Vortrag

Freitag, 08. Oktober 2021, 09:30 Uhr

HDD-Projekt Dogger Bank A & B

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Lecture

Friday, 08th October 2021, 09:30 am

HDD project Dogger Bank A & B

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Company: LMR Drilling UK
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DoggerBank HDD-Landfall

Dogger Bank A & B Offshore Wind Farm

Contents

Dogger Bank A & B Offshore Wind Farm

Project Details

- Dogger Bank A & B are separate Projects, each generating up to 1.2 GW of power
- Client a Joint Venture of SSE Renewables (40%), Equinor (40%) and Eni (20%)
- Windfarm includes offshore converter station
- 4 no. 170km HVDC export cables transmit power to shore
- From landfalls HVDC cables run to Convertor Station and Electrical Substation 30km from landfall site

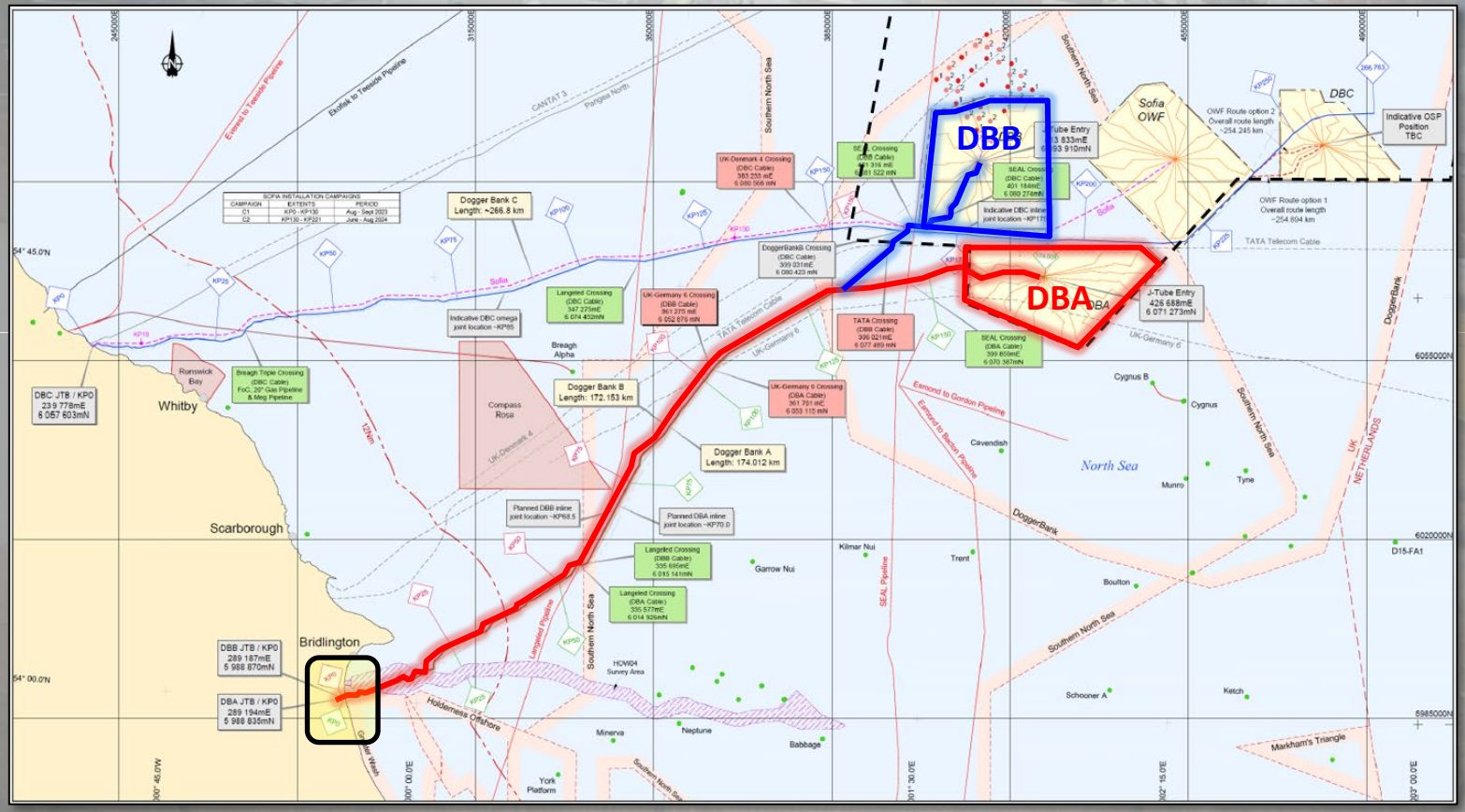
1 Project Introduction

Dogger Bank A & B Offshore Wind Farm

Windfarm Site

Dogger Bank A & B Offshore Wind Farm

Projects and Export Cable Routes



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Landfall Site

Landfall Details

- Fast eroding shoreline required trenchless solution
- Various options considered:
  - 400 – 500m HDDs into beach cofferdams
  - 400 – 500m long Direct Pipe into beach cofferdams
  - 1,400m long HDDs out to -8m LAT contour
- 4 no. 132mm OD HVDC cables to be installed into separate ducts
- 2 no. 25mm OD F/O cables to be installed alongside HVDC cables
- Ground Conditions key to determining the best option

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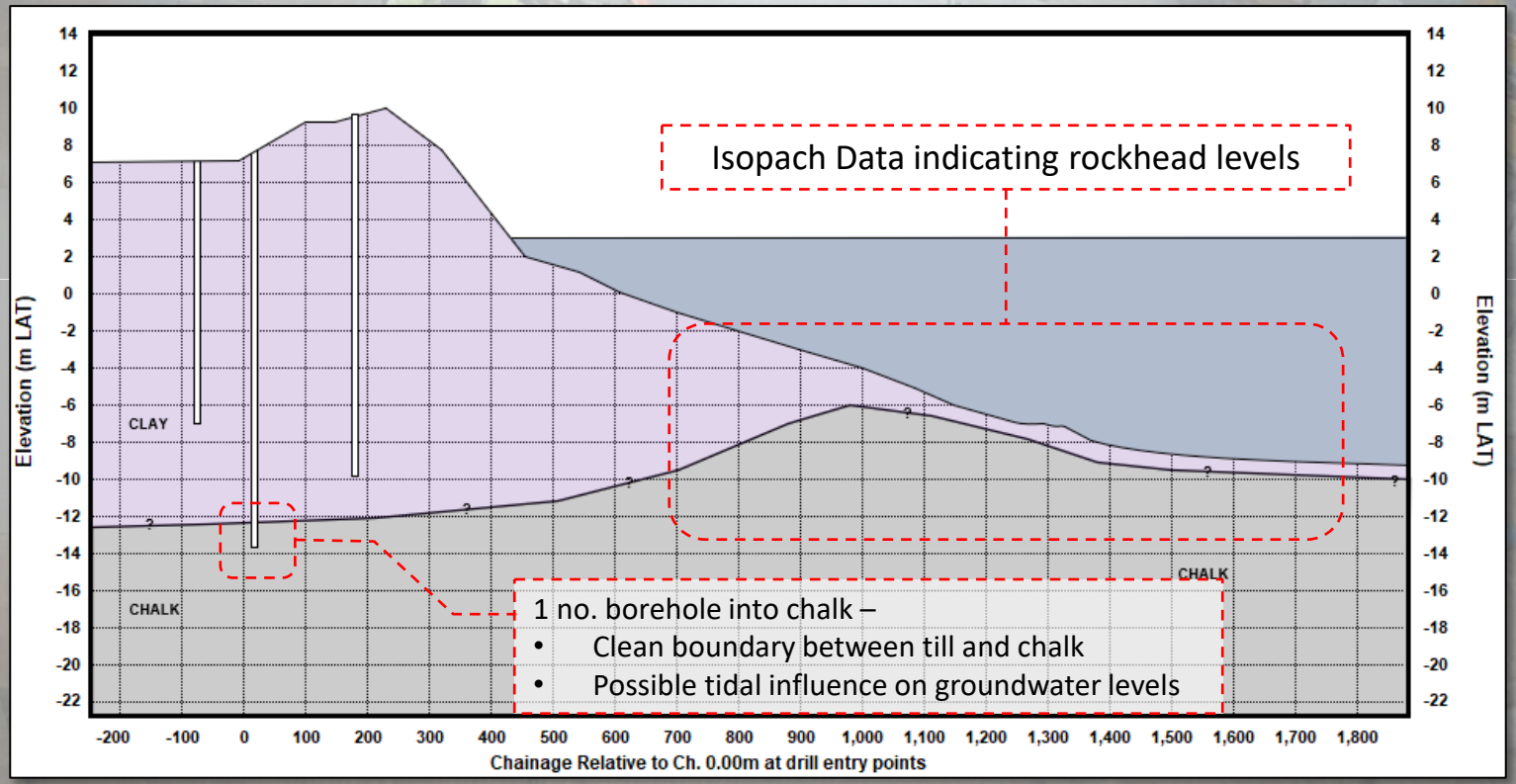
Site Investigation – Pre-Tender

- At tender stage only land-based boreholes and offshore geophysical data indicating Glacial Till overlying Chalk



Site Investigation – Marine Boreholes

- Following award to NKT 5 no. marine boreholes commissioned:
  - Little flint within the chalk, no flint beds
  - No solution/karst features within the chalk
  - Consistent weathering profile through the chalk
  - No significant weathering or gravel layer between till and chalk
  - Seabed materials mostly glacial till (clay) with layer of cobbles on seabed

But not able to shed any further light on the groundwater regime and permeability of the chalk

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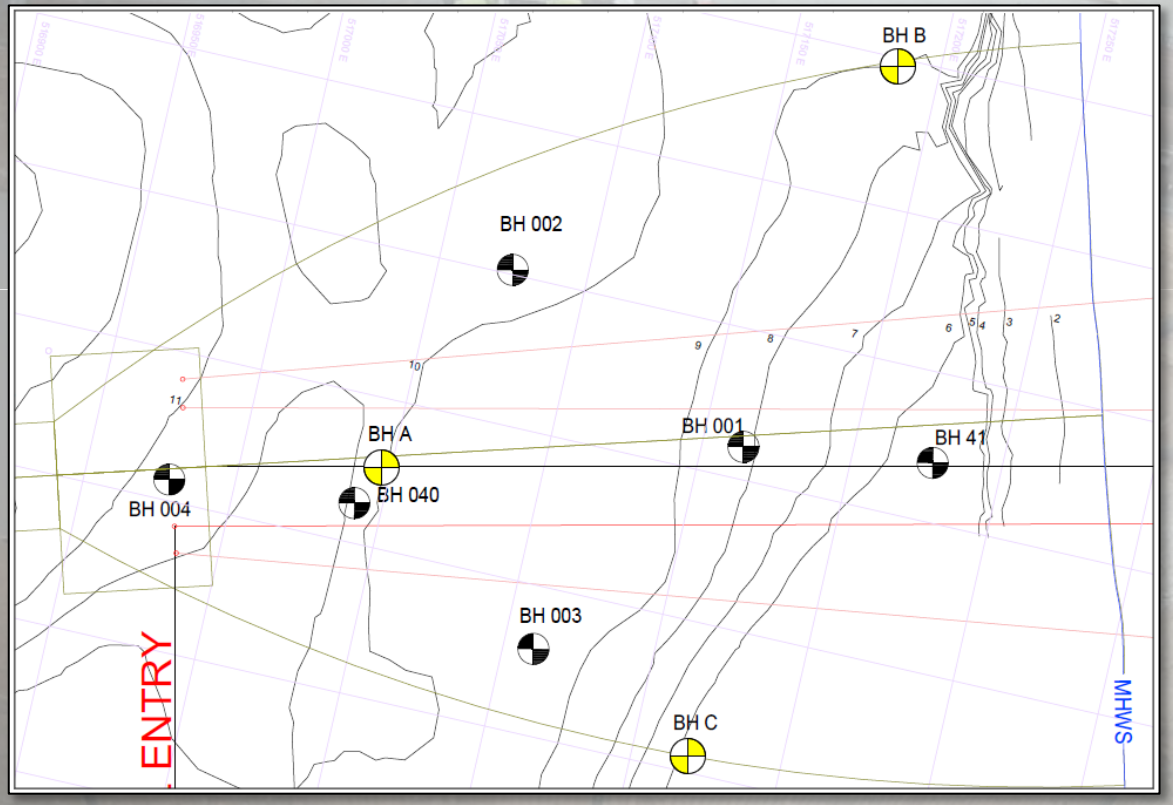
Site Investigation - Chalk

- Further 3 no. onshore boreholes to assess chalk permeability



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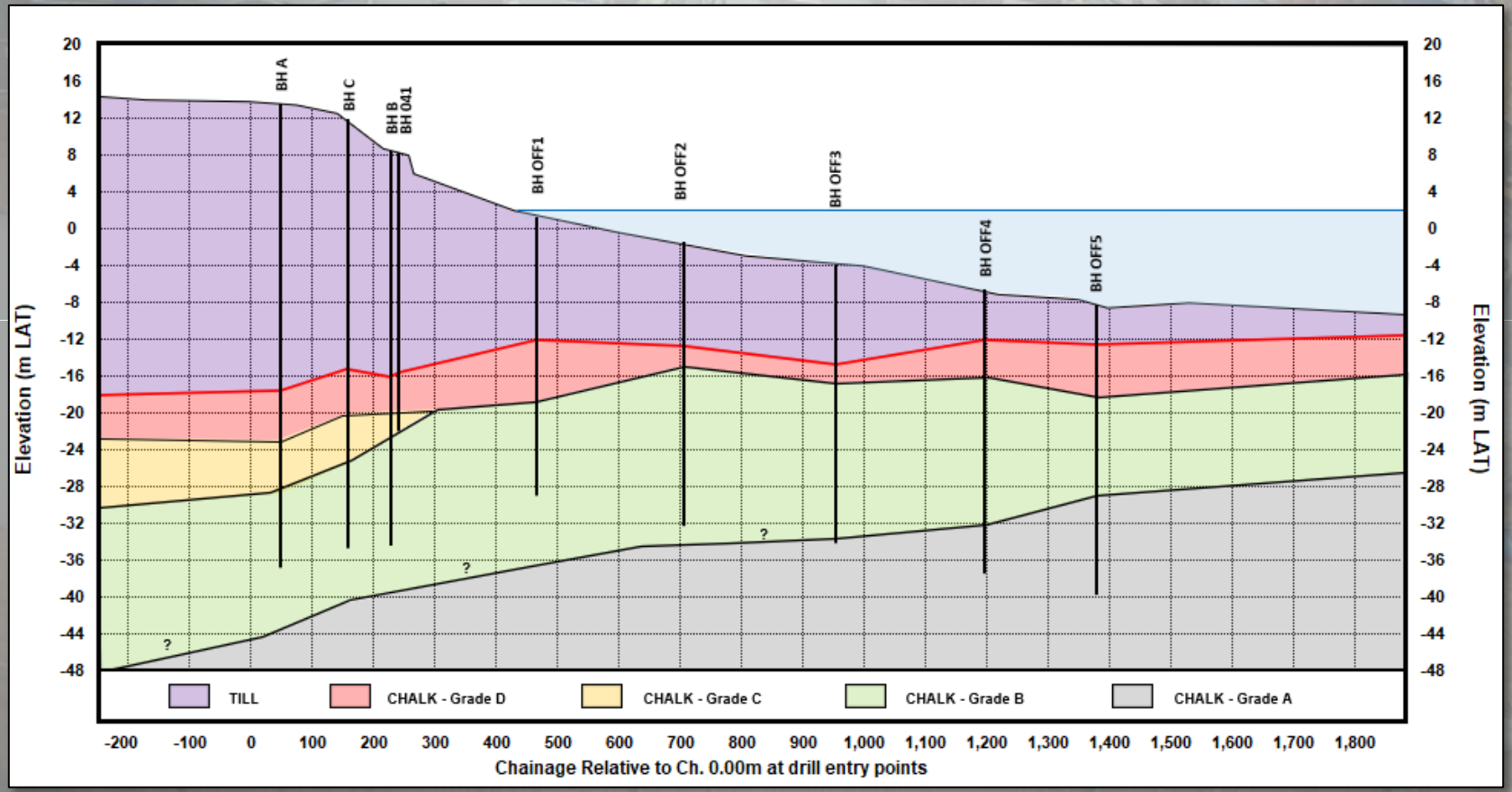
Site Investigation – Ground Model



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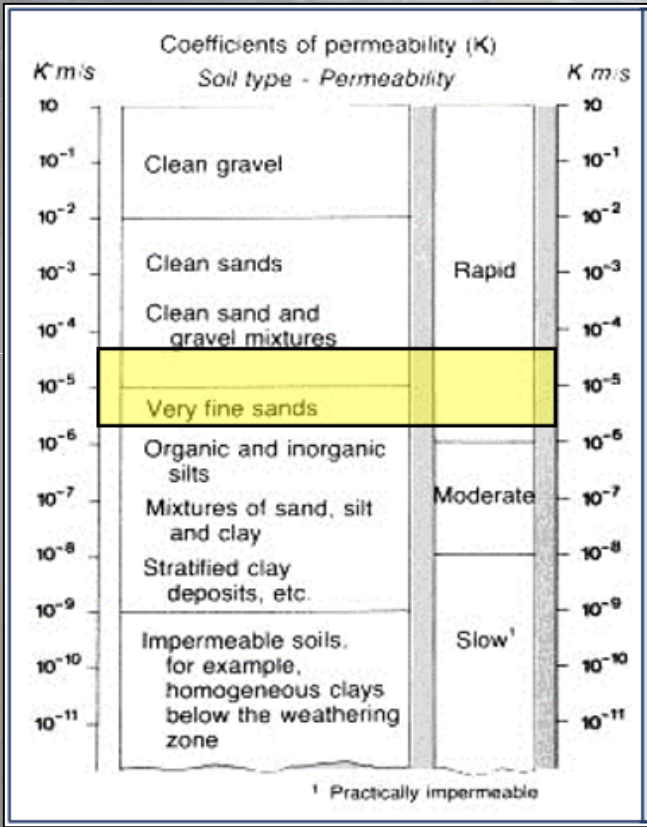
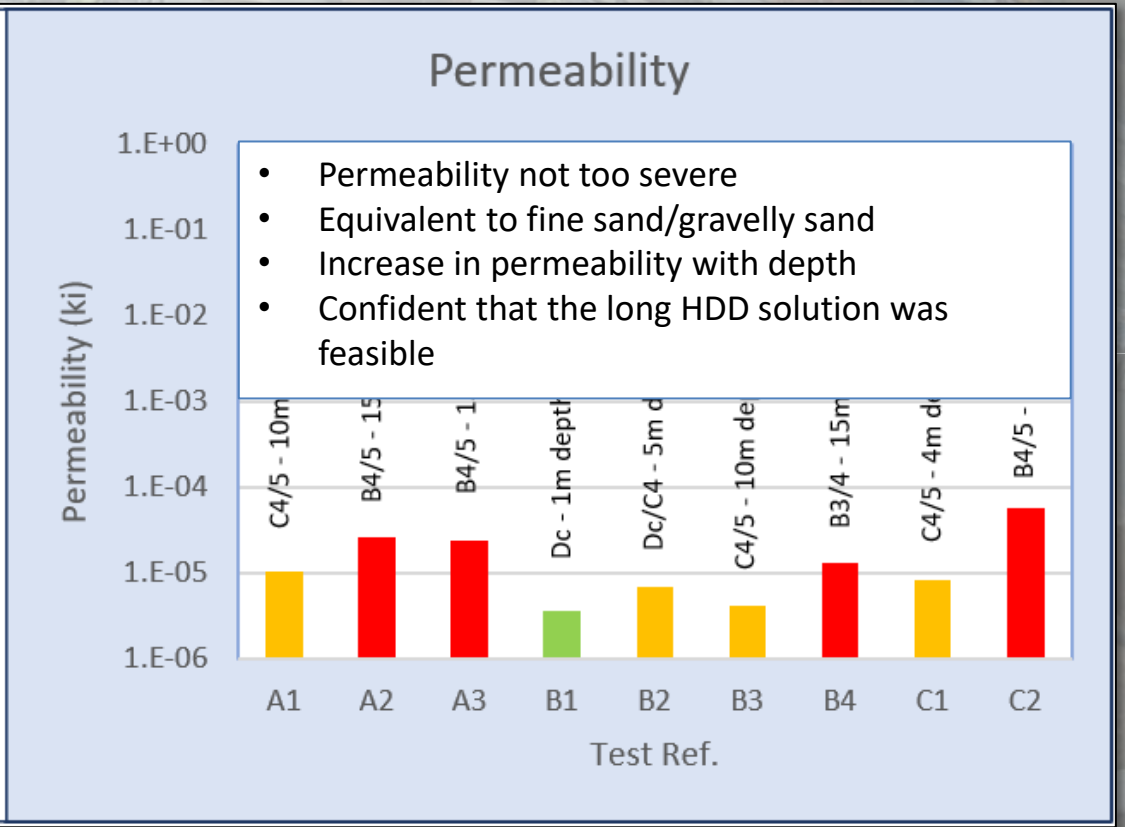
Site Investigation – Permeability Data



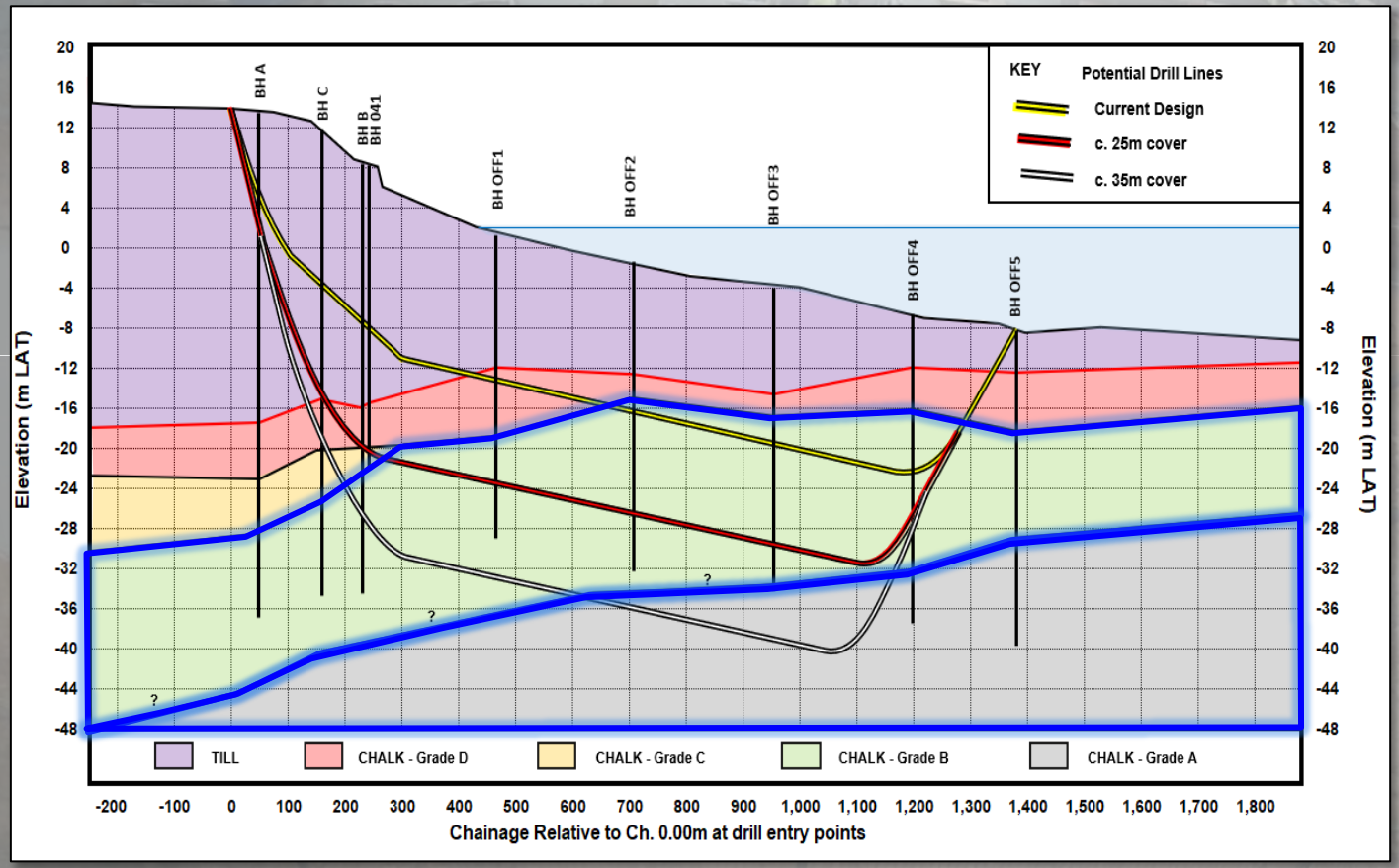


- Permeability not too severe
- Equivalent to fine sand/gravelly sand
- Increase in permeability with depth
- Confident that the long HDD solution was feasible

3 Engineering

Dogger Bank A & B Offshore Wind Farm

Drill Profiles



Any drill has to pass through more permeable grade B chalk

A deeper drill enters grade A chalk with unknown permeability

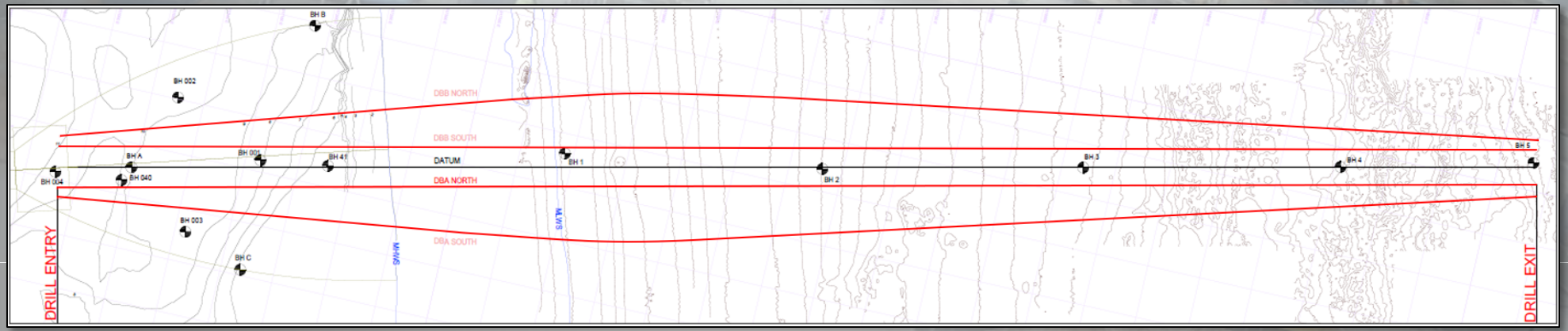
Mid-depth profile chosen to:

- Avoid Grade A chalk
- Maximise depth of cover
- Minimise risk of mud losses
- Minimise length drilled through glacial till.
- Minimise the length drilled through Grade D chalk

3 Engineering

Dogger Bank A & B Offshore Wind Farm

Drill Profiles



- 4 no. drill lines – outer drills curved to maintain depth vs. separation criteria
- Relatively close exit points due to need for trenched burial for 250m offshore
- High degree of steering accuracy required

Methodology

- Each drill required the following operations:
  - Pre-drill and enlarge first 60m of hole and install steel casing/conductor pipe
  - Drill 20” diameter pilot hole from end of conductor pipe
  - Cleaning run before punch-out
  - Breakthrough onto seabed
  - Survey to verify suitability of exit position and acceptability of separation from adjacent drilled holes
  - Install cable duct into drilled hole

Steering System

- The Vector gyro system was used with Inrock providing the tooling and survey services. Features of system included:
  - Gyro data avoiding corruption from magnetic interference. Essential with large drilling assemblies, horizontal curves, long drills and tight tolerances
  - 300m entry coil for integrated Paratrack system allowed verification of elevation and inclination bias
  - PWD system provided real-time annular pressure data
  - Ability to house the steering tool in any size of drill collar with any form of connection
  - No 'HDD-world' limit on operating pressure of gyro – flexibility with mud motor specification

3 Engineering

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Drill Site

- 2km haul road from B1242
- Good level drill site
- Standard 250t rig spread

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Early Drilling Works

- 2020 Drilling Works
  - Mobilise drill spread in November 2020 before post-Brexit Import/Export regulations take effect
  - Pre-drill and enlarge first 60m of hole and install 48m of 24” steel casing/conductor pipe
  - Drill 17½” diameter pilot hole from end of conductor pipe to depth of 300m to:
    - Assess nature of till/chalk interface
    - Give opportunity to grout pre-Christmas shutdown if required
    - Assess performance of drilling assembly in chalk
  - Results all positive
  - Trip-out drill string and close site for festive period

4 Differential Sticking

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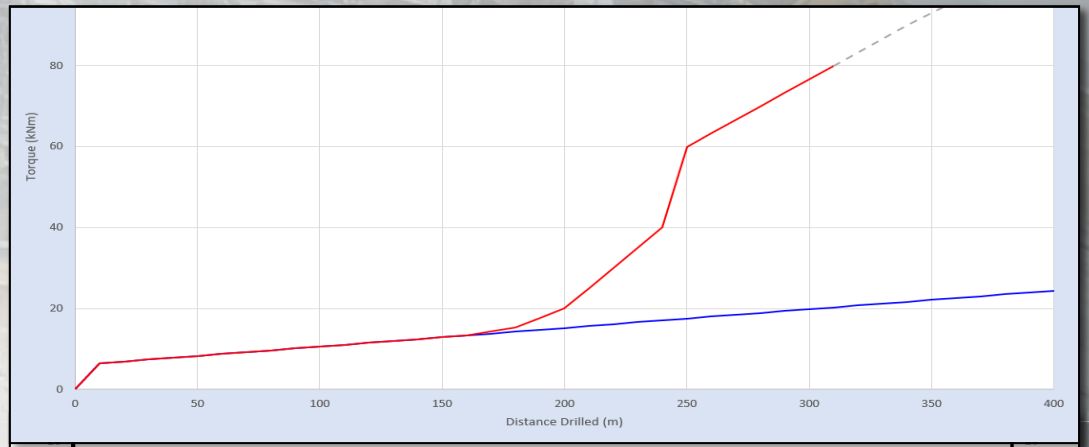
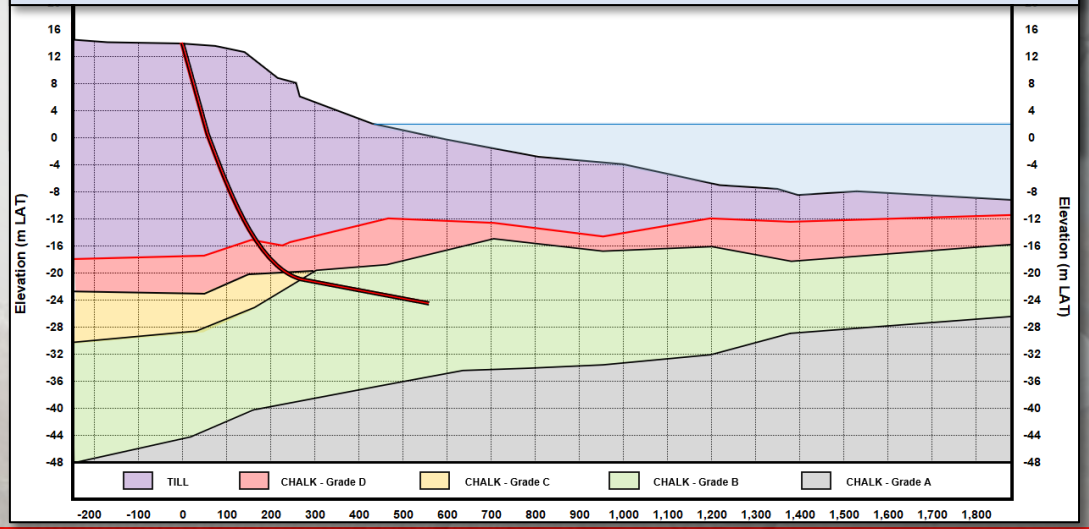
Early Drilling Works

- 2021 Drilling Works
  - Return to site on 5th January and trip-in DS
  - Drill on to 570m over 2 no. shifts – 15t pull and 15kNm of torque at end of shift
  - Following morning, 9th January, unable to free drill string with 200t pull and 90kNm
  - Perform tests on stuck string to determine stick-point
  - Results indicate string stuck over a long length of the hole
  - Evidence pointed to a long section of hole having collapsed overnight





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Attempts to Free Drill String

- With the assumption that a collapse of the hole was causing the jamming we first tried to jet away the collapsed material by running a second string of drill pipes down the side of the jammed string
- Tooling mobilised from Aberdeen to run with steering tool and PWD sub
- Despite running string in and out to 200m, 300m & 400m and high flow rates:
  - Virtually no change to the results of the twist tests.
  - Next to no material flushed from the hole
  - No difficulty running the side string and following existing hole.
  - Normal annular pressure readings
- Not fitting with explanation that the drill string had become stuck due to hole collapse

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Prepare for Overwashing

- While the side-string method was being used, we had begun the process of mobilising a string of our 13½" drill pipes so as to be able to overwash the jammed string if the side-string method failed
- Thanks to Brexit, the mobilisation of this overwash string took not 2 days, as would have been the case previously, but 9 days. As such, there were 2 or 3 days to make some further preparations to free the jammed string but no drilling operations were possible
- This included uprating the rig anchorage to enable loads in excess of 250t to be applied if required
- On the day of arrival of the overwash string we reattached to the jammed string to obtain some fresh twist-data to compare with that during the overwashing process
- Too everyone's surprise, the jammed string could now be moved with a force of 200t and 90Nm initially required before the forces immediately dropped to 25t and 20kNm. Little more than the force required at the end of the shift before the drill string became stuck
- An alternative explanation was gaining some credence – that of differential sticking

Principals of Differential Sticking

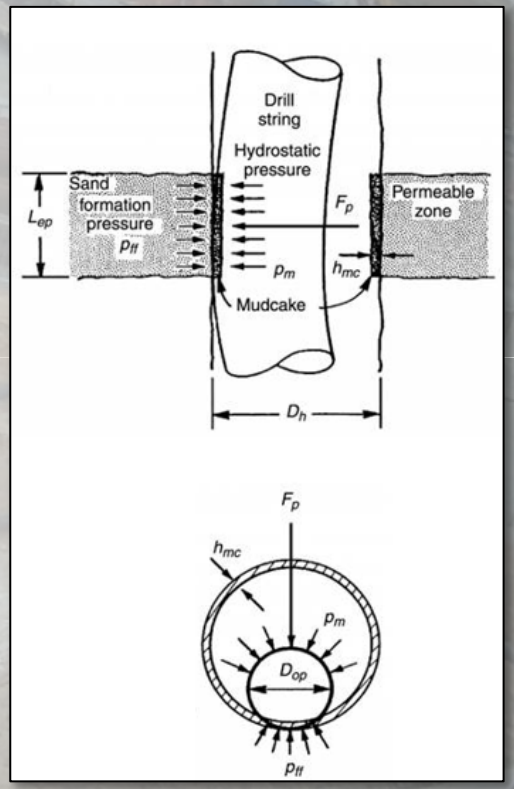
- Differential Sticking results from the difference between the annular drill fluid pressure and the groundwater pressure. There are two fundamental requirements:
  - A long (100m+) section of highly permeable formation
  - A significant difference between the annular pressure and groundwater pressure
- The force required to free a differentially stuck drill string is:

$\Delta p \cdot A \cdot Cf$ where:

Δp = The difference between the annular and groundwater pressure

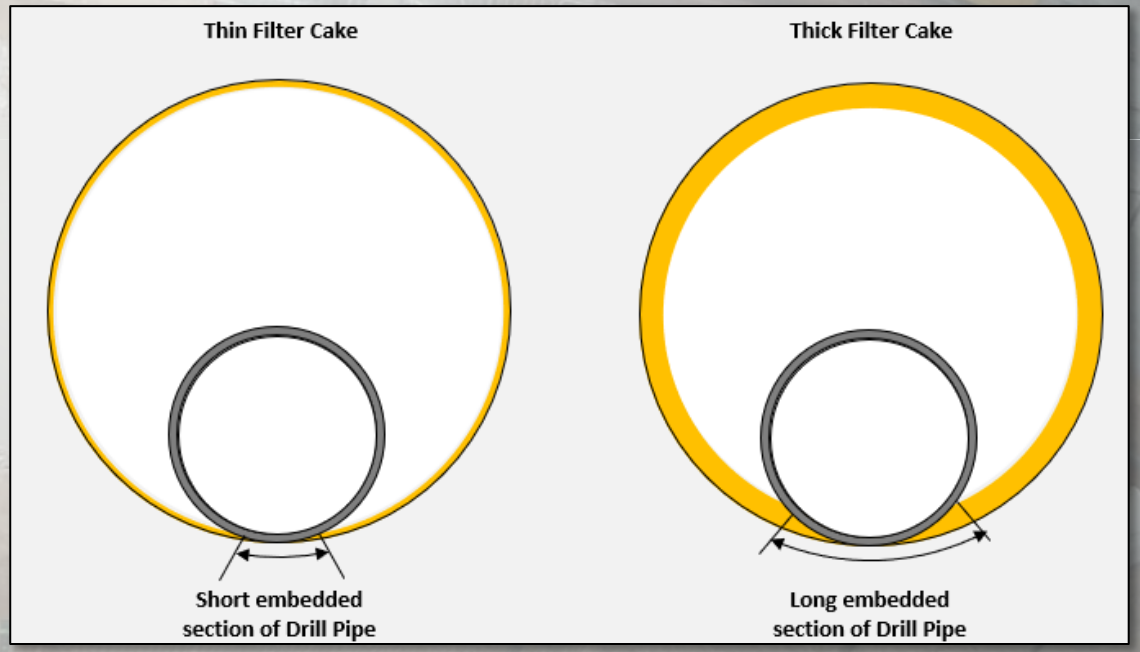
A = Surface area of pipe embedded in filter cake

Cf = Coefficient of friction



Controls – Embedded Area

- The length of the embedded section is something difficult to control unless a particular area of high permeability is identified and the drill profile designed to limit this length
- The width of the embedded section is something that could be controlled as this is a function of the thickness of the filter cake
- Key-seating can significantly increase the embedded drill pipe width and rotation of the drill string might want to be limited in certain ground conditions and/or long holes



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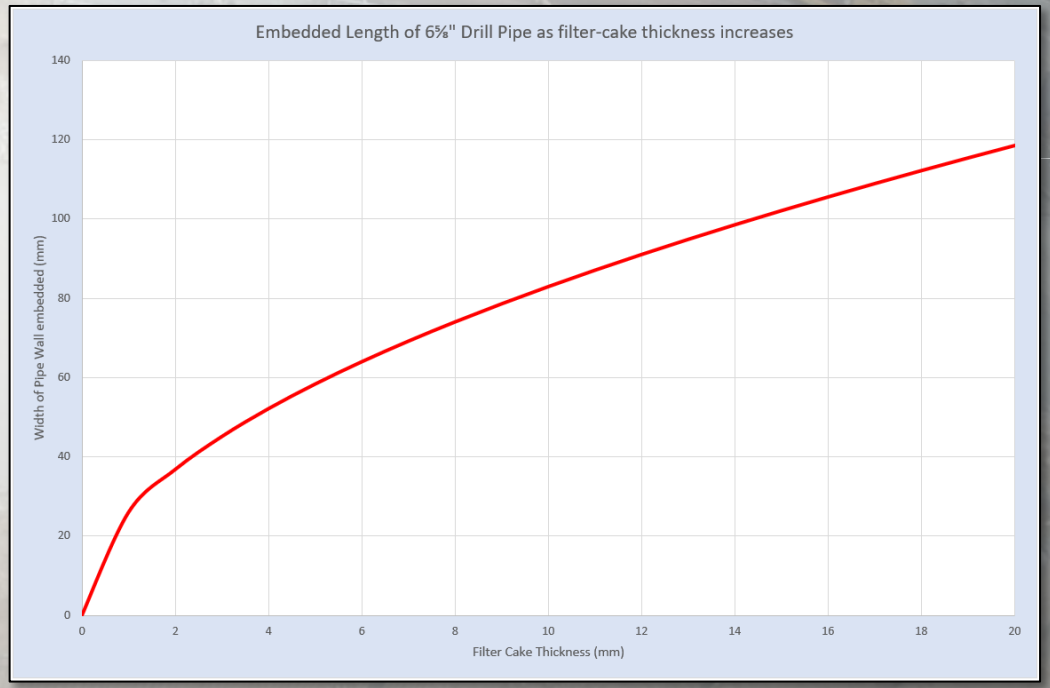
Controls – Embedded Area

- The thickness of the filter cake is a function of the volume of mud that needs to seep into the formation before the filter cake seals the borehole wall. It is the main reason why this phenomenon occurs in highly permeable formations
- In order to reduce the filter cake thickness it is necessary to control and minimise the API Fluid Loss value for the drilling fluid
- As the graph shows, the width of drill pipe embedded can be halved if the filter cake thickness can be reduced from 20mm to 5mm. A realistic possibility if good filtration control is maintained
- Halving the width = halving the value of A = halving the force required to overcome differential sticking



Controls – Differential Pressure

- Differential sticking is considered rare in HDD because it is generally considered to be necessary to have a high hydrostatic pressure to generate the necessary pressure differential
- However, landfalls are perhaps a higher risk area because the groundwater level is often depressed because of the proximity to the sea
- Possible means of reducing differential pressure could include:
  - Reducing mud weight
  - Pumping down the annular mud column in casing/conductor pipe
  - Pumping air – caution recommended, lower the annular pressure too much and the groundwater will wash away the filter cake and the drill string become buried
  - Avoid circulation of drill fluid for a period of time to minimise annular pressure
  - Avoid circulation while attempting to free the stuck string – when circulating AP always higher
  - Consider tidal conditions – if groundwater level linked to tide then groundwater pressure greater and differential pressure lower at high tide (or period at which the groundwater level is highest relative to high tide)

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Mitigation

- The one other means to limit the impact of differential sticking, on this project at least, was to keep the drill string moving. As such, we were able to avoid any repeat of the jamming of the drill string by:
  - Initiating a skeleton night shift to circulate fluid and move the drill string throughout the night
  - Once again, Brexit brought about complications (the inability to use non-UK personnel) but a majority of the remaining drilling operations were completed with 24/7 working
  - These measures proved successful and there was no repeat of the differential sticking problems. However, the force required to move the drill string after every connection was some 4-6x higher than the force required once moving and suggested that the problem remained throughout all of the drills

5 Drilling Works

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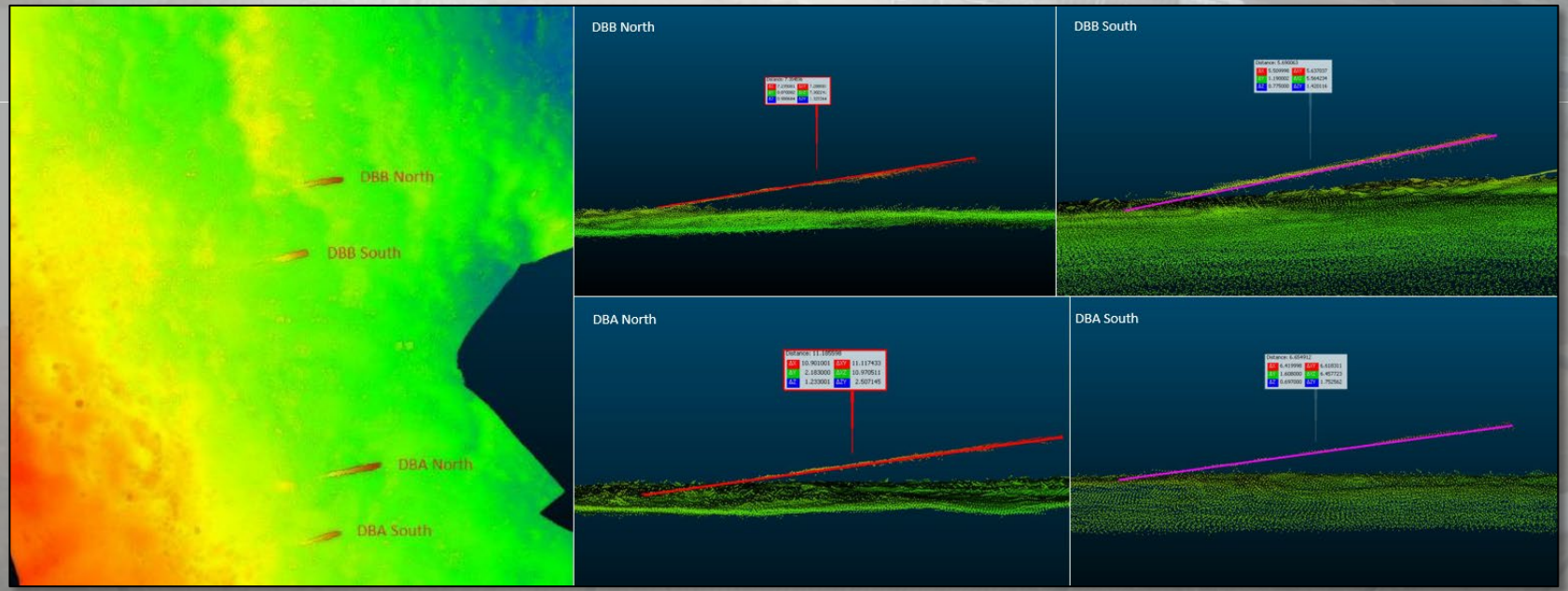
Punch-Outs and Duct Installation

- Each of the drills was largely completed without major challenges once the drill string had been freed. The fourth and final duct install was completed on 4th June 2021
- Surveys were conducted on each of the drill strings following punch-out to verify the acceptability of the drill alignment with respect to cable depth vs separation criteria. Final installation images below:



5 Drilling Works

THANK YOU FOR LISTENING