

vs

TBM

- ◆ Lower consequences in the event of technical breakdown



- ◆ Lower flexibility if technical failure
- ◆ Identify factors of importance to the machine performance to reduce the risk
- ◆ Assessment based on technology available in the market

1. Machines and equipment

2. Pre-grouting and rock support

3. OH&S

4. Need for access points

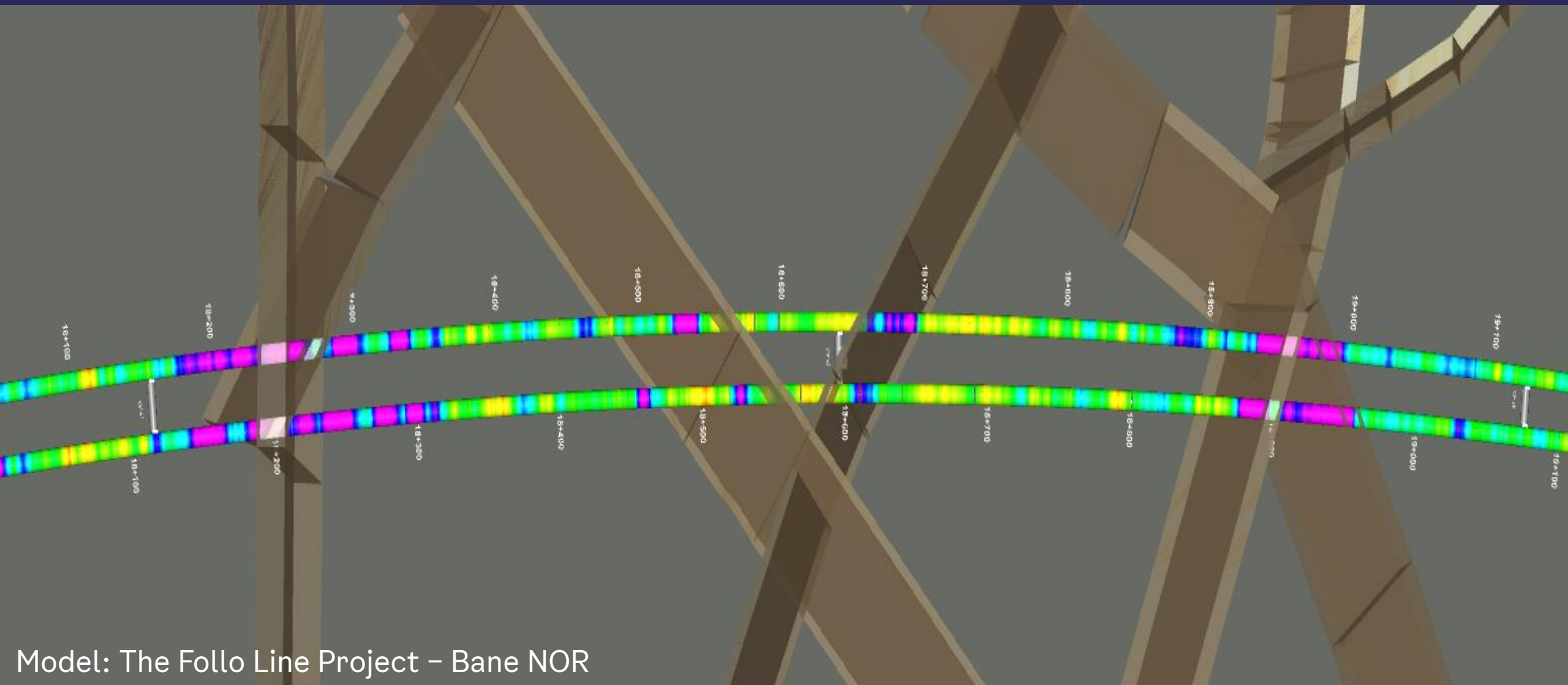
5. Environmental impact

6. Operational phase

D&B

VS

TBM



Model: The Follo Line Project – Bane NOR



D&B

vs

TBM

- ▶ Exposure to fumes
- ▶ Risk of insufficient ventilation concept with 8km of blasted tunnel in one length



1. Machines
and
equipment

2. Pre-
grouting and
rock support

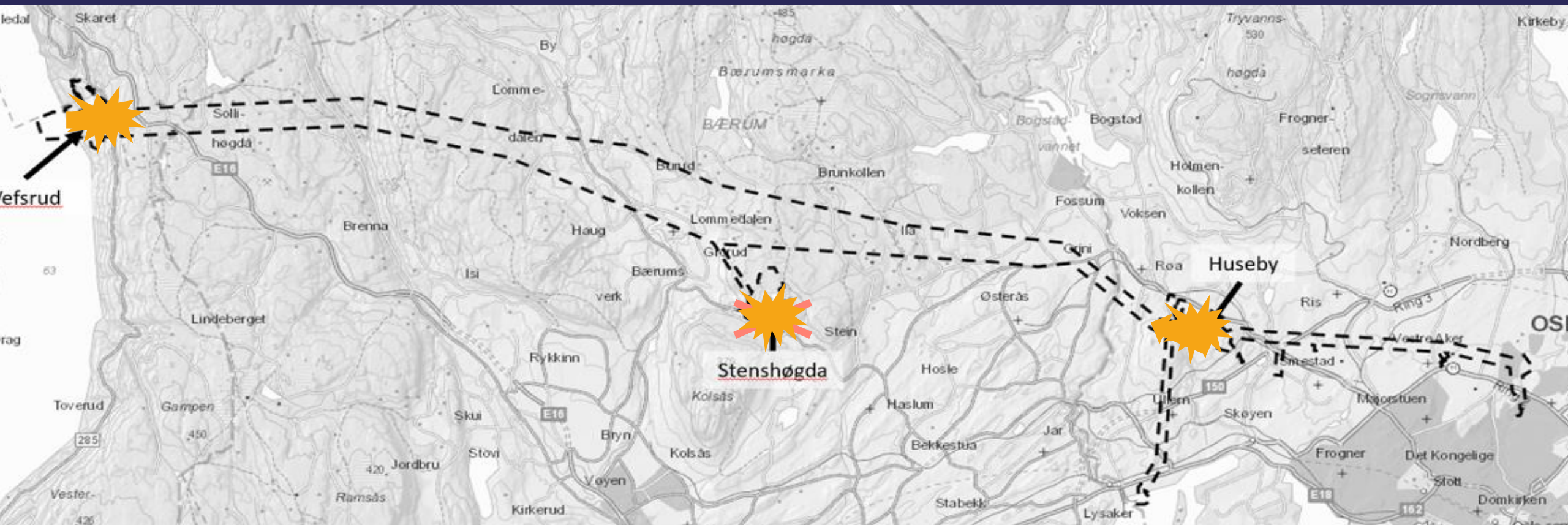
3. OH&S

4. Need for
access points

5.
Environmental
impact

6. Operational
phase





1. Machines
and
equipment

2. Pre-
grouting and
rock support

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4. Need for
access points

5.
Environmental
impact

6. Operational
phase



Oslo

11.11.2019

16

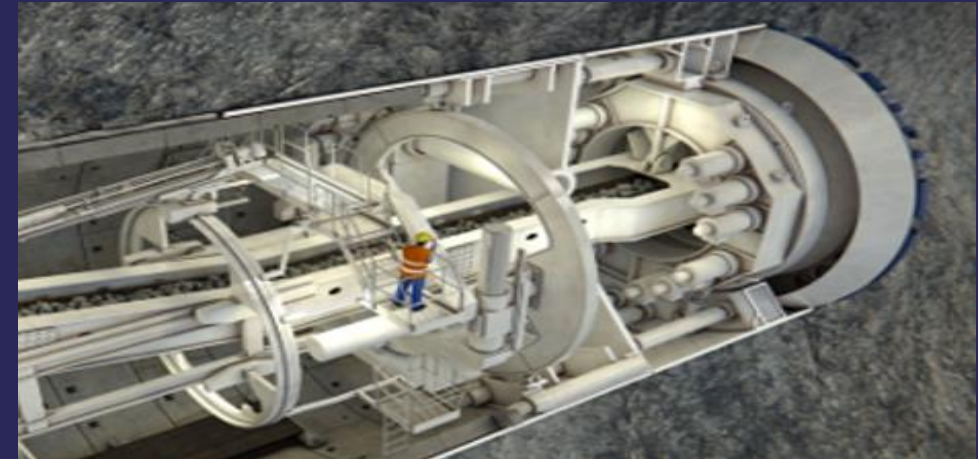
D&B

vs

TBM

- ▶ 32 m²
- ▶ Plastic and nitrogen

- ▶ 16 m²
- ▶ Less contaminated muck



1. Machines
and
equipment

2. Pre-
grouting and
rock support

3. OH&S

4. Need for
access points

5.
Environmental
impact

6.
Operational
phase

D&B

vs

TBM



Photo: Teknisk Ukeblad



Photo from the Follo Line Tunnel

1. Machines
and
equipment

2. Pre-
grouting and
rock support

3. OH&S

4. Need for
access points

5.
Environmental
impact

6. Operational
phase



	D&B 70 m/week – 7700 m tunnel	TBM 4.7m/hr – 35% machine utilisation
Excavation time (weeks)	110	55
Time for probe drilling and pregrouting (weeks)	50	69
Time for rock bolting (weeks)	33	
Total time(weeks)	193	124

TBM – alternative is

- ▶ Fastest
- ▶ With less risk of delay due to increased amount of rock support
- ▶ Most robust because 100% of pregrouting is included

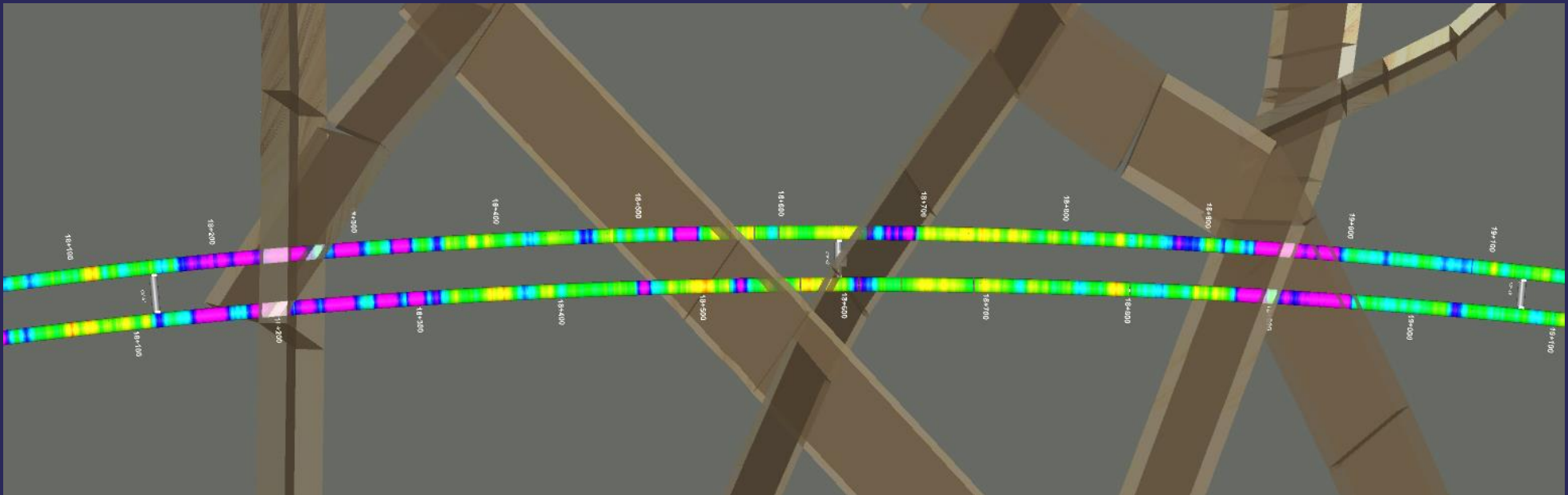
Cost estimate by NTNU – Sintef

	P50 (mill. NOK)	P85 (mill. NOK)
D&B	1971	2424
TBM	1424	1817

...also found to be the cheapest alternative

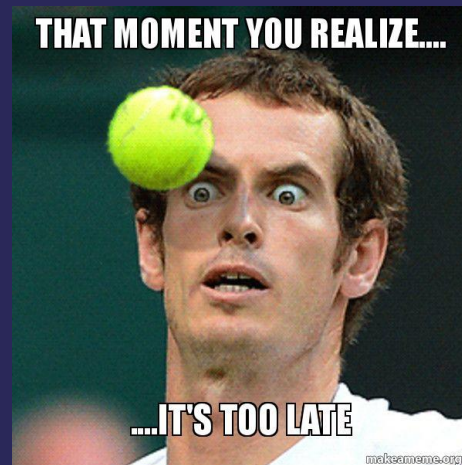
Conclusions

In the end: the client is responsible for
all deviating ground conditions



Conclusions

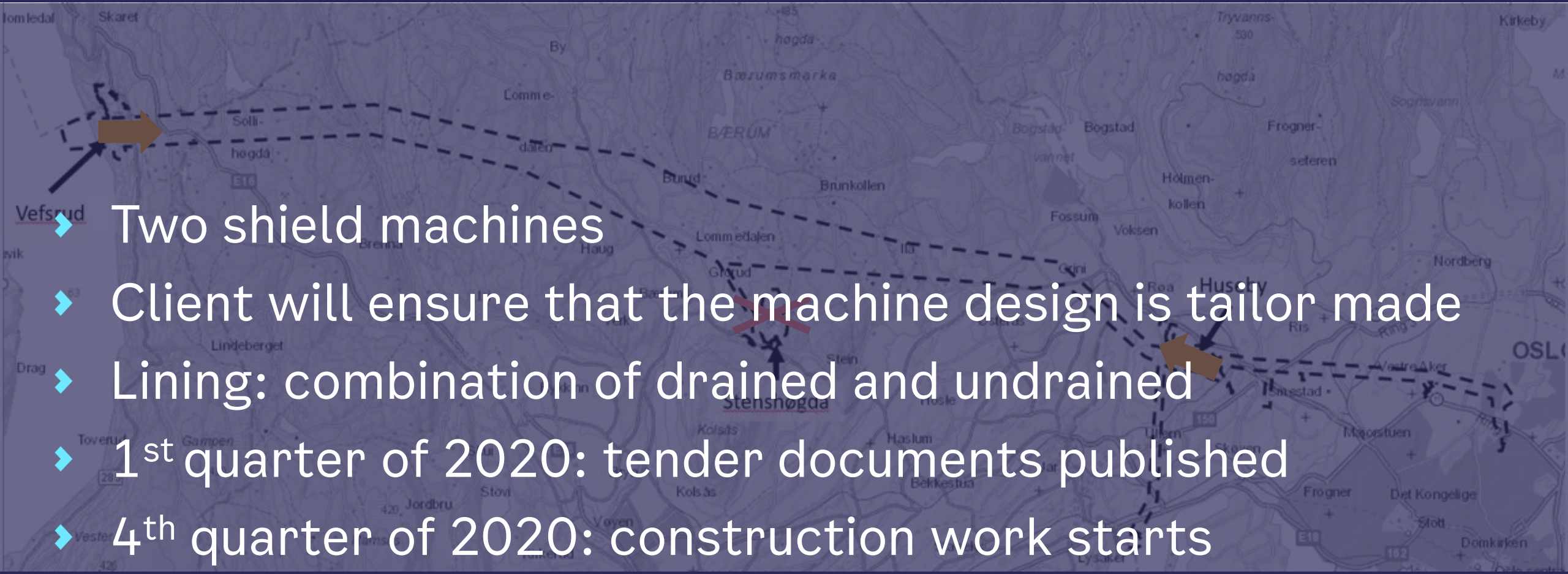
Assessment regarding tunnel
concept and excavation
method must be done in an
early project phase





The client's early involvement of skilled personnel with experience from construction sites is crucial

The result

- 
- Two shield machines
 - Client will ensure that the machine design is tailor made
 - Lining: combination of drained and undrained
 - 1st quarter of 2020: tender documents published
 - 4th quarter of 2020: construction work starts



Thank you for the attention!