Kalvebod skybrudstunnel og pumpestation

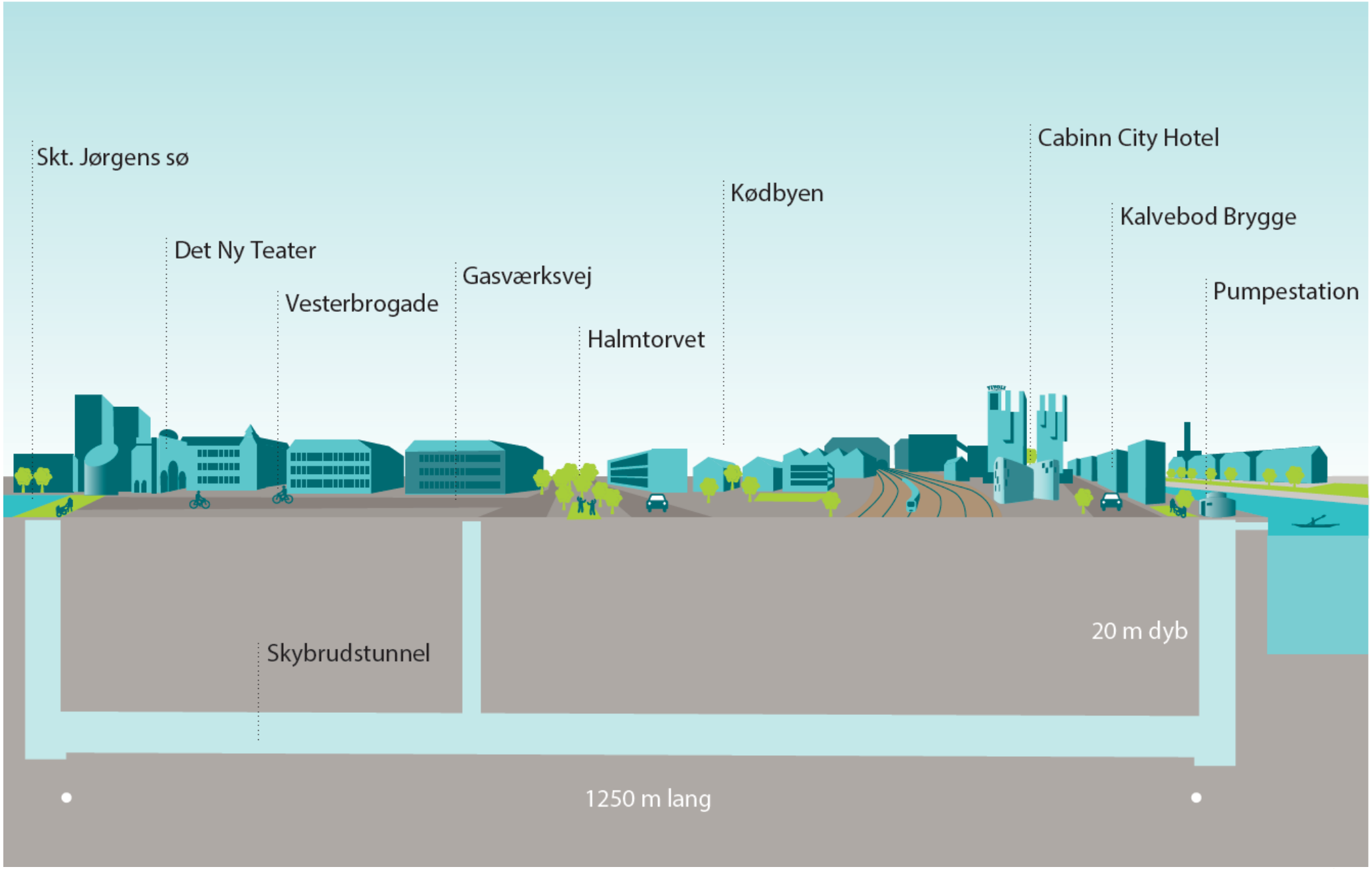
EVA temadag.
Pumper
5. Oktober 2023

Kæmpe pumpestationer
Kæmpe udfordringer

Niels Eriksen
Chefkonsulent
HOFOR

2. Juli 2011

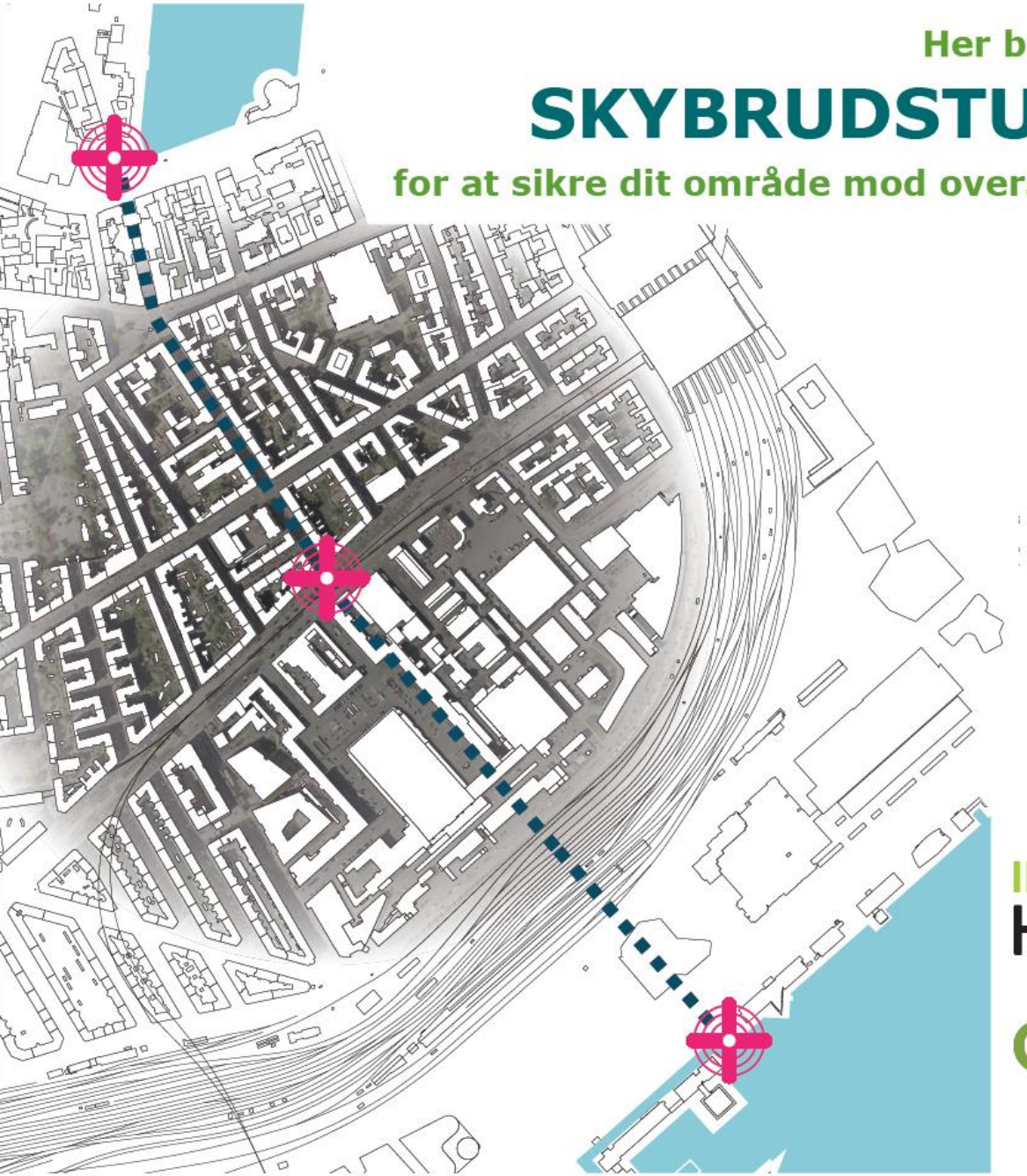
- https://www.youtube.com/watch?v=t7-CERo-_qM


Skt. Jørgens sø
Det Ny Teater
Vesterbrogade
Gasværksvej
Halmtorvet
Kødbyen
Cabinn City Hotel
Kalvebod Brygge
Pumpestation
Skybrudstunnel
20 m dyb
1250 m lang

Her bygger vi en

SKYBRUDSTUNNEL

for at sikre dit område mod oversvømmelse



HOFOR

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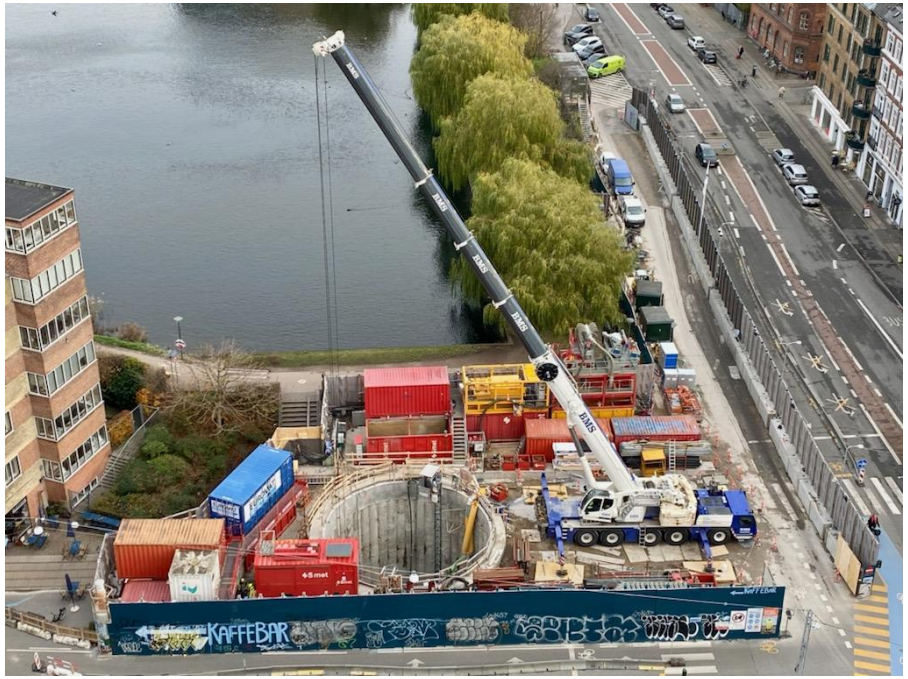
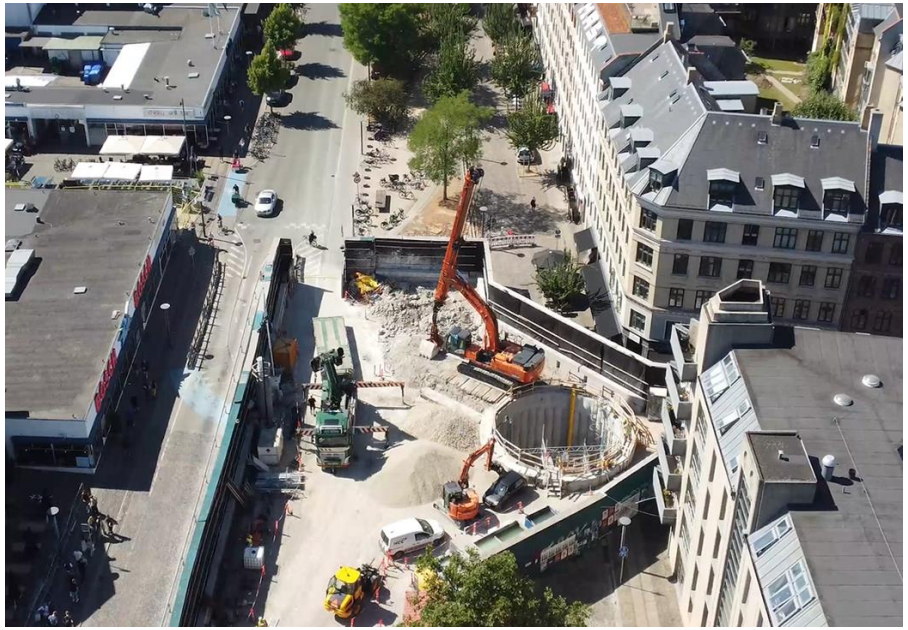
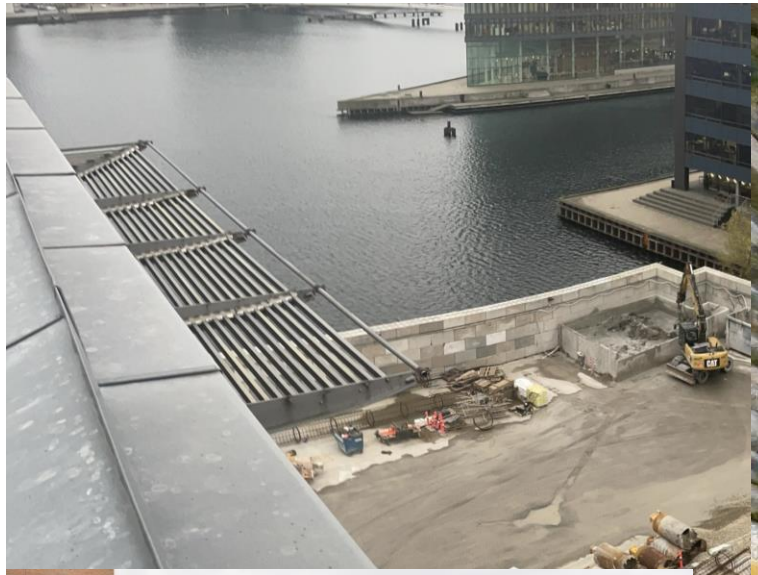
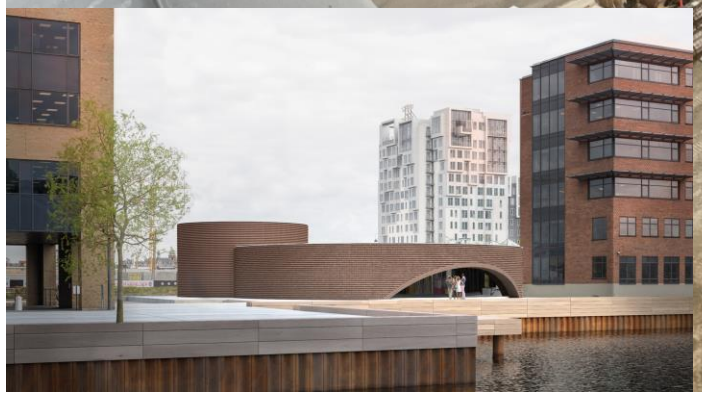




Pumpestation KAL
Kalvebod Brygge Nord for Fisketorvet





Kalvebod Skybrudstunnel og pumpestation
Særlige pumpetekniske udfordringer

Skybrudspumperne

- Egnet pumpetype
- Sumpdesign og tilløbsforhold
- Transienter.
- Begrænset mulighed for fuldskala test
- Driftssikkerhed

Tømmepumper

- Meget stor variation i driftsvandspejl

Hvilken pumpetype er egnet?

Høj kapacitet ved lavt løft
Dykket installation

Skaktrørspumpe af propellertypen.

Men duer sådan en til spildevand?
Kan den fungere i de pladsforhold der er til rådighed?

Købt efter EU udbud.

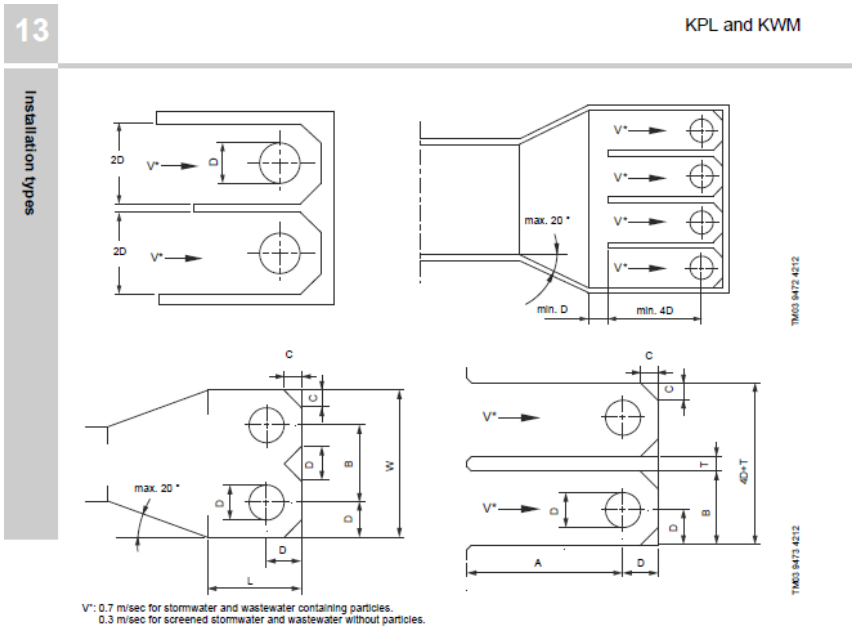
- 6 stk. Grundfos KPL 1500.500
- Ø1500 mm skaktrørspumpe
- Propeller Ø1060 mm
- Motor 500 kW 690V 485 o/min
- Kapacitet. 5,1 m3/s
- 4 m høj 6.700 kg

Aflastningspumpestation Åmarken
Pumpeforsøg med spildevand.

Besøg hus
Hillerød
forsyning

Åmarken
2*1,5 m^3/s

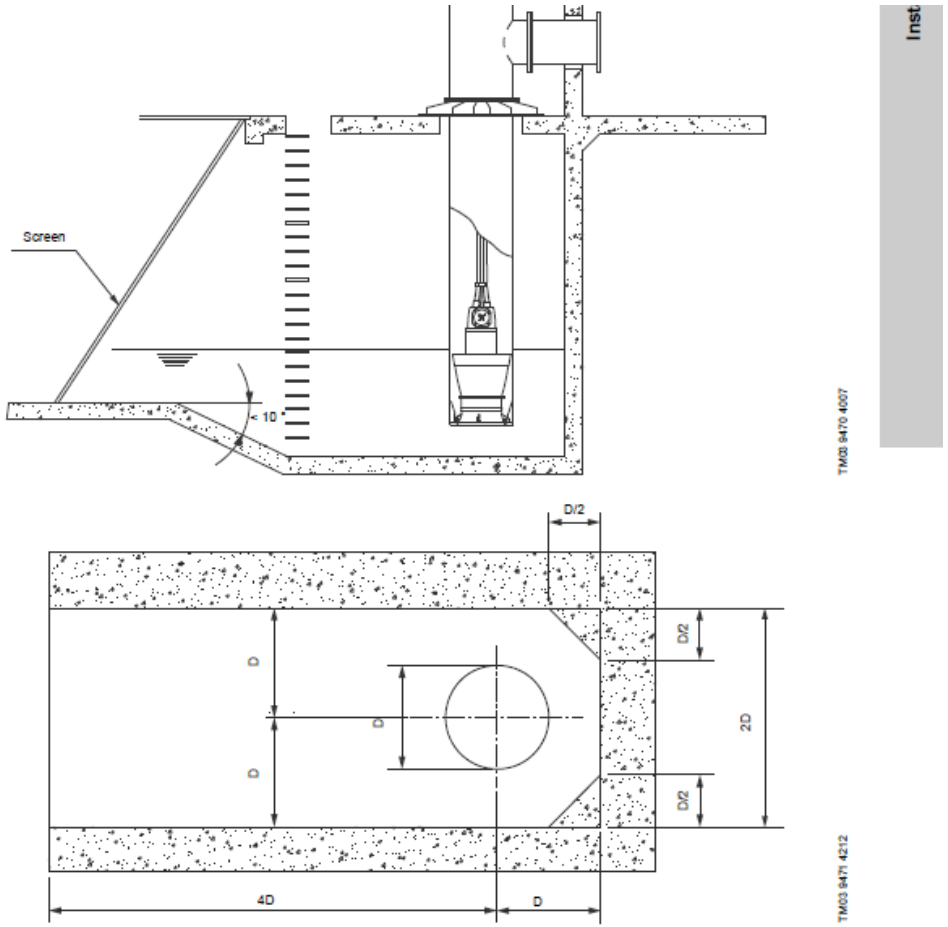
Hvordan designer man en pumpesump?
Følg design regler!



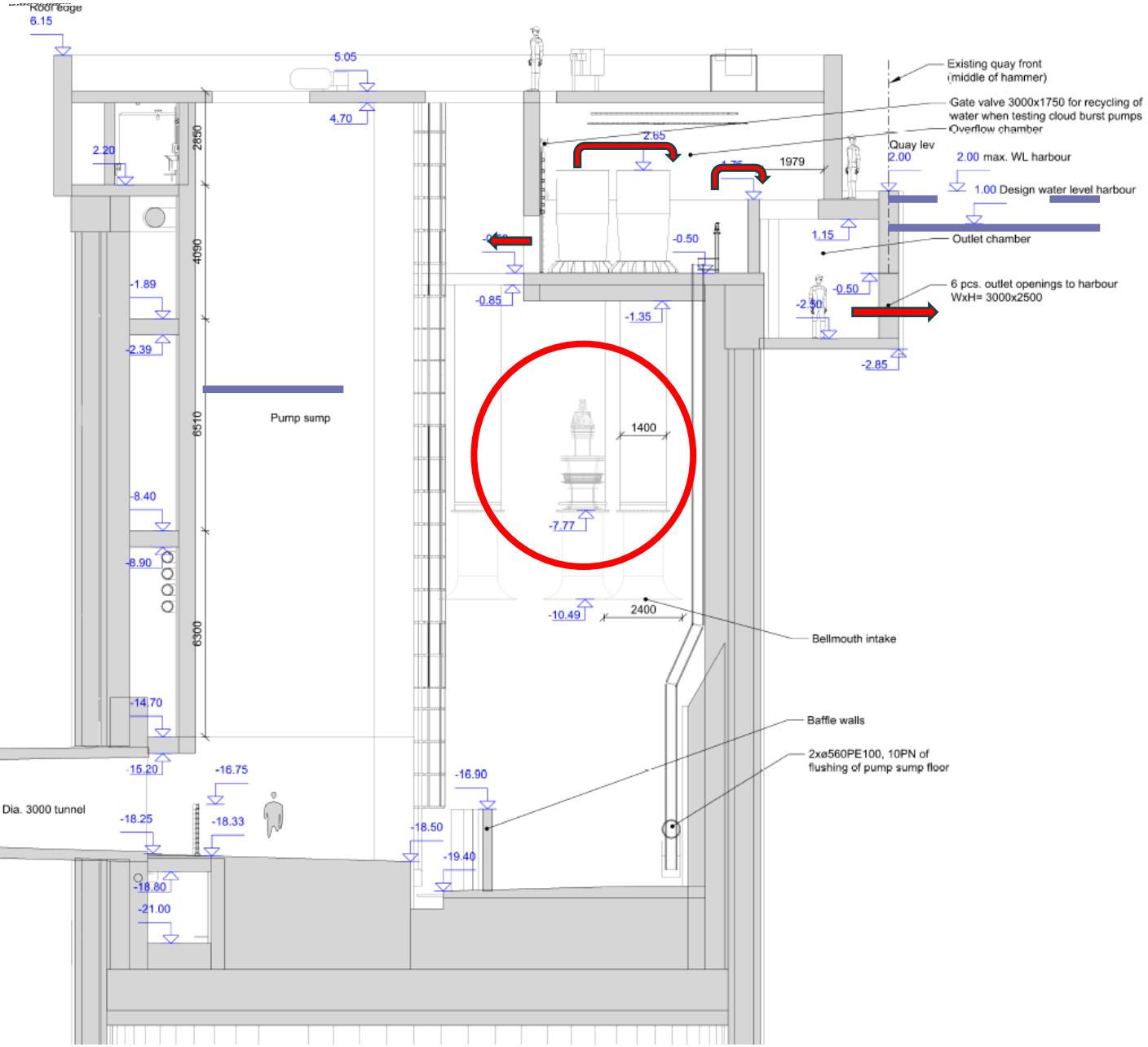
V*: 0.7 m/sec for stormwater and wastewater containing particles.
0.3 m/sec for screened stormwater and wastewater without particles.

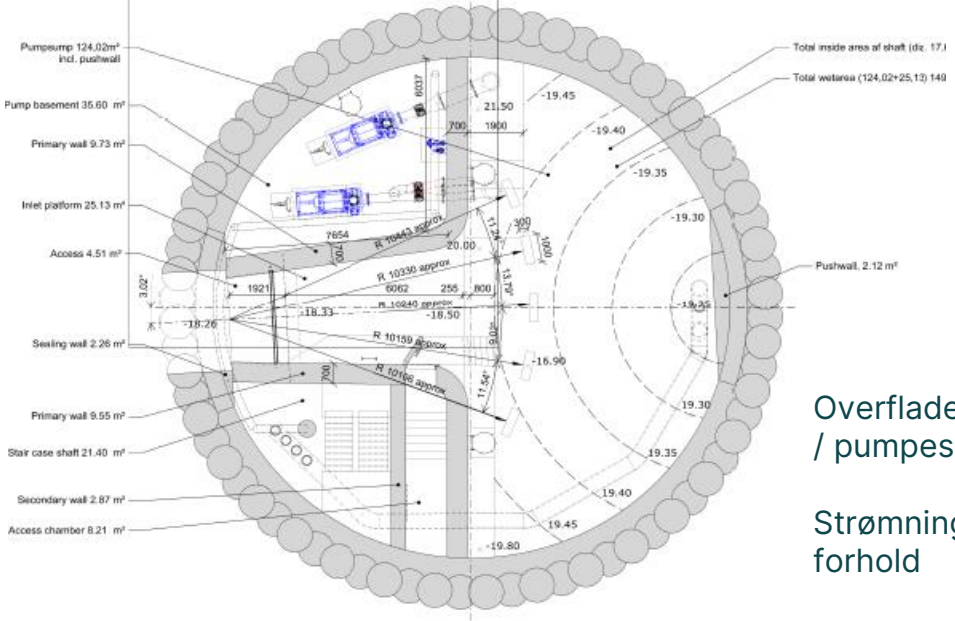
Dimensions

D (pipe diameter DN) [mm]	A [mm]	B [mm]	C [mm]	W [mm]	T	L [mm]
500	2000	1000	250	2000	Depending on construction	2000
600	2400	1200	300	2400		2400
650	2600	1300	325	2600		2600
700	2800	1400	350	2800		2800
800	3200	1600	400	3200		3200
900	3600	1800	450	3600		3600
1000	4000	2000	500	4000		4000
1100	4400	2200	550	4400		4400
1200	4800	2400	600	4800		4800
1400	5600	2800	700	5600		5600

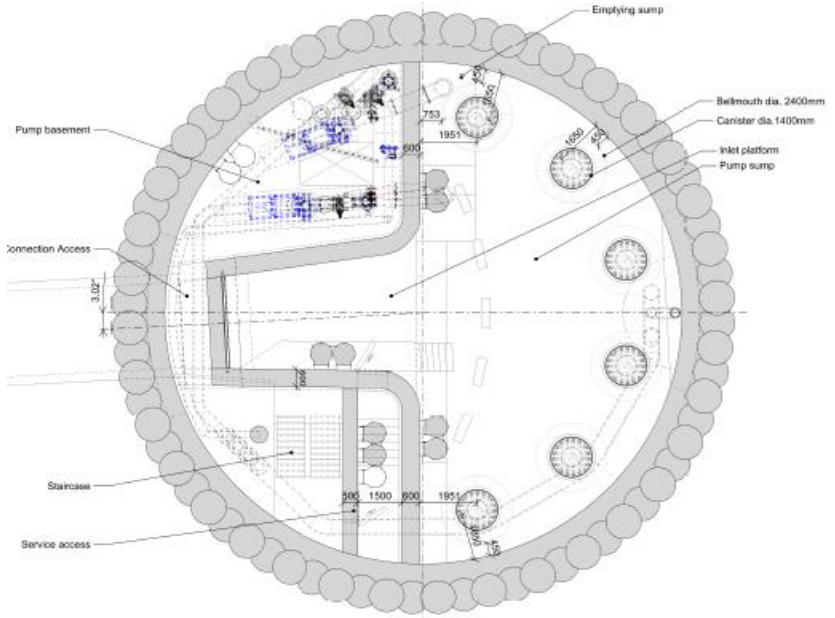


KAL Skybrudspumpestation i plan og snit





SECTION IN LEVEL -16.75, BOTTOM FLOOR OF SHAFT (PUMPBASEMENT)



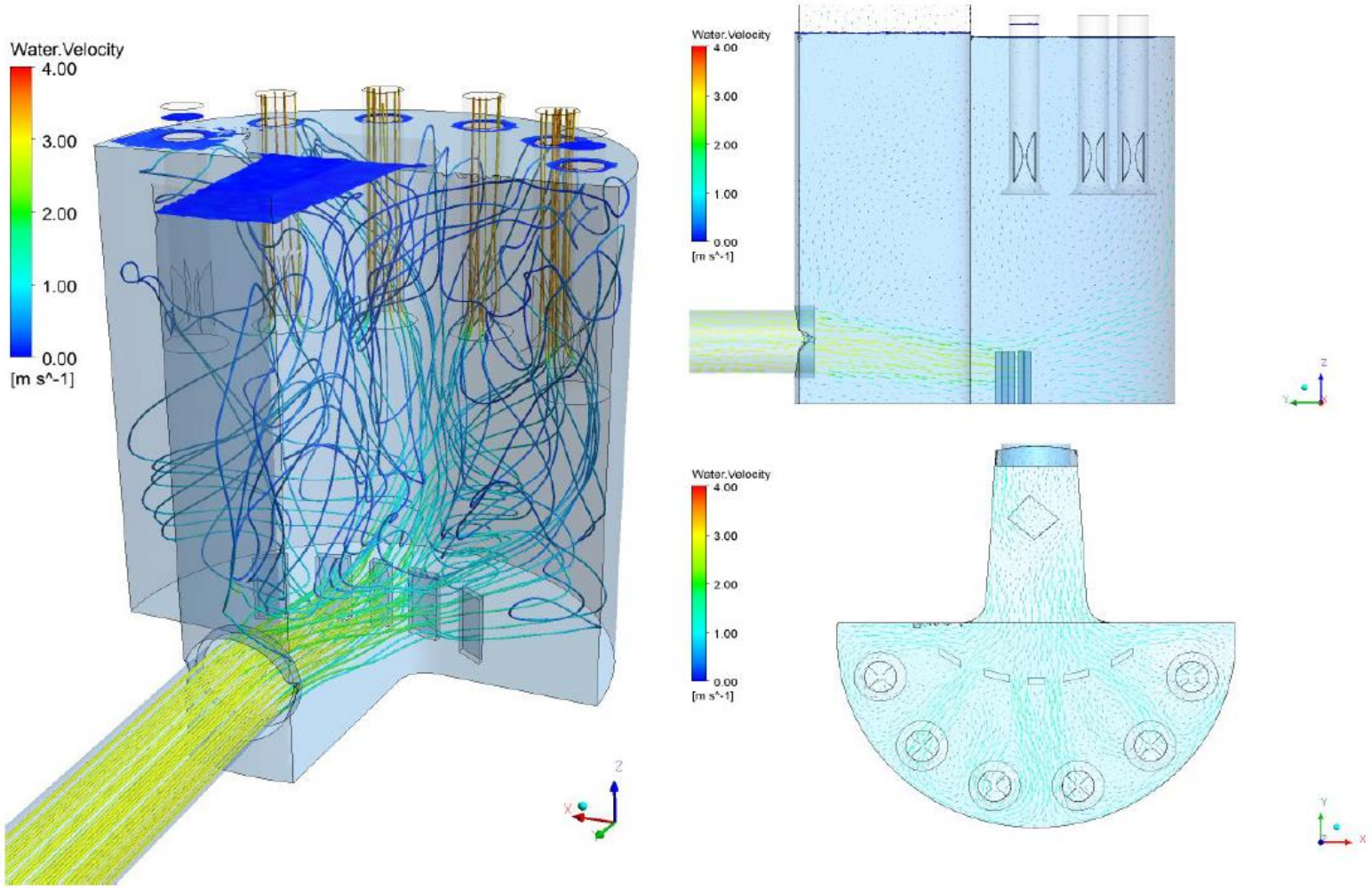
Overflade areal / pumpestarter

Strømning-forhold

Udviklingen af aktuelle design

CFD modellering af sump design og pumpeindtag

Open Shaft Layout with Baffle Blocks – Phase 2 Results



Swirl Angle measured at -7.8m

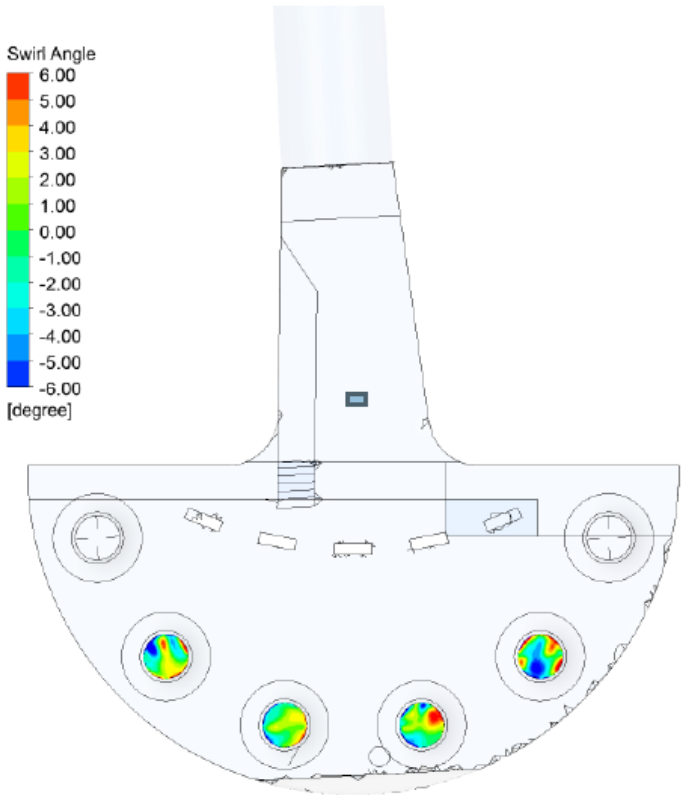
$\theta = tan^{-1}(Vt/Va)$

Swirl Angle, Where V_t= tangential velocity and Va is axial velocity.

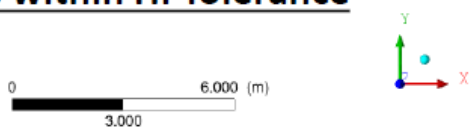
≤ -5° Swirl Angle

≥ 5° Swirl Angle

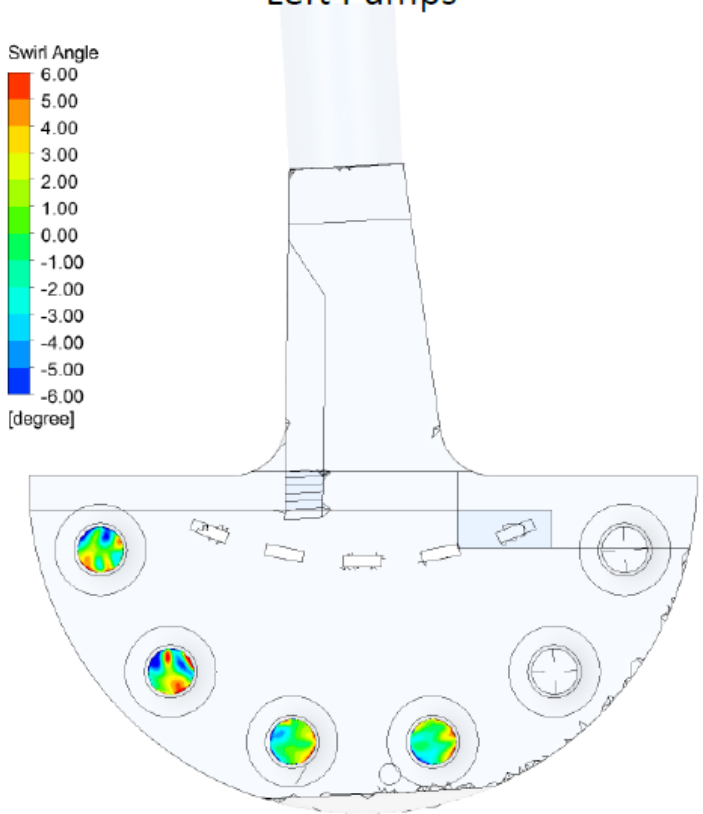
Middle Pumps



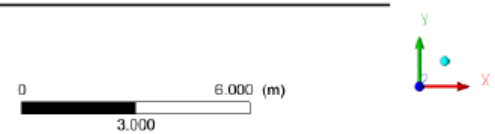
86% within HI Tolerance



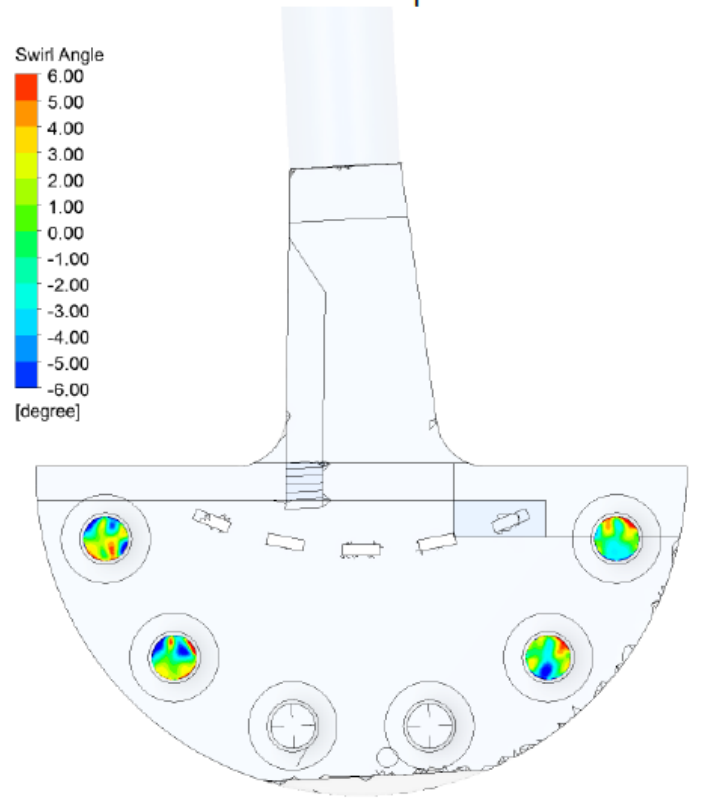
Left Pumps



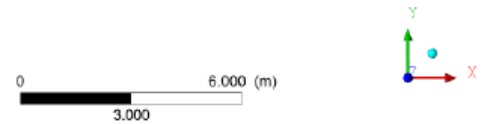
88% within HI Tolerance



Side Pumps



88% within HI Tolerance

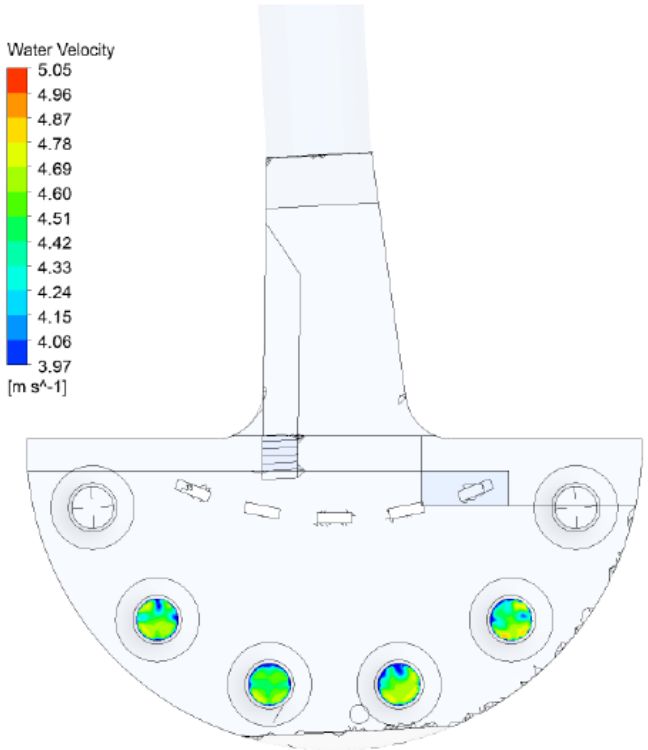


Velocity Distribution at -7.8 m

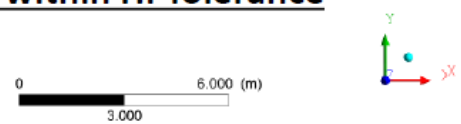
≤ 10% velocity distribution

≥ 10% velocity distribution

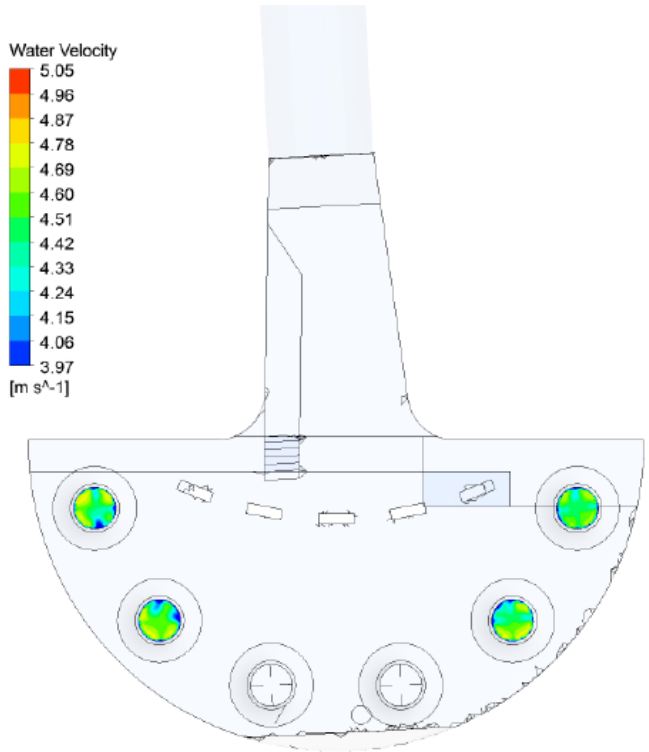
Middle Pumps



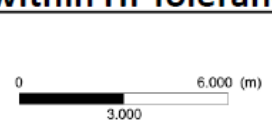
91% within HI Tolerance



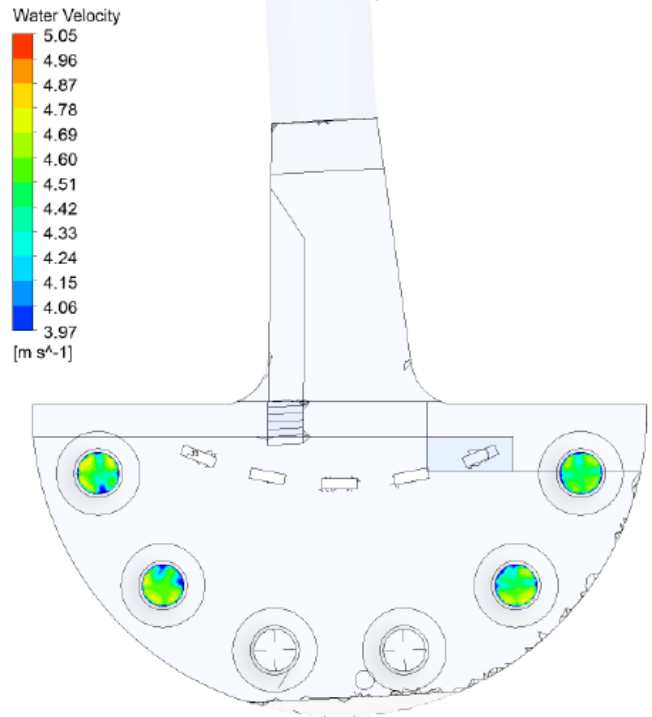
Left Pumps



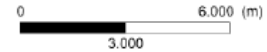
90% within HI Tolerance



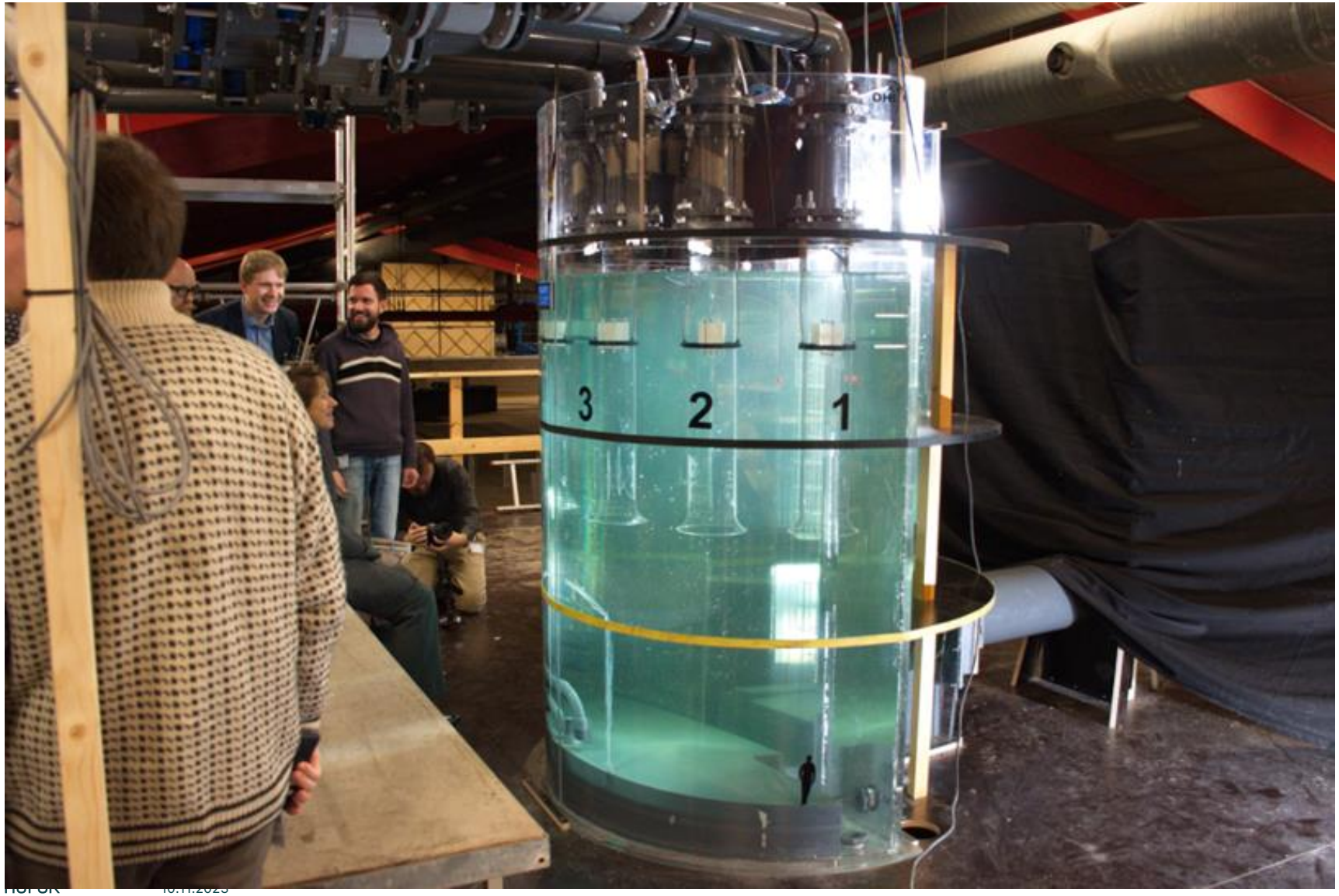
Side Pumps



92% within HI Tolerance



Skalamodel test DHI



Skala 1:20

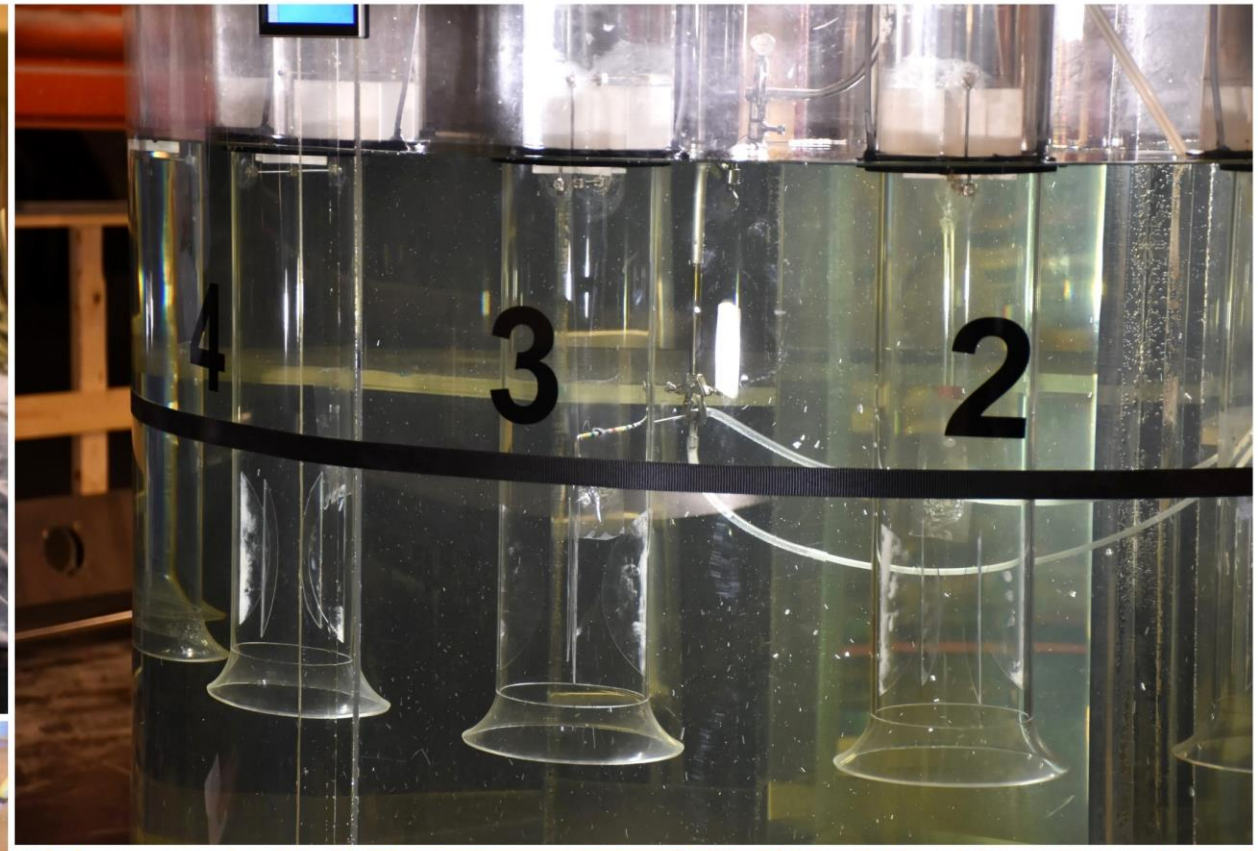
Tilløbsforhold til pumpesump og pumper:

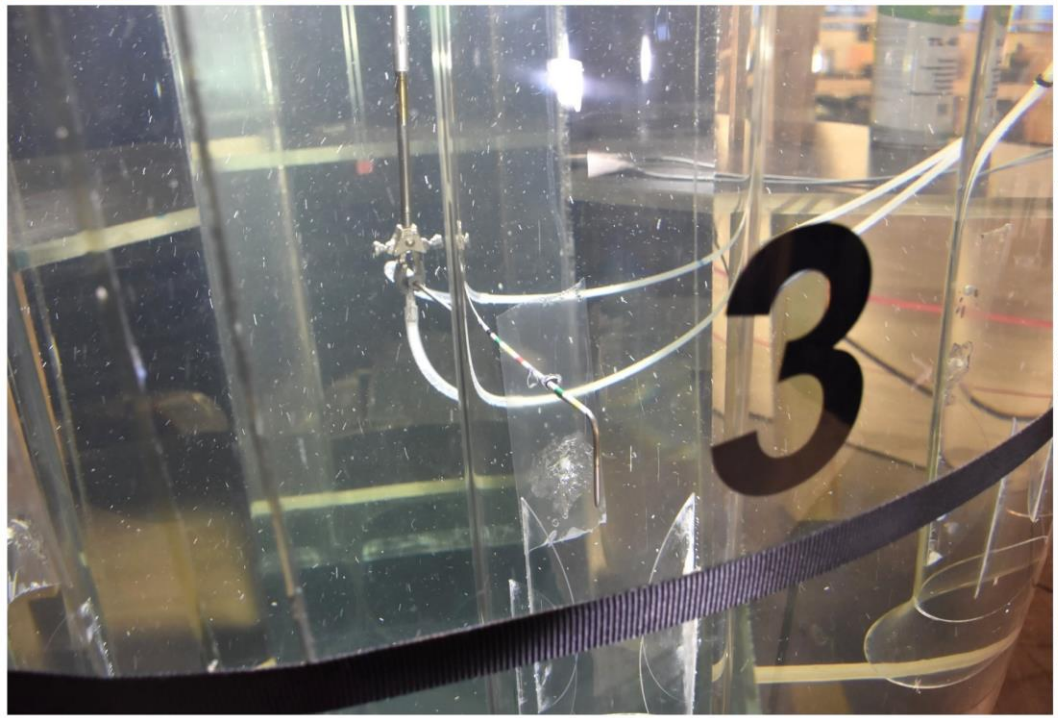
- Vortex til overflade
- Flowretning ”vinkel”
- Flow fordeling i skaktrør

- Effekt af recirkulering

- Sediment ansamling i sump

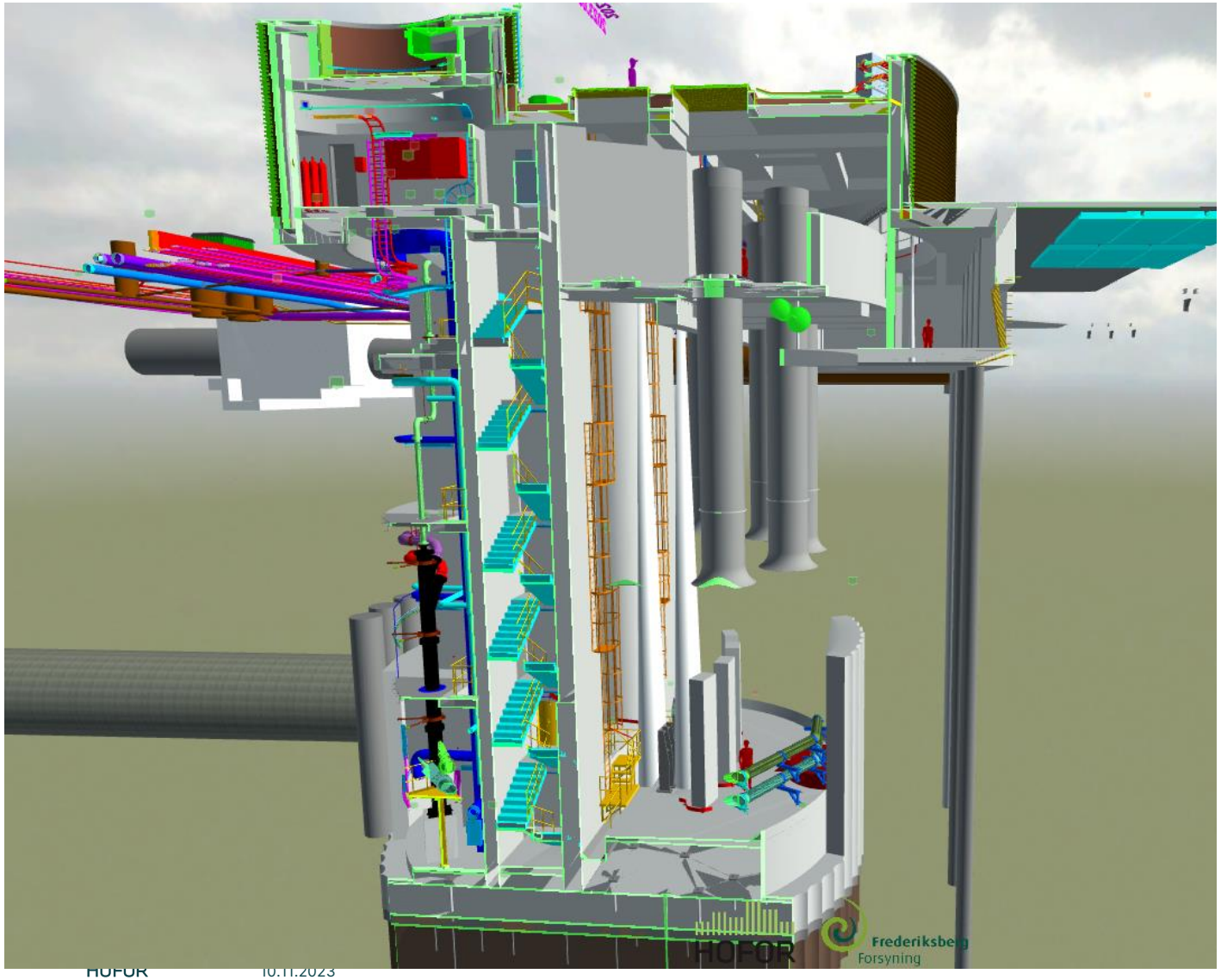

2
1

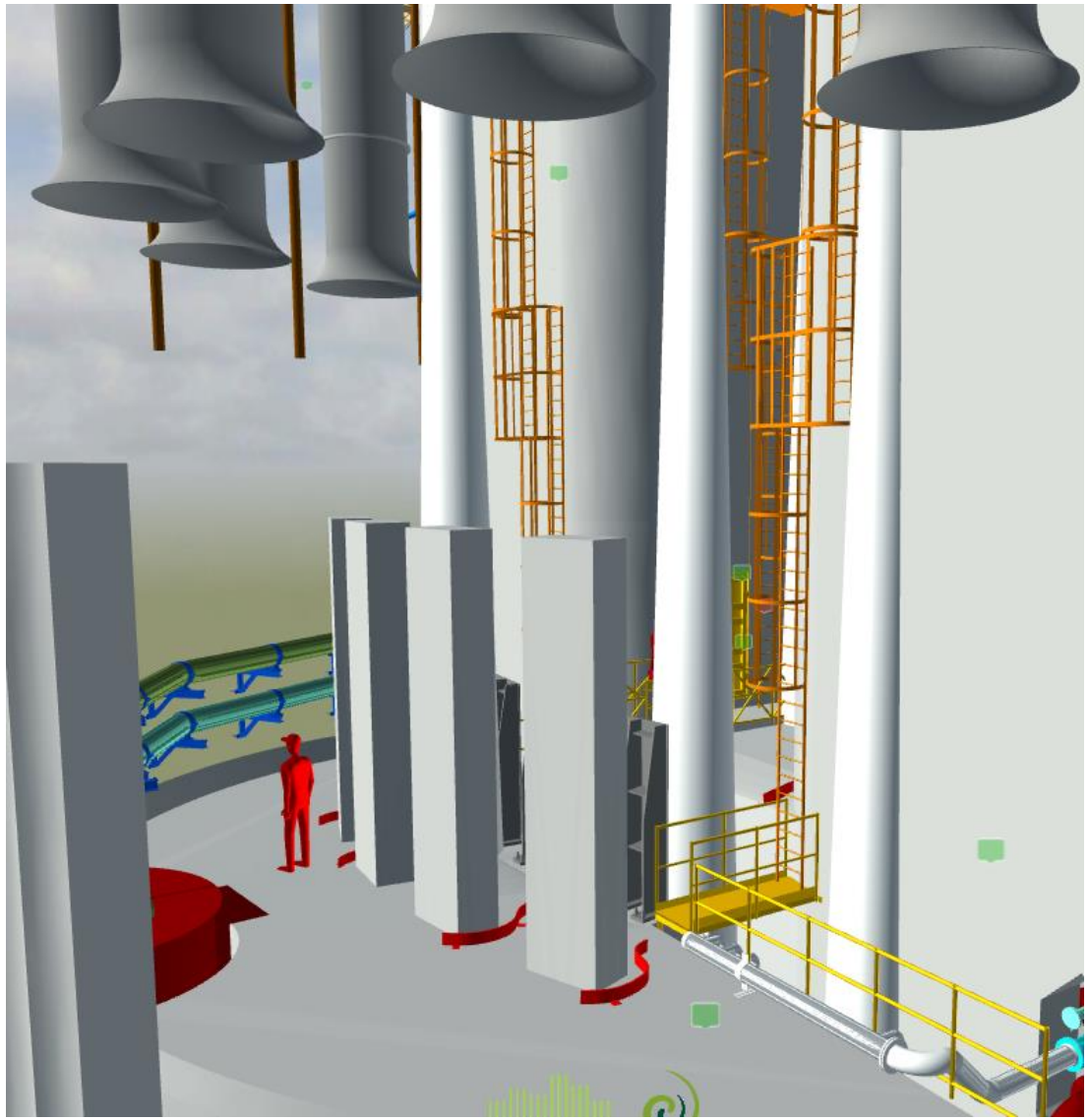

4
3
2


3

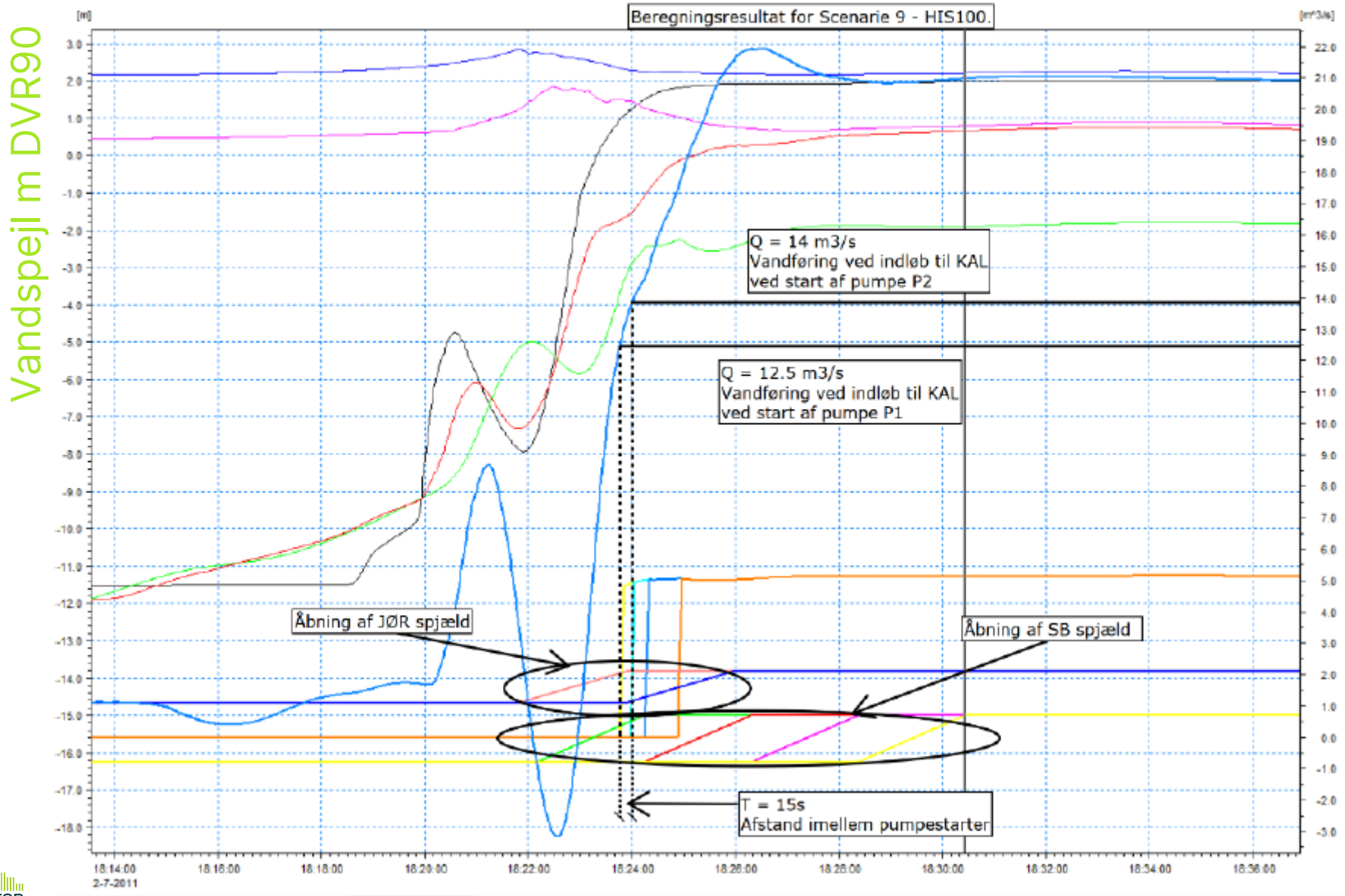

5
4
3
2

Ekstra baffel vægge sump indløb





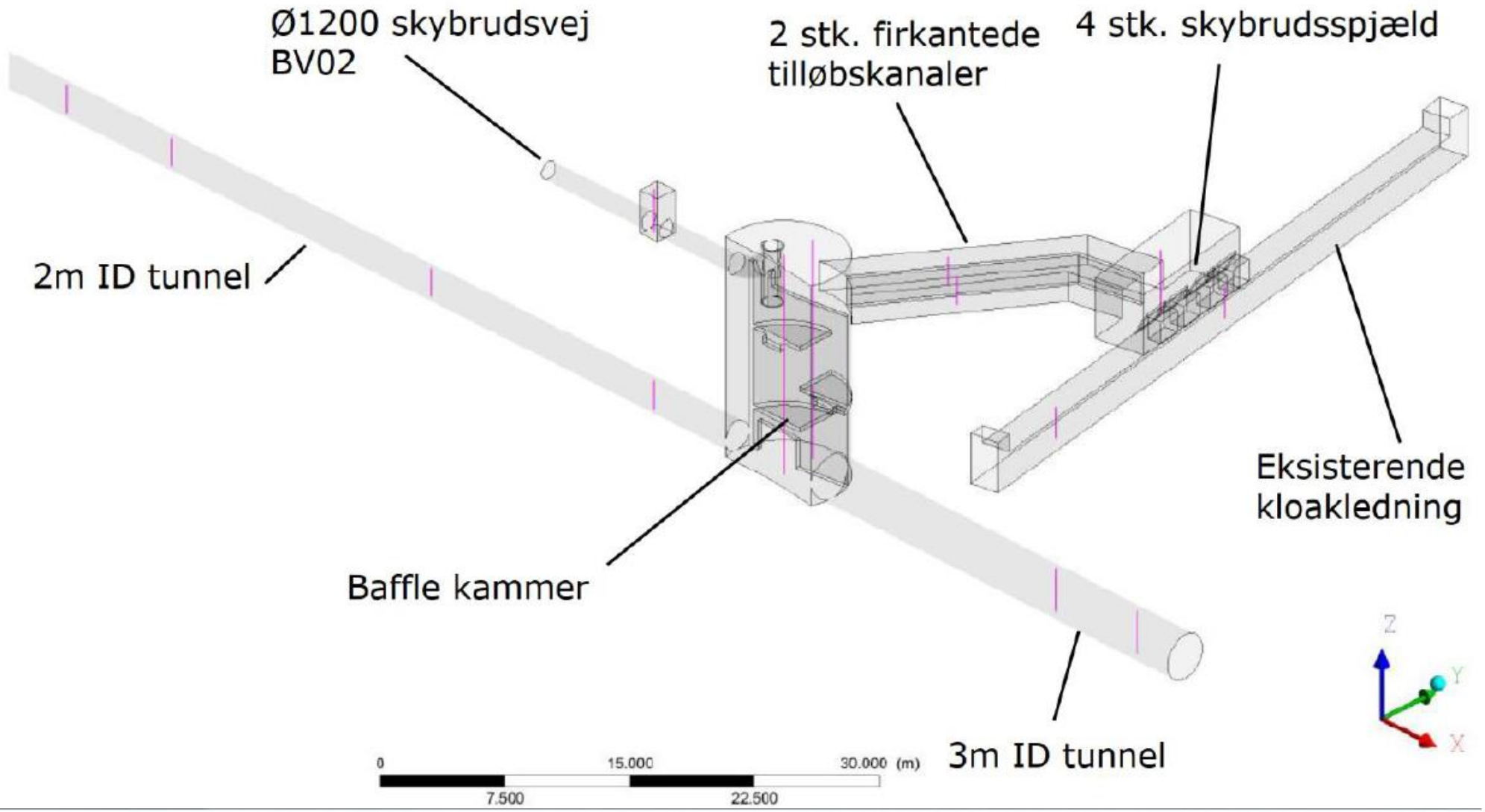
Transienter. Simulering af driftssituationer i MIKE URBAN



- Ikke en statisk situation
- Pumpestart
- Ændringer i klap positioner
- Skvulp

HOFOR

Skybrudsklapper.
Tilførsel af vand til tunnel fra afskærende hjælpeledning hhv. hovedkloak



Driftssikkerhed

Byg et projekt til 500 mio. kr. der skal fungere i skybrud 1 gang / 5 - 10 år

Forhåbentligt fungerer det 1. gang !

Kan ikke fuldskala testes !

Forstudie udarbejdet af Rambøll.

- Sikker el forsyning
- 4+2 pumper
- Minimering af antal komponenter
- Oppetids analyse og krav til komponenter