WHITE CROSS

HDD Hydrofracture Assessment

Export Cable Landfall and Onshore Crossings (Feasibility Stage)

Document Code:	FLO-WHI-TEC-0013	
Contractor Document Number:	110-099-TIN-004	
Version Number:	02	
Date:	30-11-2023	
Prepared by:	Waterman Infrastructure & Environment Ltd	
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Version Number	Reason for Issue / Major Changes	Date of Change
A1	Issued for Client Review	28-07-2023
00	Issued for Use	14-08-2023
01	Issued for Use – updated to reflect the site-specific geotechnical data	07-11-2023
02	Issued for Use - Client comments incorporated	30-11-2023

CLIENT	**Flotation Energy**
PROJECT TITLE	**White Cross Offshore Windfarm**
CONTRACT NO.	**110-099**

DOCUMENT NUMBER

110-099-TIN-004

DOCUMENT TITLE

HDD Hydrofracture Assessment – Export Cable Landfall and Onshore Crossings (Feasibility Stage)

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A04	30.11.23	Issued for Use	Waterman Infrastructure & Environment	M Gardner Engineering Manager	S Stephens Specialist Project Director
A03	07.11.23	Issued for Use	Waterman Infrastructure & Environment	M Gardner Engineering Manager	S Stephens Specialist Project Director
A02	14.08.23	Issued for Use	Waterman Infrastructure & Environment	M Gardner Engineering Manager	S Stephens Specialist Project Director
A01	28.07.23	Issued for Review	Waterman Infrastructure & Environment	M Gardner Engineering Manager	S Stephens Specialist Project Director
REV	**DATE**	**ISSUE STATUS**	**PREPARED**	**REVIEWED**	**APPROVED**

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White Cross Wind Farm: Export Cable Landfall and Onshore Crossings

HDD Hydrofracture Assessment – Feasibility Stage

Date:	27th November 2023
Client Name:	Stockton Drilling Ltd (on behalf of Flotation Energy Ltd)
Document Reference:	WIE12731-153-TN-2-4-3

This document has been prepared and checked in accordance with
Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS EN ISO 45001:2018)

Issue	Prepared by	Checked & Approved by
	Lewis Phin	Chris Gell
	Engineer	Technical Director
2-4-3		

1. Background

Waterman Infrastructure & Environment Ltd ('WIE') have been appointed by Stockton Drilling Limited ('SDL') to provide support of the onshore cable route Front-End Engineering Design (FEED) for the proposed White Cross Offshore Wind Farm, located approximately 50km off the Devon Coast. The 7 No. Wind Turbine Generators will comprise innovative floating substructure technology that is anchored to the seabed. The maximum capacity of the completed windfarm will be 100MW. Power will be exported by means of a subsea cable(s) that will make landfall on the Devon coast at Saunton Sands before running generally south to either a new or the existing sub-station at East Yelland.

As part of the cable route, up to 3 No. trenchless drills, by Horizontal Directional Drilling (HDD) methodology, are required for passing constraints. These drills are denoted as the 'Landfall', 'Golf Course Crossing' and 'River Taw Crossing'.

Within the HDD process, there can be a risk of drill fluid breakout to the surface, which is a phenomenon known as Hydrofracture, commonly termed 'frac-out'. In support of the FEED design, WIE have completed a preliminary assessment of the likelihood of hydrofracture based on the feasibility stage crossing profiles developed.

An intrusive ground investigation has been completed by Raeburn Drilling & Geotechnical Ltd, trading as Igne, to WIE's specification in October 2023. This ground investigation covered the entire onshore cable route with exploratory hole locations specifically targeting the proposed trenchless crossings. On this basis, the preliminary hydrofracture assessment has been updated to reflect this site-specific geotechnical data.

The ground investigation did not extend to the nearshore / offshore length of the landfall HDD, covering the onshore section only.

The assessment should be revised on finalisation of design profiles.

This Technical Note presents the results of the hydrofracture assessment. The crossing profile drawings, hydrofracture calculations and Ground Investigation Draft Factual Report are appended.

1.1 Limitations

A number of assumptions have been made to undertake these calculations including but not limited to bore dimensions and bore profiles. Whilst WIE have endeavoured to make assumptions conservatively and realistically, we can accept no liability for any inaccuracies. The calculations should be treated as preliminary until such time the variables become more defined whereby the calculations should be revised accordingly.

2. Analysis Methodology

2.1 General

Hydrofracture occurs if during the drilling process the drilling fluid pressure in the borehole exceeds the resistance of the overburden soils resulting in a breakout at the surface. In this instance, there is a potential risk that this could occur within the intertidal zone, on the golf course, or within the River Taw leading to a potential pollution incident.

The HDD designer typically accounts for hydrofracture by ensuring that there is adequate cover depth of the bore path, which in turn provides a larger overburden pressure, and best mitigates hydrofracture. In granular soils, casing is typically used over the initial length of the bore to assist with mitigating the risk.

There are several possible methodologies for assessing the likelihood of hydrofracture, but this analysis has been based upon the widely used 'Dutch' method which was developed by Luger & Hergarden (1988) assuming a cavity expansion.

2.2 Geotechnical Parameters

The geology beneath the site has been determined based on the recently completed intrusive ground investigation. A copy of the ground investigation Factual Report is included in Appendix C.

Based on the findings of the ground investigation, specific geotechnical parameters can be interpreted for each trenchless crossing. This section sets out the parameters being used in each analysis.

Standardised parameters used within all hydrofracture analysis for the trenchless crossings are summarised within Table 1.

Table 1: Standardised Analysis Parameters

Parameter	Assumed Value
Gravity (m/s/s)	9.81
Density of Water (kg/m^3)	1000
Density of Drilling Mud (kg/m^3)	1300
Allowable Plastic Radius Factor	0.50

2.2.1 River Taw Crossing

The River Taw Crossing was targeted specifically by 2 No. boreholes, BH14 and BH15, which encountered rockhead at 5.7m bgl (-1.9m AOD) and 4.2m bgl (-0.3m AOD) respectively. Based on design drawing 12731-135-WIE-ZZ-XX-M3-C-91003, this would indicate that almost the entire borepath will be within the rock, barring the sections near the entry and exit points.

It is anticipated that the bores would be cased through the loose superficial deposits that were encountered, and thus the selected geotechnical parameters shall be based on the encountered rock.

The rock encountered in BH14 (located north of the River Taw) typically encountered very weak to weak siltstone or mudstone and was recovered predominantly as non-intact angular gravel and gravelly clay.

The rock encountered in BH15 (located south of the River Taw) typically encountered medium strong to strong, locally weak, siltstone, with very close to medium spaced fracturing. Locally recovered as a gravelly clay in places.

On this basis, in order to remain conservative, the selected geotechnical parameters have been selected to represent a coarse gravel as this is the worst-case scenario in terms of hydrofracture, owing to the additional voids through which drill fluids could migrate. Table 2 sets out the River Taw crossing geotechnical parameters adopted.

Table 2: River Taw Crossing Geotechnical Parameters

Parameter	Assumed Value
Soil / Rock Density (kg/m^3)	2600
Cohesion (kN/m^2)	0
Friction Angle (°)	28
Poission's Ratio	0.3
Elastic Modulus (kN/m^2)	20000

2.2.2 Golf Course Crossing

The Golf Course Crossing was targeted specifically by 3 No. boreholes, BH03, BH04 and BH05, which encountered rockhead at 8.7m bgl (0.2m AOD), 14.8m bgl (-0.9m AOD) and 13.2m bgl (-1.1m AOD) respectively. Based on design drawing 12731-135-WIE-ZZ-XX-M3-C-91006, this would indicate that the bore profile is running approximately commensurate with rockhead. This would be considered bad practice for carrying out an HDD as steering and selection of drill head would be difficult if skipping along rockhead. It is therefore recommended that at detailed design stage, the profile is dropped by an additional 5m to ensure that the bore remains within competent rock.

A re-design of the bore profile is outside of the scope of this assessment. The hydrofracture calculations presented herein however assume the bore will be advanced through rock (barring the entry and exit points).

It is anticipated that the bores would be cased through the loose superficial deposits that were encountered, and thus the selected geotechnical parameters shall be based on the encountered rock.

The rock encountered in all relevant boreholes was typically siltstone and was recovered as predominately competent rock, with closely to medium spaced fractures.

In order to remain conservative, the selected geotechnical parameters have been selected to represent a coarse gravel with some cohesion, to best represent a highly fractured rock, as this is considered the worst-case scenario in terms of hydrofracture, owing to the additional voids through which drill fluids could migrate. Table 3 sets out the Golf Course crossing geotechnical parameters adopted.

Table 3: Golf Course Crossing Geotechnical Parameters

Parameter	Assumed Value
Soil / Rock Density (kg/m^3)	2600
Cohesion (kN/m^2)	0
Friction Angle (°)	30
Poission's Ratio	0.3
Elastic Modulus (kN/m^2)	30000

2.2.3 Landfall

The onshore section of the landfall was targeted specifically by 1 No. borehole, BH01, which encountered rockhead at 13.2m bgl (0m AOD).

Borehole BH01 was located at the onshore entry point of the proposed bore profile. No nearshore boreholes were undertaken as part of this ground investigation and thus the assumption for this analysis is the ground conditions are consistent along the bore profile length. This should be confirmed as part of a nearshore ground investigation. Based on design drawing 12731-153-WIE-LF-XX-M3-C-91001, almost the entire borepath will be within the rock, barring the sections near the entry and exit points.

It is anticipated that the bores would be cased through the loose superficial deposits that were encountered, and thus the selected geotechnical parameters shall be based on the encountered rock.

The rock encountered in BH01 was mudstone and was recovered predominantly as competent rock with medium to very closely spaced fracturing and localised clay infill.

In order to remain conservative, the selected geotechnical parameters have been selected to represent a coarse gravel with some cohesion, to best represent a highly fractured rock, as this is considered the worst-case scenario in terms of hydrofracture, owing to the additional voids through which drill fluids could migrate. Table 4 sets out the Landfall geotechnical parameters adopted.

Table 4: Landfall Geotechnical Parameters

Parameter	Assumed Value
Soil / Rock Density (kg/m^3)	2600
Cohesion (kN/m^2)	0
Friction Angle (°)	30
Poission's Ratio	0.3
Elastic Modulus (kN/m^2)	30000

2.3 Groundwater

Groundwater monitoring is ongoing in the installed standpipes as part of the recent Ground Investigation. To date groundwater levels during the site works and on 3 No. subsequent visits have been undertaken. Table 5 summarises the suggested groundwater level based on the factual data obtained to date.

Table 5: Groundwater Levels

Location	Recorded Groundwater Level (m AOD)			Design Groundwater Level
	10/10/23	25/10/23	08/11/23	
River Taw	3.04	3.30	3.30	3.30
Golf Course	10.51	10.70	10.97	10.70
Landfall	4.38	4.33	4.44	4.40

2.4 Bore Diameters

The bore diameters for the HDD crossings are to be confirmed as part of detailed design once all cable specifications are confirmed. It is anticipated that there will be a transition joint bay between the offshore and onshore cable(s) within the vicinity of the Saunton Sands beach car park. The landfall calculations therefore assume an offshore cable specification, with the Golf Course and River Taw calculations assuming an onshore cable specification (with a consequent reduction in likely cable and duct diameter).

The diameters assumed within the preliminary calculations, based on the feasibility stage designs, are summarised in Table 6.

Table 6: Bore Diameters

Cable Specification	Pilot Hole Diameter (m)	Reamed Hole Diameter (m)
Onshore (River Taw / Golf Course)	0.305 (12”)	0.610 (24”)
Offshore (Landfall)	0.305 (12”)	1.118 (44”)

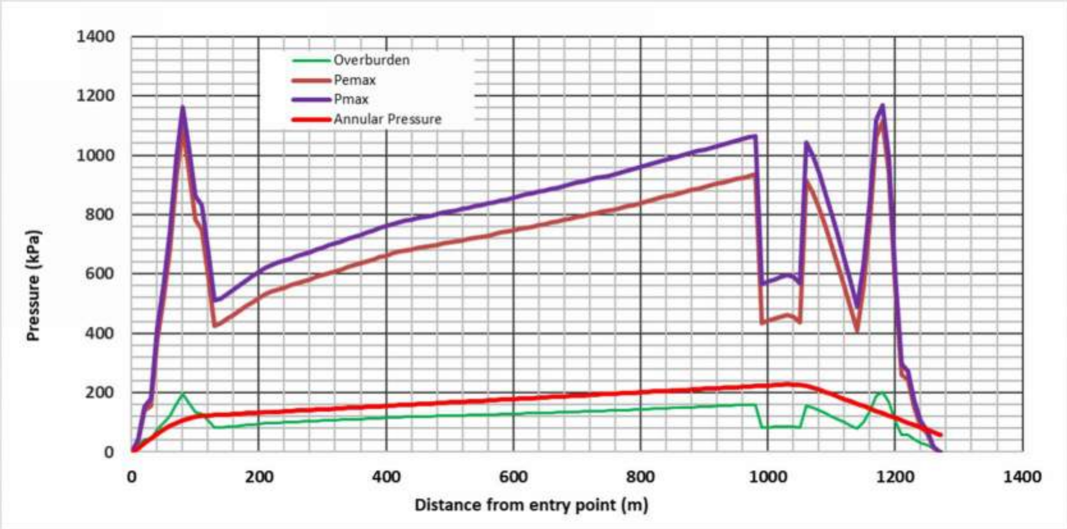
3. Assessment Results

3.1 River Taw Crossing

Under WIE’s original appointment for the Pre-FEED Study of the onshore cable route a bore profile for crossing the River Taw was developed. This profile is presented on drawing 12731-135-WIE-ZZ-XX-M3-C-91003 included in Appendix A and is discussed within the Onshore Cable Route Feasibility Assessment (WIE12731-135-R-1-2-4, June 2022). Considering the profile developed in terms of hydrofracture, results in estimates as presented in Figure 1.

Calculations are presented in Appendix B.

Figure 1: River Taw Crossing - Hydrofracture and Annular Pressure Estimates



The variation in pressures along the borehole are shown in Figure 1, where it can be seen the permissible boreholes pressures P_{emax} and P_{max} graphs initially vary due to cover depth changes where the topography rises before trending downwards into the river channel. The deepened channel that is indicatively drawn on the profile drawing (not picked up by bathymetric survey) results in a loss of cover depth and thus a drop in permissible pressure and then the point where the profile passes back of the river channel creates some variation in the cover and hence an erratic permissible pressure.

Another feature to note on this graph is that the permissible pressures are significantly larger than the overburden pressure and this is due to the nature of the assumptions in the 'Dutch' model. The difference between P_{emax} and P_{max} arises from consideration of the water table level and the added confinement pressure due to its hydrostatic effect.

The most significant line on Figure 1 is the Annular Pressure which is the pressure in the borehole due to the drill fluid return flow. This pressure varies as the borehole progresses and is the sum of the static head and friction (flow) head. For most of the distance the annular pressure is well below P_{emax} and thus hydrofracture is not considered a concern. In the final stages of the bore profile the calculations show hydrofracture is likely as the profile begins to lose cover depth shortly before punch-out at CH1250. This is unavoidable but the effects can be easily controlled / mitigated onshore by putting appropriate site measures in place such as sandbagging and/or casing, to reduce and contain any hydrofracture. All drill fluids used should also be self-flocculating, environmentally inert and CEFAS approved.

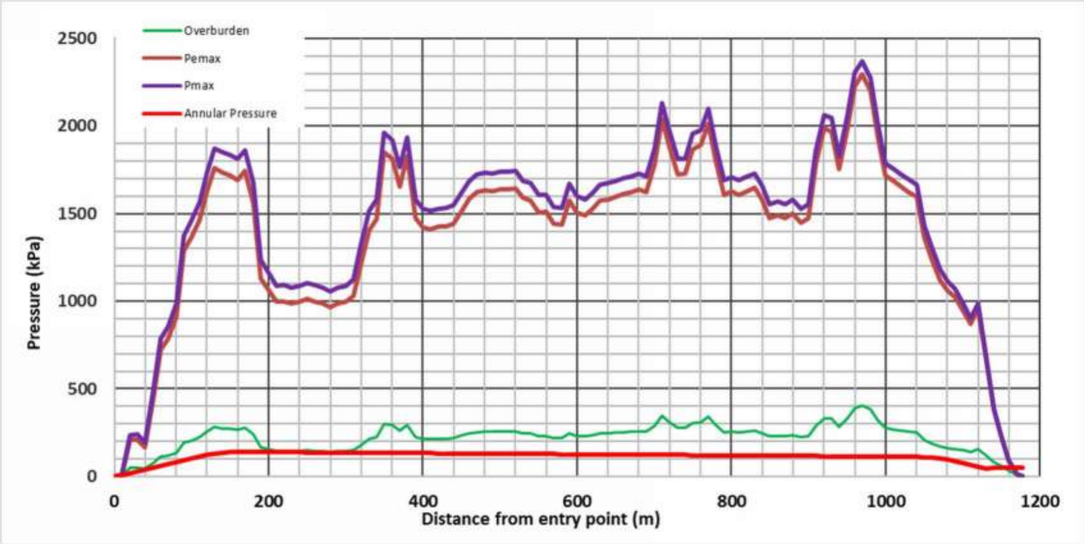
3.2 Golf Course Crossing

Under WIE's original appointment for the Pre-FEED Study of the onshore cable route a bore profile for crossing the Golf Course was developed. This profile is presented on drawing 12731-135-WIE-ZZ-XX-M3-C-91006 included in Appendix A and is discussed within the Onshore Cable Route

Feasibility Assessment (WIE12731-135-R-1-2-4, June 2022). Considering the profile developed in terms of hydrofracture, results in estimates as presented in Figure 2.

Calculations are presented in Appendix B.

Figure 2: Golf Course Crossing - Hydrofracture and Annular Pressure Estimates



The variation in pressures along the borehole are shown in Figure 2, where it can be seen the permissible boreholes pressures P_{emax} and P_{max} graphs vary due to topography changes across the golf course causing cover depth alterations.

Another feature to note on this graph is that the permissible pressures are significantly larger than the overburden pressure and this is due to the nature of the assumptions in the 'Dutch' model. The difference between P_{emax} and P_{max} arises from consideration of the water table level and the added confinement pressure due to its hydrostatic effect.

The most significant line on Figure 2 is the Annular Pressure which is the pressure in the borehole due to the drill fluid return flow. This pressure varies as the borehole progresses and is the sum of the static head and friction (flow) head. For most of the distance the annular pressure is well below P_{emax} and thus hydrofracture is not considered a concern. In the final stages of the bore profile the calculations show hydrofracture is likely as the profile begins to lose cover depth shortly before punch-out at CH1130. As with the River Taw crossing, this is unavoidable but the effects can be easily controlled / mitigated onshore by putting appropriate site measures in place such as sandbagging and/or casing, to reduce and contain any hydrofracture. All drill fluids used should also be self-flocculating, environmentally inert and CEFAS approved.

3.3 Landfall

In support of the cable route FEED study, WIE have developed an indicative profile for the cable landfall in order to demonstrate that an HDD methodology is feasible and to form the basis of preliminary hydrofracture calculations.

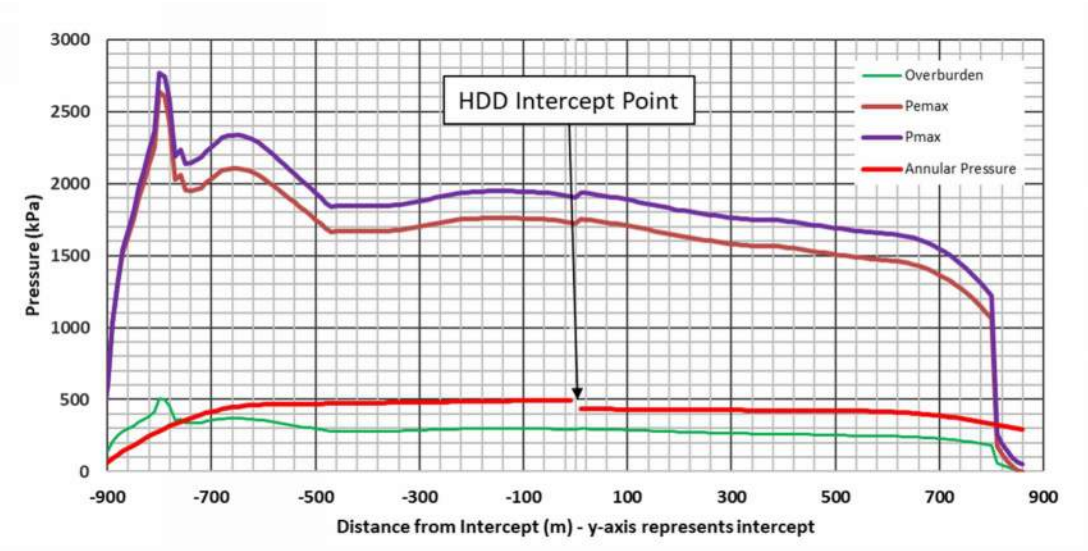
The preliminary profile design is presented on Drawing 12731-153-WIE-LF-XX-M3-C-91001 included in Appendix A. This indicative concept design has considered an entry point within the Saunton Sands beach car park extending out to a minimum water depth of -5m LAT, which is considered a likely minimum water depth for the follow-on cable installation works. This results in a bore length of circa 1860m.

Owing to the length of bore, and required ream size, at this stage it is considered likely that an intercept HDD methodology would be required with an onshore and offshore spread drilling pilot holes to 'intercept' at a point approximately mid-way along the bore. The bore would then be reamed by push-pull reaming from the onshore and offshore spreads. The offshore spread would require a Jack-Up Barge (JUB).

On this basis, considering a hydrofracture calculation requires consideration of the pressure head at both the onshore end, denoted by the entry hole level, and also the level of the jack-up barge sitting offshore. This would be determined by the HDD contractor at detailed design stage, thus, for the purpose of these calculations an arbitrary level of 8m AOD has been assumed based on a typical JUB deck height and allowing for wave clearance.

Calculations are presented in Appendix B.

Figure 3: Landfall - Hydrofracture and Annular Pressure Estimates



The variation in pressures along the borehole are shown in Figure 3, where it can be seen the permissible boreholes pressures P_{emax} and P_{max} initially vary due to cover depth changes within the sand dunes before trending gently downwards as per the seabed profile and subsequent cover depth.

Another feature to note on this graph is that the permissible pressures are significantly larger than the overburden pressure and this is due to the nature of the assumptions in the 'Dutch' model. The difference between P_{emax} and P_{max} arises from consideration of the water table level and the added confinement pressure due to its hydrostatic effect.

The most significant line on Figure 3 is the Annular Pressure which is the pressure in the borehole due to the drill fluid return flow. This pressure varies as the borehole progresses and is the sum of the static head and friction (flow) head. For most of the distance the annular pressure is well below P_{emax} and thus hydrofracture is not considered a concern. In the final stages of the bore profile the calculations show hydrofracture is likely as the profile begins to lose cover depth shortly before punch-out at CH1860. This is unavoidable but would be mitigated through use of casing which will be required in any case to support the bore between the JUB deck and the seabed. All drill fluids used should also be self-flocculating, environmentally inert and CEFAS approved.

4. Conclusions & Recommendations

This preliminary hydrofracture assessment demonstrates that there is no significant risk of frac-out along the bore profiles with the exception of the final stages of the bore where the profile begins to rise resulting in loss of cover. This is unavoidable, but can be easily controlled onshore by site measures such as sandbagging and casing, in line with general HDD working methodologies. For the landfall, and assuming an intercept methodology, the risk will be controlled by the use of casing extending from the JUB deck down to the seabed (which is required regardless, to support the bore over this length).

It is recommended that the golf course crossing profile should be revised to ensure that the profile does not run commensurate with rockhead level, as is currently the case, since this will likely lead to issues including drill head selection and steering due to the variability between the rock and overlying soil.

These preliminary calculations should be updated as the design process develops and the variables become more known, such as bore diameters and nearshore ground conditions. Notwithstanding, the preliminary calculations undertaken and presented here indicate that the preliminary designs as developed are satisfactory in terms of hydro-fracture.

A. Design Drawings

This drawing should not be scaled. Dimensions to be verified on site.
Any discrepancies should be referred to the Engineer prior to work being put in hand.

This drawing is the property of Waterman Infrastructure & Environment Limited, and the drawing is issued on the condition that it is not copied reproduced, retained or disclosed to any unauthorised person, either wholly or in part without the consent in writing of Waterman Infrastructure & Environment Limited
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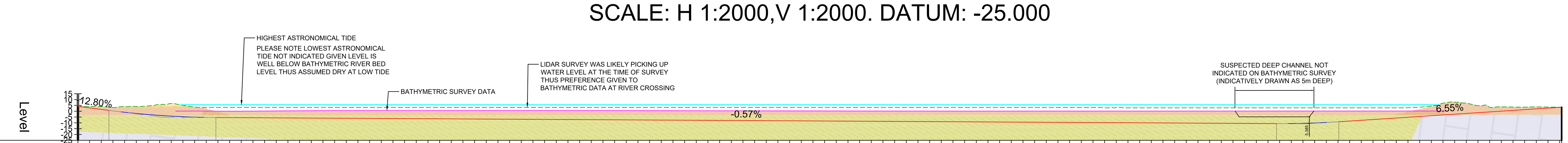
GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL ENGINEER'S, ARCHITECT'S OR OTHER RELEVANT DRAWINGS AND SPECIFICATIONS.
2. ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE BY THE CONTRACTOR PRIOR TO PREPARING ANY WORKING DRAWINGS OR COMMENCING ON SITE.
3. THE CONTRACTOR MUST ENSURE AND WILL BE HELD RESPONSIBLE FOR THE OVERALL STABILITY OF THE BUILDING/STRUCTURE/EXCAVATION AT ALL STAGES OF THE WORK.
4. ALL WORK BY THE CONTRACTOR MUST BE CARRIED OUT IN SUCH A WAY THAT ALL REQUIREMENTS UNDER THE HEALTH AND SAFETY AT WORK ACT ARE SATISFIED.
5. ALL WORK IS TO BE CARRIED OUT IN COMPLIANCE WITH THE REQUIREMENTS OF THE RELEVANT STATUTORY AUTHORITIES AND REGULATIONS.

SITE COMPOUND LAYOUT KEY:
1. 50 KVA GENERATOR 2M X 2M
2. TOILET BLOCK 6M X 2M
3. DRY/CHANGE ROOM 6M X 2M
4. CANTEEN 6M X 2M
5. OFFICE 6M X 2M
6. OFFICE 6M X 2M
7. 21 TON TRACKED 360 EXCAVATOR
8. DRILL PIPE STORAGE 10M X 2M
9. HDD DRILL RIG 16M X 2M
10. POWER PACK 6M X 2M
11. CONTROL CABIN 6M X 2M
12. MUD LAB 3M X 2M
13. MUD ENTRY PIT 3M X 4M
14. HIGH PRESSURE MUD PUMP 6M X 2M
15. MUD MIXING TANK 7M X 2M
16. 350 KVA GENERATOR 5M X 2M
17. RECYCLING UNIT 6M X 2M
18. WATER STORAGE TANK 6M X 2M
19. DRY DRILLING FLUID STORAGE 4M X 10M
20. WORKSHOP 6M X 2M
21. STORES 6M X 2M

ILFRACOMBE TIDE GAUGE SITE	
TIDE LEVELS	ORDNANCE DATUM NEWLYN (mAOD)
HIGHEST ASTRONOMICAL TIDE	5.46
MEAN HIGH WATER SPRINGS	4.47
MEAN HIGH WATER NEAPS	2.19
MEAN LOW WATER NEAPS	-1.69
MEAN LOW WATER SPRINGS	-3.94
LOWEST ASTRONOMICAL TIDE	-4.89

RIVER CROSSING - LONGSECTION
SCALE: H 1:2000,V 1:2000. DATUM: -25.000



Chainage	Existing Levels	Level Difference
0.000	0.033	
10.000	0.081	1.202
20.000	0.123	2.508
30.000	0.165	2.960
40.000	0.186	4.834
50.000	0.163	5.969
60.000	0.141	7.331
70.000	0.119	9.231
80.000	0.097	10.751
90.000	0.108	9.764
100.000	0.139	8.697
110.000	0.094	8.496
120.000	0.025	8.594
130.000	0.000	8.661
140.000	0.013	8.721
150.000	0.082	8.782
160.000	0.150	8.849
170.000	0.219	8.912
180.000	0.288	8.984
190.000	0.356	9.018
200.000	0.425	9.068
210.000	0.493	9.139
220.000	0.507	9.191
230.000	0.511	9.261
240.000	0.516	9.328
250.000	0.521	9.367
260.000	0.525	9.419
270.000	0.530	9.459
280.000	0.535	9.528
290.000	0.539	9.595
300.000	0.544	9.671
310.000	0.549	9.739
320.000	0.553	9.762
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450.000	0.541	10.551
460.000	0.521	10.615
470.000	0.502	10.650
480.000	0.483	10.715
490.000	0.464	10.765
500.000	0.445	10.823
510.000	0.426	10.867
520.000	0.406	10.946
530.000	0.387	10.955
540.000	0.368	11.034
550.000	0.349	11.099
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580.000	0.305	11.296
590.000	0.292	11.323
600.000	0.279	11.381
610.000	0.266	11.444
620.000	0.253	11.519
630.000	0.240	11.560
640.000	0.227	11.629
650.000	0.215	11.688
660.000	0.202	11.758
670.000	0.189	11.805
680.000	0.177	11.866
690.000	0.167	11.889
700.000	0.156	11.948
710.000	0.149	12.037
720.000	0.138	12.088
730.000	0.134	12.152
740.000	0.123	12.190
750.000	0.102	12.271
760.000	0.086	12.299
770.000	0.088	12.354
780.000	0.090	12.425
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800.000	0.095	12.497
810.000	0.097	12.550
820.000	0.100	12.689
830.000	0.102	12.673
840.000	0.104	12.781
850.000	0.107	12.840
860.000	0.109	12.815
870.000	0.111	12.940
880.000	0.114	12.690
890.000	0.116	13.015
900.000	0.118	12.807
910.000	0.121	12.862
920.000	0.123	12.920
930.000	0.125	12.977
940.000	0.128	13.035
950.000	0.130	13.092
960.000	0.132	13.150
970.000	0.135	13.207
980.000	0.137	13.264
990.000	0.139	13.322
1000.000	0.141	13.380
1010.000	0.144	13.437
1020.000	0.146	13.494
1030.000	0.148	13.547
1040.000	0.151	13.502
1050.000	0.153	13.323
1060.000	0.155	13.012
1070.000	0.158	12.567
1080.000	0.160	11.988
1090.000	0.162	11.334
1100.000	0.165	10.680
1110.000	0.167	10.025
1120.000	0.169	9.371
1130.000	0.172	8.716
1140.000	0.174	8.176
1150.000	0.176	7.906
1160.000	0.179	8.286
1170.000	0.181	10.151
1180.000	0.183	10.371
1190.000	0.186	8.801
1200.000	0.188	5.996
1210.000	0.190	3.972
1220.000	0.193	3.677
1230.000	0.195	2.811
1240.000	0.197	2.091
1250.000	0.199	1.680
1260.000	0.202	0.844
1270.000	0.204	0.090
1271.719	0.205	

Horizontal Geometry
L =1271.719

Vertical Geometry
G =-12.799%
L =26.583
R =750.000
K =7.500
L =91.681
G =-0.574%
L =909.051
R =750.000
K =7.500
L =53.399
G =6.545%
L =190.892

GEOLOGY KEY
BLOWN SANDS (SAND DUNES)
DRIFT DEPOSITS
ESTUARINE DEPOSITS
ROCK

1:2000 0 20m 40m 60m 80m 100m 120m 140m 160m 180m 200m
1:1 0 10 20 30 40 50 60 70 80 90 100

P03	11.08.23	SITE COMPOUND LAYOUTS REMOVED. RE-ISSUED FOR INFORMATION AS PART OF PLANNING SUBMISSION	LP	CG
P02	10.03.23	TITLE UPDATED & DRAFT BANNER REMOVED	LP	CG
P01	23.05.22	DRAFT ISSUE FOR INFORMATION ONLY	LP	CG
Rev	Date	Description	By	Chk

Amendments

Project
WHITE CROSS FLOATING WINDFARM

Title
RIVER TAW OUTLINE HDD PLAN AND PROFILE

Client
FLOTATION ENERGY LTD

waterman
STOCKTON
Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t: 01738 449 801
mail@watermangroup.com www.watermangroup.com

Suitability
FOR PLANNING SUBMISSION

Designed By LP	Director CG	Waterman Ref WIE12731-135
Drawn By LP	Date 20.05.22	Scales @ A0 AS NOTED
Stockton Checker	Stockton Approver	Date

Project - Originator - Volume - Level - Type - Role - Number	Revision
12731-135-WIE-ZZ-XX-M3-C-91003	P03
110-099-DRG-022	A01
FLO-WHI-LAY-0019	A1

File Path
N:\Projects\WIE12731_Stockton_HDD\135 - White Cross Floating Windfarm\100\6_Design\C3D\ALIGNMENTS & PROFILE\

This drawing should not be scaled. Dimensions to be verified on site.
Any discrepancies should be referred to the Engineer prior to work being put in hand.

GENERAL NOTES

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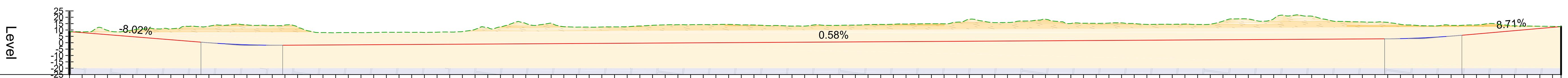
SITE COMPOUND LAYOUT KEY:
1. 50 KVA GENERATOR 2M X 2M
2. TOILET BLOCK 6M X 2M
3. DRY/CHANGE ROOM 6M X 2M
4. CANTEEN 6M X 2M
5. OFFICE 6M X 2M
6. OFFICE 6M X 2M
7. 21 TON TRACKED 360 EXCAVATOR
8. DRILL PIPE STORAGE 10M X 2M
9. HDD DRILL RIG 16M X 2M
10. POWER PACK 6M X 2M
11. CONTROL CABIN 6M X 2M
12. MUD LAB 3M X 2M
13. MUD ENTRY PIT 3M X 4M
14. HIGH PRESSURE MUD PUMP 6M X 2M
15. MUD MIXING TANK 7M X 2M
16. 350 KVA GENERATOR 5M X 2M
17. RECYCLING UNIT 6M X 2M
18. WATER STORAGE TANK 6M X 2M
19. DRY DRILLING FLUID STORAGE 4M X 10M
20. WORKSHOP 6M X 2M
21. STORES 6M X 2M

GOLF COURSE CROSSING - LONGSECTION
SCALE: H 1:2000,V 1:2000. DATUM: -25.000



Chainage	Existing Levels	Level Difference
0.000	8.743	-0.014
10.000	8.569	0.614
20.000	10.513	3.360
30.000	9.745	3.394
40.000	8.543	2.994
50.000	10.018	5.271
60.000	11.081	7.136
70.000	10.848	7.706
80.000	10.998	8.657
90.000	12.770	11.233
100.000	12.756	12.020
110.000	12.944	12.984
120.000	13.763	14.455
130.000	14.512	15.723
140.000	14.023	15.619
150.000	13.739	15.587
160.000	13.453	15.421
170.000	13.887	15.842
180.000	12.436	14.333
190.000	8.995	10.835
200.000	7.997	9.779
210.000	7.882	9.606
220.000	7.975	9.641
230.000	7.907	9.516
240.000	8.065	9.616
250.000	8.261	9.755
260.000	8.198	9.633
270.000	8.138	9.516
280.000	8.022	9.343
290.000	8.258	9.520
300.000	8.405	9.610
310.000	8.761	9.909
320.000	10.486	11.576
330.000	11.898	12.931
340.000	12.385	13.359
350.000	15.458	16.375
360.000	15.163	16.022
370.000	13.924	14.725
380.000	15.365	16.108
390.000	12.590	13.276
400.000	12.258	12.886
410.000	12.220	12.790
420.000	12.362	12.875
430.000	12.430	12.886
440.000	12.577	12.975
450.000	13.165	13.505
460.000	13.695	13.977
470.000	14.033	14.258
480.000	14.138	14.305
490.000	14.137	14.246
500.000	14.269	14.320
510.000	14.310	14.304
520.000	14.392	14.329
530.000	13.997	13.876
540.000	13.935	13.756
550.000	13.460	13.223
560.000	13.519	13.225
570.000	13.047	12.695
580.000	13.073	12.663
590.000	14.098	13.631
600.000	13.629	13.104
610.000	13.735	13.152
620.000	13.853	13.212
630.000	14.248	13.550
640.000	14.366	13.610
650.000	14.493	13.680
660.000	14.647	13.776
670.000	14.796	13.867
680.000	14.929	13.943
690.000	14.877	13.833
700.000	16.152	15.050
710.000	18.458	17.299
720.000	17.079	15.862
730.000	15.813	14.538
740.000	15.873	14.540
750.000	17.068	15.678
760.000	17.302	15.854
770.000	18.433	16.928
780.000	16.645	15.082
790.000	15.133	13.512
800.000	15.299	13.621
810.000	15.206	13.469
820.000	15.406	13.612
830.000	15.583	13.731
840.000	15.103	13.194
850.000	14.361	12.394
860.000	14.491	12.467
870.000	14.441	12.359
880.000	14.672	12.532
890.000	14.318	12.121
900.000	14.550	12.295
910.000	16.951	14.638
920.000	18.731	16.361
930.000	18.609	16.181
940.000	16.851	14.365
950.000	18.812	16.269
960.000	21.090	18.489
970.000	21.760	19.101
980.000	20.882	18.166
990.000	18.539	15.765
1000.000	16.761	13.930
1010.000	16.551	13.662
1020.000	16.336	13.389
1030.000	16.163	13.158
1040.000	15.989	12.923
1050.000	14.429	11.205
1060.000	13.817	10.303
1070.000	13.331	9.393
1080.000	13.353	8.857
1090.000	13.624	8.437
1100.000	13.759	7.750
1110.000	13.961	7.081
1120.000	15.095	7.344
1130.000	14.112	5.491
1140.000	13.297	3.805
1150.000	13.097	2.735
1160.000	12.951	1.718
1170.000	12.796	0.692
1176.745	12.740	0.049

Horizontal Geometry: L =1176.745

Vertical Geometry:

G =-8.022%	L =103.742
R =750.000, K =7.500	L =64.488
G =0.577%	L =869.295
R =750.000, K =7.500	L =60.976
G =8.707%	L =78.827

GEOLOGY KEY
BLOWN SANDS (SAND DUNES)
DRIFT DEPOSITS
ROCK

1:2000 0 20m 40m 60m 80m 100m 120m 140m 160m 180m 200m
1:1 0 10 20 30 40 50 60 70 80 90 100

Rev	Date	Description	By	Chk
P03	11.08.23	SITE COMPOUND LAYOUTS REMOVED. RE-ISSUED FOR INFORMATION AS PART OF PLANNING SUBMISSION	LP	CG
P02	10.03.23	TITLE UPDATED AND DRAFT BANNER REMOVED	LP	CG
P01	20.05.22	DRAFT ISSUE FOR INFORMATION ONLY	LP	CG

Amendments

Project
WHITE CROSS FLOATING WINDFARM

Title
SAUNTON GOLF CLUB OUTLINE HDD PLAN AND PROFILE

Client
FLOTATION ENERGY LTD

waterman
STOCKTON
Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t: 01738 449 801
mail@watermangroup.com www.watermangroup.com

Suitability
FOR PLANNING SUBMISSION

Designed By: LP	Director: CG	Waterman Ref: WIE12731-135
Drawn By: LP	Date: 20.05.22	Scales @ A0: AS NOTED
Stockton Checker	Stockton Approver	Date

Project - Originator - Volume - Level - Type - Role - Number	Revision
12731-135-WIE-ZZ-XX-M3-C-91006	P03
110-099-DRG-021	A01
FLO-WHI-LAY-0018	A1

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File Path

ONSHORE ←

→ OFFSHORE

CHAINAGE (m)	ONSHORE EXISTING LEVELS (m AOD)	OFFSHORE EXISTING LEVELS (m AOD)	BORE PROFILE LEVEL (m AOD) (TOP OF PIPE)
0+000	12.966		12.966
0+010	13.080		11.208
0+020	13.181		9.450
0+030	13.580		7.692
0+040	14.118		5.935
0+050	14.147		4.177
0+060	13.984		2.419
0+070	13.739		0.661
0+080	13.452		-1.061
0+090	13.362		-2.717
0+100	13.277		-4.306
0+110	13.223		-5.829
0+120	13.372		-7.284
0+130	16.245		-8.674
0+140	15.014		-9.996
0+150	12.462		-11.252
0+160	8.021		-12.441
0+170	7.558		-13.563
0+180	5.960		-14.619
0+190	5.286		-15.608
0+200	4.717		-16.531
0+210	4.298		-17.387
0+220	3.972		-18.176
0+230	3.662		-18.898
0+240	3.393		-19.554
0+250	3.174		-20.143
0+260			-20.666
0+270			-21.122
0+280			-21.511
0+290			-21.833
0+300			-22.089
0+310			-22.278
0+320			-22.401
0+330			-22.456
0+340			-22.468
0+350			-22.480
0+360			-22.491
0+370			-22.502
0+380			-22.513
0+390			-22.524
0+400			-22.535
0+410			-22.546
0+420			-22.557
0+430			-22.568
0+440			-22.579
0+450			-22.590
0+460		-4.792	-22.601
0+470		-4.746	-22.612
0+480		-4.718	-22.624
0+490		-4.739	-22.635
0+500		-4.760	-22.646
0+510		-4.780	-22.657
0+520		-4.800	-22.668
0+530		-4.800	-22.679
0+540		-4.800	-22.690
0+550		-4.800	-22.701
0+560		-4.800	-22.712
0+570		-4.800	-22.723
0+580		-4.800	-22.734
0+590		-4.800	-22.745
0+600		-4.749	-22.756
0+610		-4.681	-22.768
0+620		-4.612	-22.779
0+630		-4.544	-22.790
0+640		-4.476	-22.801
0+650		-4.407	-22.812
0+660		-4.339	-22.823
0+670		-4.270	-22.834
0+680		-4.202	-22.845
0+690		-4.134	-22.856
0+700		-4.065	-22.867
0+710		-4.003	-22.878
0+720		-3.992	-22.889
0+730		-3.981	-22.900
0+740		-3.970	-22.912
0+750		-3.959	-22.923
0+760		-3.949	-22.934
0+770		-3.940	-22.945
0+780		-3.957	-22.956
0+790		-3.973	-22.967
0+800		-3.989	-22.978
0+810		-4.011	-22.989
0+820		-4.041	-23.000
0+830		-4.070	-23.011
0+840		-4.100	-23.022
0+850		-4.124	-23.033
0+860		-4.146	-23.044
0+870		-4.167	-23.056
0+880		-4.215	-23.067
0+890		-4.287	-23.078
0+900		-4.359	-23.089
0+910		-4.431	-23.100
0+920		-4.503	-23.111
0+930		-4.575	-23.122
0+940		-4.627	-23.133
0+950		-4.707	-23.144
0+960		-4.790	-23.155
0+970		-4.888	-23.166
0+980		-4.989	-23.177
0+990		-5.089	-23.188
1+000		-5.189	-23.200
1+010		-5.290	-23.211
1+020		-5.390	-23.222
1+030		-5.490	-23.233
1+040		-5.591	-23.244
1+050		-5.691	-23.255
1+060		-5.778	-23.266
1+070		-5.851	-23.277
1+080		-5.927	-23.288
1+090		-6.003	-23.299
1+100		-6.079	-23.310
1+110		-6.155	-23.321
1+120		-6.231	-23.332
1+130		-6.303	-23.344
1+140		-6.367	-23.355
1+150		-6.450	-23.366
1+160		-6.501	-23.377
1+170		-6.549	-23.388
1+180		-6.598	-23.399
1+190		-6.646	-23.410
1+200		-6.695	-23.421
1+210		-6.743	-23.432
1+220		-6.748	-23.443
1+230		-6.751	-23.454
1+240		-6.770	-23.465
1+250		-6.794	-23.476
1+260		-6.851	-23.488
1+270		-6.922	-23.499
1+280		-6.992	-23.510
1+290		-7.062	-23.521
1+300		-7.132	-23.532
1+310		-7.203	-23.543
1+320		-7.273	-23.554
1+330		-7.340	-23.565
1+340		-7.407	-23.576
1+350		-7.474	-23.587
1+360		-7.539	-23.598
1+370		-7.605	-23.609
1+380		-7.670	-23.620
1+390		-7.736	-23.632
1+400		-7.801	-23.643
1+410		-7.852	-23.654
1+420		-7.903	-23.665
1+430		-7.953	-23.676
1+440		-8.004	-23.687
1+450		-8.055	-23.698
1+460		-8.106	-23.709
1+470		-8.157	-23.720
1+480		-8.208	-23.731
1+490		-8.259	-23.732
1+500		-8.309	-23.712
1+510		-8.360	-23.673
1+520		-8.411	-23.614
1+530		-8.462	-23.534
1+540		-8.513	-23.435
1+550		-8.564	-23.316
1+560		-8.614	-23.176
1+570		-8.665	-23.017
1+580		-8.714	-22.838
1+590		-8.761	-22.638
1+600		-8.802	-22.419
1+610		-8.840	-22.180
1+620		-8.882	-21.920
1+630		-8.923	-21.641
1+640		-8.960	-21.341
1+650		-8.997	-21.022
1+660		-9.034	-20.683
1+670		-9.072	-20.323
1+680		-9.116	-19.944
1+690		-9.160	-19.545
1+700		-9.204	-19.125
1+710		-9.248	-18.686
1+720		-9.292	-18.227
1+730		-9.336	-17.747
1+740		-9.380	-17.248
1+750		-9.424	-16.728
1+760		-9.468	-16.189
1+770		-9.512	-15.630
1+780		-9.556	-15.050
1+790		-9.600	-14.451
1+800		-9.643	-13.832
1+810		-9.687	-13.192
1+820		-9.731	-12.533
1+830		-9.774	-11.854
1+840		-9.816	-11.155
1+850		-9.855	-10.450
1+860		-9.893	
1+870		-9.932	
1+880		-9.971	
1+890		-10.009	
1+900		-10.048	

BORE VERTICAL GEOMETRY

G =-17.577% L =69.709m	R =1500.000m K =15.000 L =262.001m	G =-0.111% L =1148.071m	R =5000.000m K =50.000 L =357.991m	G =7.049% L =20.231m

GENERAL NOTES

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3. THE CONTRACTOR MUST ENSURE AND WILL BE HELD RESPONSIBLE FOR THE OVERALL STABILITY OF THE BUILDING/STRUCTURE/EXCAVATION AT ALL STAGES OF THE WORK.
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17 August 2023 - - DRAFT - -

Amendments

Rev	Date	Description	By	Chk
P02	11.08.23	UPDATED WITH CLIENT COMMENTS. RE-ISSUED FOR INFORMATION	LP	CG
P01	28.07.23	ISSUED AS DRAFT FOR INFORMATION	LP	CG

Project
WHITE CROSS FLOATING WINDFARM

Title
CABLE LANDFALL OUTLINE HDD PLAN AND PROFILE

Client
FLOTATION ENERGY LTD

Broxden House Broxden Business Park Lamberkine Drive Perth PH1 1RA
t 01738 449 801
mail@watermangroup.com www.watermangroup.com

Suitability
FOR PLANNING SUBMISSION

Designed By LP	Director CG	Waterman Ref WIE12731-153
Drawn By LP	Date JULY 23	Scales @ A0 1:1250
Stockton Checker	Stockton Approver	Date

Project - Originator - Volume - Level - Type - Role - Number	Revision
12731-153-WIE-LF-XX-M3-C-91001	P01
110-099-DRG-020	A01
FLO-WHI-LAY-0017	A1

A0-Wat-SDL-S

File Path \\s-ph\WIEL\Projects\WIE12731_Stockton_HDD\153 - White Cross Phase 2\7_CAD\91\

B. Hydrofracture Calculations

Hydrofracture - Longitudinal Profile Check

[redacted]

$$Pmax = Pemax + U$$ ***Eqn(1)***

$$Pemax = (Pf + c.\cot\emptyset).\left\{\left(\frac{Ro}{Rpmax}\right)^2 + Q\right\}^{\frac{-\sin\emptyset}{1+\sin\emptyset}} - c.\cot\emptyset$$ ***Eqn(2)***

$$Q = \frac{(\sigma o.\sin\emptyset + c.\cos\emptyset)}{G}$$ ***Eqn(3)***

$$Pf = \sigma o\,(1 + \sin\emptyset) + c.\cos\emptyset$$ ***Eqn(4)***

$$G = \frac{E}{2}\,(1 + \vartheta)$$ ***Eqn(5)***

Where:

Pmax	maximum allowable mud pressure
U	initial in-situ pore pressure
Pemax	maximum allowable effective mud pressure
σ_o	initial effective stress
ϕ	internal angle of friction
c	cohesion
Ro	internal radius of borehole
Rpmax	maximum allowable radius of plastic zone
G	shear modulus
E	elasticity modulus
N	Poisson's ratio

[redacted]

General variables

Gravity (m/s/s):	**g**	9.81				
Density of water (kg/m3):	**ɣw**	1000				
Density of drilling mud (kg/m3):	**ɣm**	1300				
Soil density (kg/m^3):	**ɣs**	2600				*Ground parameters are informed by results of ground investigation and laboratory testing.*
Cohesion (kN/m^2):	**Coh**	0				
Friction angle (deg):	**Φ**	28		Radians Φr =	0.4887	
Poission's ratio :	**v**	0.3				
Elasticity modulus (kPa):	**Emod**	20000				
Shear modulus (kPa):	Gmod =	7692				
Product pipe OD (m):						
Drill bit diameter (inch):		24.00	inch	**Do**	0.610 m	*Diameters assumed at feasibility stage.*
Drill pipe OD (inch):		12.00	inch	**Di**	0.305 m	
Initial radius of borehole (m):	**Ro**	0.305		*Equal half drill bit diameter*		*Rpmax usually assumed between 1/2 and 2/3 depth, assumed 1/2 as worst case scenario*
Allowable plastic radius factor	**Rpmax**	0.50				
Consider lateral soil pressure:	**No**			***Use drop-down to select Y/N***		

Passive coefficient **ko** = IF(Y_N = "Yes", 1 - SIN(Φr), 0)
= IF(= "Yes", 1 - SIN(0.48869), 0)
= **0**

Conservative to not consider lateral soil pressures

Annular pressure calculations

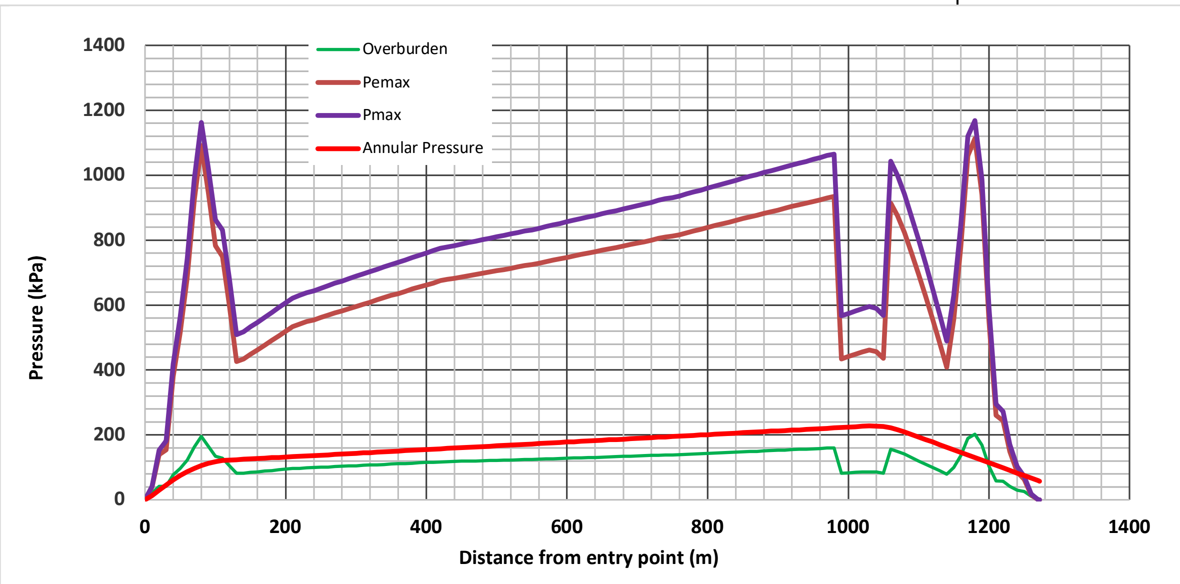
Darcy Weisbach equation for flow in an annulus is: H = f(L/Dh)(V^2/2g), where Dh is the hydraulic diameter, V the flow velocity, L flow pipe length and f is a friction factor. In the case of co-centered circular pipes Dh = Do - Di. The exact drilling operational parameters, such as flow rate are unknown, but some estimated values have been applied - but require verification. The total head is the flow head plus the static head.

Assumed flow velocity (m/s):	V	0.50
Assumed friction coefficient:	f	1.00

The calculations at each chainage location are performed in the frac-out table

Summary Figures

Elevation of entrance hole mOD =	**4.11**	**mOD**		
Elevation of exit hole mOD =	**3.44**	**mOD**	***Diff =***	***0.67*** m
Maximum cover to HDD borehole =	**10.4**	**m**		
Maximum overburden pressure =	**202.3**	**kN/m^2**		***2.0 Bar***
Maximum safe effective stress **Pemax** =	**1114**	**kN/m^2**		***11.1 Bar***
Maximum safe stress **Pmax** =	**1168**	**kN/m^3**		***11.7 Bar***



Expressions used in hydrofracture calculations

In the tabulation below the following functions are applied

Saturated Layer **Sat'd**: IF (WTL<=HDD, Elevn-HDD, Max(Elevn-WTL, 0))

Bouyant Layer **Bou't**: IF (WTL<=HDD, 0, Min(WTL-HDD, Elevn-HDD))

σv = (ɣs*Satd+(ɣs-ɣw)*Bout)*g/1000

σo = SQRT((ɣs*Satd+(ɣs-ɣw)*Bout)^2 + (ko * (ɣs*Satd + (ɣs-ɣw)*Bout))^2))

Q = (σo*SIN(Φr) + Coh*COS(Φr)) / Gmod

Pf = (σo * (1+SIN(Φr))) + (Coh * COS(Φr))

Pemax = (Pf + Coh*COT(Φr)) * (((Ro/Rpmax)^2 + Q)^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

Pelim = (Pf + Coh*COT(Φr)) * (Q^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

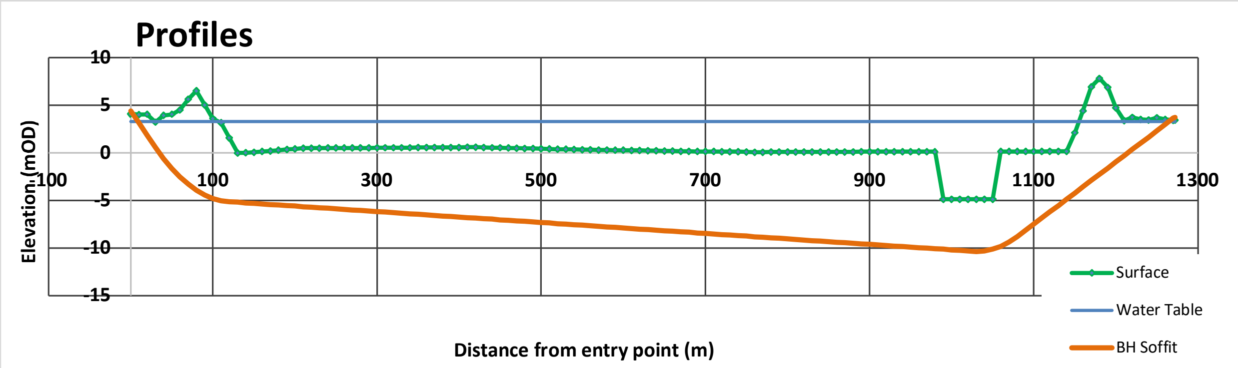
WT controls: 3.3   LAT -4.89

Dist (m)	Elev'n (mOD)	Loc'n	WTL (mOD)	C-Line (mOD)	Soffit (mOD)	Cover (m)	Sat'd (m)	Bou't (m)	U kN/m2	Hs kN/m3
0.00	4.11	On	3.30	4.11	4.41	0.00	0.00	0.00	0	0
10.00	4.03	On	3.30	2.83	3.13	0.90	0.73	0.17	2	12
20.00	4.06	On	3.30	1.55	1.85	2.21	0.76	1.45	14	29
30.00	3.24	On	3.30	0.28	0.58	2.66	0.00	2.66	27	45
40.00	3.94	On	3.30	-0.89	-0.59	4.53	0.64	3.89	38	60
50.00	4.04	On	3.30	-1.93	-1.63	5.67	0.74	4.93	48	73
60.00	4.50	On	3.30	-2.83	-2.53	7.03	1.20	5.83	57	85
70.00	5.64	On	3.30	-3.59	-3.29	8.93	2.34	6.59	65	94
80.00	6.52	On	3.30	-4.23	-3.93	10.45	3.22	7.23	71	102
90.00	5.03	On	3.30	-4.73	-4.43	9.46	1.73	7.73	76	109
100.00	3.60	On	3.30	-5.10	-4.80	8.39	0.30	8.10	79	114
110.00	3.16	On	3.30	-5.33	-5.03	8.19	0.00	8.19	82	117
120.00	1.58	On	3.30	-5.43	-5.13	6.71	0.00	6.71	83	118
130.00	0.00	On	3.30	-5.49	-5.19	5.19	0.00	5.19	83	119
140.00	0.01	On	3.30	-5.55	-5.25	5.26	0.00	5.26	84	119
150.00	0.08	On	3.30	-5.61	-5.31	5.39	0.00	5.39	84	120
160.00	0.15	On	3.30	-5.66	-5.36	5.51	0.00	5.51	85	121
170.00	0.22	On	3.30	-5.72	-5.42	5.63	0.00	5.63	85	121
180.00	0.29	On	3.30	-5.78	-5.48	5.76	0.00	5.76	86	122
190.00	0.36	On	3.30	-5.84	-5.54	5.89	0.00	5.89	87	123
200.00	0.43	On	3.30	-5.89	-5.59	6.01	0.00	6.01	87	124
210.00	0.49	On	3.30	-5.95	-5.65	6.14	0.00	6.14	88	124
220.00	0.51	On	3.30	-6.01	-5.71	6.21	0.00	6.21	88	125
230.00	0.51	On	3.30	-6.07	-5.77	6.28	0.00	6.28	89	126
240.00	0.52	On	3.30	-6.12	-5.82	6.33	0.00	6.33	89	127
250.00	0.52	On	3.30	-6.18	-5.88	6.40	0.00	6.40	90	127
260.00	0.53	On	3.30	-6.24	-5.94	6.46	0.00	6.46	91	128
270.00	0.53	On	3.30	-6.30	-6.00	6.53	0.00	6.53	91	129
280.00	0.54	On	3.30	-6.35	-6.05	6.58	0.00	6.58	92	130
290.00	0.54	On	3.30	-6.41	-6.11	6.64	0.00	6.64	92	130
300.00	0.54	On	3.30	-6.47	-6.17	6.71	0.00	6.71	93	131
310.00	0.55	On	3.30	-6.53	-6.23	6.77	0.00	6.77	93	132
320.00	0.55	On	3.30	-6.58	-6.28	6.83	0.00	6.83	94	132
330.00	0.56	On	3.30	-6.64	-6.34	6.89	0.00	6.89	95	133
340.00	0.56	On	3.30	-6.70	-6.40	6.96	0.00	6.96	95	134
350.00	0.57	On	3.30	-6.76	-6.46	7.02	0.00	7.02	96	135
360.00	0.57	On	3.30	-6.81	-6.51	7.08	0.00	7.08	96	135
370.00	0.58	On	3.30	-6.87	-6.57	7.14	0.00	7.14	97	136
380.00	0.58	On	3.30	-6.93	-6.63	7.21	0.00	7.21	97	137
390.00	0.59	On	3.30	-6.99	-6.69	7.27	0.00	7.27	98	138
400.00	0.59	On	3.30	-7.04	-6.74	7.33	0.00	7.33	98	138
410.00	0.60	On	3.30	-7.10	-6.80	7.39	0.00	7.39	99	139
420.00	0.60	On	3.30	-7.16	-6.86	7.45	0.00	7.45	100	140
430.00	0.58	On	3.30	-7.22	-6.92	7.49	0.00	7.49	100	141
440.00	0.56	On	3.30	-7.27	-6.97	7.53	0.00	7.53	101	141
450.00	0.54	On	3.30	-7.33	-7.03	7.57	0.00	7.57	101	142
460.00	0.52	On	3.30	-7.39	-7.09	7.61	0.00	7.61	102	143
470.00	0.50	On	3.30	-7.44	-7.14	7.64	0.00	7.64	102	143
480.00	0.48	On	3.30	-7.50	-7.20	7.68	0.00	7.68	103	144
490.00	0.46	On	3.30	-7.56	-7.26	7.72	0.00	7.72	104	145
500.00	0.45	On	3.30	-7.62	-7.32	7.76	0.00	7.76	104	146
510.00	0.43	On	3.30	-7.67	-7.37	7.79	0.00	7.79	105	146

520.00	0.41	On	3.30	-7.73	-7.43	7.83	0.00	7.83	105	147
530.00	0.39	On	3.30	-7.79	-7.49	7.87	0.00	7.87	106	148
540.00	0.37	On	3.30	-7.85	-7.55	7.91	0.00	7.91	106	149
550.00	0.35	On	3.30	-7.90	-7.60	7.94	0.00	7.94	107	149
560.00	0.33	On	3.30	-7.96	-7.66	7.99	0.00	7.99	107	150
570.00	0.32	On	3.30	-8.02	-7.72	8.03	0.00	8.03	108	151
580.00	0.31	On	3.30	-8.08	-7.78	8.08	0.00	8.08	109	152
590.00	0.29	On	3.30	-8.13	-7.83	8.12	0.00	8.12	109	152
600.00	0.28	On	3.30	-8.19	-7.89	8.16	0.00	8.16	110	153
610.00	0.27	On	3.30	-8.25	-7.95	8.21	0.00	8.21	110	154
620.00	0.25	On	3.30	-8.31	-8.01	8.26	0.00	8.26	111	155
630.00	0.24	On	3.30	-8.36	-8.06	8.30	0.00	8.30	111	155
640.00	0.23	On	3.30	-8.42	-8.12	8.34	0.00	8.34	112	156
650.00	0.22	On	3.30	-8.48	-8.18	8.39	0.00	8.39	113	157
660.00	0.20	On	3.30	-8.54	-8.24	8.44	0.00	8.44	113	157
670.00	0.19	On	3.30	-8.59	-8.29	8.47	0.00	8.47	114	158
680.00	0.18	On	3.30	-8.65	-8.35	8.52	0.00	8.52	114	159
690.00	0.17	On	3.30	-8.71	-8.41	8.57	0.00	8.57	115	160
700.00	0.16	On	3.30	-8.77	-8.47	8.62	0.00	8.62	115	160
710.00	0.15	On	3.30	-8.82	-8.52	8.66	0.00	8.66	116	161
720.00	0.14	On	3.30	-8.88	-8.58	8.71	0.00	8.71	116	162
730.00	0.13	On	3.30	-8.94	-8.64	8.77	0.00	8.77	117	163
740.00	0.12	On	3.30	-9.00	-8.70	8.82	0.00	8.82	118	163
750.00	0.10	On	3.30	-9.05	-8.75	8.85	0.00	8.85	118	164
760.00	0.09	On	3.30	-9.11	-8.81	8.89	0.00	8.89	119	165
770.00	0.09	On	3.30	-9.17	-8.87	8.95	0.00	8.95	119	165
780.00	0.09	On	3.30	-9.23	-8.93	9.02	0.00	9.02	120	166
790.00	0.09	On	3.30	-9.28	-8.98	9.07	0.00	9.07	120	167
800.00	0.10	On	3.30	-9.34	-9.04	9.13	0.00	9.13	121	168
810.00	0.10	On	3.30	-9.40	-9.10	9.19	0.00	9.19	122	168
820.00	0.10	On	3.30	-9.46	-9.16	9.26	0.00	9.26	122	169
830.00	0.10	On	3.30	-9.51	-9.21	9.31	0.00	9.31	123	170
840.00	0.10	On	3.30	-9.57	-9.27	9.37	0.00	9.37	123	171
850.00	0.11	On	3.30	-9.63	-9.33	9.43	0.00	9.43	124	171
860.00	0.11	On	3.30	-9.69	-9.39	9.49	0.00	9.49	124	172
870.00	0.11	On	3.30	-9.74	-9.44	9.55	0.00	9.55	125	173
880.00	0.11	On	3.30	-9.80	-9.50	9.61	0.00	9.61	126	174
890.00	0.12	On	3.30	-9.86	-9.56	9.67	0.00	9.67	126	174
900.00	0.12	On	3.30	-9.91	-9.61	9.72	0.00	9.72	127	175
910.00	0.12	On	3.30	-9.97	-9.67	9.79	0.00	9.79	127	176
920.00	0.12	On	3.30	-10.03	-9.73	9.85	0.00	9.85	128	176
930.00	0.13	On	3.30	-10.09	-9.79	9.91	0.00	9.91	128	177
940.00	0.13	On	3.30	-10.14	-9.84	9.96	0.00	9.96	129	178
950.00	0.13	On	3.30	-10.20	-9.90	10.03	0.00	10.03	129	179
960.00	0.13	On	3.30	-10.26	-9.96	10.09	0.00	10.09	130	179
970.00	0.14	On	3.30	-10.32	-10.02	10.15	0.00	10.15	131	180
980.00	0.14	On	3.30	-10.37	-10.07	10.20	0.00	10.20	131	181
990.00	-4.86	On	3.30	-10.43	-10.13	5.27	0.00	5.27	132	182
1000.00	-4.86	On	3.30	-10.49	-10.19	5.33	0.00	5.33	132	182
1010.00	-4.86	On	3.30	-10.55	-10.25	5.39	0.00	5.39	133	183
1020.00	-4.85	On	3.30	-10.60	-10.30	5.45	0.00	5.45	133	184
1030.00	-4.85	On	3.30	-10.66	-10.36	5.51	0.00	5.51	134	184
1040.00	-4.85	On	3.30	-10.61	-10.31	5.46	0.00	5.46	133	184
1050.00	-4.85	On	3.30	-10.43	-10.13	5.28	0.00	5.28	132	182
1060.00	0.16	On	3.30	-10.12	-9.82	9.97	0.00	9.97	129	178
1070.00	0.16	On	3.30	-9.68	-9.38	9.53	0.00	9.53	124	172
1080.00	0.16	On	3.30	-9.10	-8.80	8.96	0.00	8.96	119	165
1090.00	0.16	On	3.30	-8.44	-8.14	8.30	0.00	8.30	112	156
1100.00	0.17	On	3.30	-7.79	-7.49	7.65	0.00	7.65	106	148
1110.00	0.17	On	3.30	-7.14	-6.84	7.00	0.00	7.00	99	140
1120.00	0.17	On	3.30	-6.48	-6.18	6.34	0.00	6.34	93	131
1130.00	0.17	On	3.30	-5.83	-5.53	5.70	0.00	5.70	87	123
1140.00	0.17	On	3.30	-5.17	-4.87	5.04	0.00	5.04	80	114
1150.00	2.13	On	3.30	-4.52	-4.22	6.35	0.00	6.35	74	106
1160.00	4.42	On	3.30	-3.86	-3.56	7.98	1.12	6.86	67	98
1170.00	6.94	On	3.30	-3.21	-2.91	9.85	3.64	6.21	61	89
1180.00	7.82	On	3.30	-2.55	-2.25	10.06	4.52	5.55	54	81

1190.00	6.90	On	3.30	-1.90	-1.60	8.50	3.60	4.90	***48***	***73***
1200.00	4.75	On	3.30	-1.24	-0.94	5.69	1.45	4.24	***42***	***64***
1210.00	3.38	On	3.30	-0.59	-0.29	3.67	0.08	3.59	***35***	***56***
1220.00	3.74	On	3.30	0.06	0.36	3.38	0.44	2.94	***29***	***48***
1230.00	3.53	On	3.30	0.72	1.02	2.51	0.23	2.28	***22***	***39***
1240.00	3.47	On	3.30	1.37	1.67	1.79	0.17	1.63	***16***	***31***
1250.00	3.71	On	3.30	2.03	2.33	1.37	0.41	0.97	***9***	***23***
1260.00	3.53	On	3.30	2.68	2.98	0.54	0.23	0.32	***3***	***14***
1270.00	3.43	On	3.30	3.34	3.64	0.00	0.00	0.00	***0***	***6***
1272.00	3.44	On	3.30	3.44	3.74	0.00	0.00	0.00	***0***	***5***

HDD borehole profile graph based on the above table



Dist (m)	σv (kN/m^2)	σh (kN/m^2)	σo (kN/m^2)	Pf (kN/m^2)	Q	Rpmax (m)	Pemax (kN/m^2)	Pmax (kN/m^2)	Hf (kN/m^2)	H (kN/m^2)
0.0	0.0	0.0	0.0	0.0	0.00000	0.3	0	0	0	0
10.0	21.2	0.0	21.2	31.2	0.00129	0.4	40	41	0	13
20.0	42.1	0.0	42.1	61.8	0.00257	1.1	139	153	1	30
30.0	41.7	0.0	41.7	61.2	0.00254	1.3	154	181	1	46
40.0	77.4	0.0	77.4	113.7	0.00472	2.3	380	418	2	62
50.0	96.3	0.0	96.3	141.4	0.00587	2.8	516	564	2	75
60.0	122.0	0.0	122.0	179.3	0.00745	3.5	686	744	3	87
70.0	163.0	0.0	163.0	239.6	0.00995	4.5	924	989	3	97
80.0	195.5	0.0	195.5	287.3	0.01193	5.2	1091	1162	3	106
90.0	165.4	0.0	165.4	243.0	0.01009	4.7	945	1021	4	113
100.0	134.7	0.0	134.7	197.9	0.00822	4.2	783	863	4	118
110.0	128.5	0.0	128.5	188.9	0.00785	4.1	749	831	5	121
120.0	105.2	0.0	105.2	154.7	0.00642	3.4	596	678	5	123
130.0	81.4	0.0	81.4	119.6	0.00497	2.6	426	509	5	124
140.0	82.5	0.0	82.5	121.3	0.00504	2.6	434	518	6	125
150.0	84.6	0.0	84.6	124.3	0.00516	2.7	449	533	6	126
160.0	86.4	0.0	86.4	127.0	0.00527	2.8	462	547	7	127
170.0	88.4	0.0	88.4	130.0	0.00540	2.8	477	562	7	129
180.0	90.5	0.0	90.5	132.9	0.00552	2.9	491	577	8	130
190.0	92.5	0.0	92.5	135.9	0.00564	2.9	506	592	8	131
210.0	96.3	0.0	96.3	141.6	0.00588	3.1	533	621	9	133
220.0	97.5	0.0	97.5	143.3	0.00595	3.1	542	630	9	134
230.0	98.5	0.0	98.5	144.8	0.00601	3.1	549	638	10	136
240.0	99.4	0.0	99.4	146.0	0.00607	3.2	555	644	10	137
250.0	100.4	0.0	100.4	147.5	0.00613	3.2	562	652	10	138
260.0	101.4	0.0	101.4	149.0	0.00619	3.2	569	660	11	139
270.0	102.4	0.0	102.4	150.5	0.00625	3.3	576	667	11	140
280.0	103.3	0.0	103.3	151.8	0.00630	3.3	582	674	12	141
290.0	104.3	0.0	104.3	153.2	0.00637	3.3	589	681	12	142
300.0	105.3	0.0	105.3	154.7	0.00643	3.4	596	689	13	144
310.0	106.3	0.0	106.3	156.2	0.00649	3.4	603	697	13	145
320.0	107.2	0.0	107.2	157.5	0.00654	3.4	609	703	13	146
330.0	108.2	0.0	108.2	159.0	0.00660	3.4	616	710	14	147
340.0	109.2	0.0	109.2	160.5	0.00667	3.5	623	718	14	148
350.0	110.2	0.0	110.2	162.0	0.00673	3.5	630	725	15	149
360.0	111.1	0.0	111.1	163.2	0.00678	3.5	636	732	15	150
370.0	112.1	0.0	112.1	164.7	0.00684	3.6	642	739	15	152
380.0	113.1	0.0	113.1	166.2	0.00690	3.6	649	747	16	153
390.0	114.1	0.0	114.1	167.7	0.00697	3.6	656	754	16	154
400.0	115.0	0.0	115.0	169.0	0.00702	3.7	662	760	17	155
410.0	116.0	0.0	116.0	170.5	0.00708	3.7	668	767	17	156
420.0	117.0	0.0	117.0	171.9	0.00714	3.7	675	775	18	157
430.0	117.6	0.0	117.6	172.9	0.00718	3.7	679	779	18	159
440.0	118.1	0.0	118.1	173.6	0.00721	3.8	682	783	18	160
450.0	118.8	0.0	118.8	174.5	0.00725	3.8	687	788	19	161
460.0	119.4	0.0	119.4	175.4	0.00729	3.8	691	793	19	162
470.0	119.9	0.0	119.9	176.2	0.00732	3.8	694	796	20	163
480.0	120.5	0.0	120.5	177.1	0.00736	3.8	698	801	20	164
490.0	121.2	0.0	121.2	178.0	0.00739	3.9	702	806	20	165
500.0	121.8	0.0	121.8	179.0	0.00743	3.9	706	811	21	167
510.0	122.3	0.0	122.3	179.7	0.00746	3.9	710	814	21	168

*The pressure calculations are set out in this table. Note that **Rpmax** varies as it is set to be a proportion of the cover depth.*

Hf is a rough estimate of the drilling mud pressure in the return annular flow.

*The total head **H** is the static head **Hs** (table above) and **Hf**.*

520.0	122.9	0.0	122.9	180.6	0.00750	3.9	714	819	*22*	*169*
530.0	123.6	0.0	123.6	181.6	0.00754	3.9	718	824	*22*	*170*
540.0	124.2	0.0	124.2	182.5	0.00758	4.0	722	828	*23*	*171*
550.0	124.7	0.0	124.7	183.2	0.00761	4.0	725	832	*23*	*172*
560.0	125.3	0.0	125.3	184.2	0.00765	4.0	729	837	*23*	*173*
570.0	126.1	0.0	126.1	185.3	0.00770	4.0	734	842	*24*	*175*
580.0	126.8	0.0	126.8	186.4	0.00774	4.0	739	847	*24*	*176*
590.0	127.4	0.0	127.4	187.2	0.00778	4.1	742	851	*25*	*177*
600.0	128.1	0.0	128.1	188.3	0.00782	4.1	747	857	*25*	*178*
610.0	128.9	0.0	128.9	189.4	0.00787	4.1	752	862	*26*	*179*
620.0	129.6	0.0	129.6	190.5	0.00791	4.1	756	867	*26*	*180*
630.0	130.2	0.0	130.2	191.3	0.00795	4.1	760	871	*26*	*181*
640.0	130.9	0.0	130.9	192.4	0.00799	4.2	764	876	*27*	*183*
650.0	131.7	0.0	131.7	193.5	0.00804	4.2	769	882	*27*	*184*
660.0	132.4	0.0	132.4	194.6	0.00808	4.2	774	887	*28*	*185*
670.0	133.0	0.0	133.0	195.5	0.00812	4.2	777	891	*28*	*186*
680.0	133.8	0.0	133.8	196.6	0.00816	4.3	782	896	*28*	*187*
690.0	134.5	0.0	134.5	197.7	0.00821	4.3	787	901	*29*	*188*
700.0	135.3	0.0	135.3	198.8	0.00826	4.3	791	907	*29*	*190*
710.0	136.0	0.0	136.0	199.8	0.00830	4.3	795	911	*30*	*191*
720.0	136.8	0.0	136.8	201.0	0.00835	4.4	800	917	*30*	*192*
730.0	137.6	0.0	137.6	202.3	0.00840	4.4	805	922	*31*	*193*
740.0	138.4	0.0	138.4	203.4	0.00845	4.4	810	928	*31*	*194*
750.0	138.9	0.0	138.9	204.1	0.00848	4.4	813	931	*31*	*195*
760.0	139.6	0.0	139.6	205.1	0.00852	4.4	817	936	*32*	*196*
770.0	140.5	0.0	140.5	206.5	0.00858	4.5	823	942	*32*	*198*
780.0	141.5	0.0	141.5	207.9	0.00864	4.5	828	948	*33*	*199*
790.0	142.3	0.0	142.3	209.1	0.00868	4.5	833	954	*33*	*200*
800.0	143.3	0.0	143.3	210.6	0.00875	4.6	839	960	*33*	*201*
810.0	144.3	0.0	144.3	212.0	0.00881	4.6	845	966	*34*	*202*
820.0	145.3	0.0	145.3	213.5	0.00887	4.6	851	973	*34*	*203*
830.0	146.1	0.0	146.1	214.7	0.00892	4.7	855	978	*35*	*205*
840.0	147.1	0.0	147.1	216.1	0.00898	4.7	861	984	*35*	*206*
850.0	148.0	0.0	148.0	217.6	0.00904	4.7	867	991	*36*	*207*
860.0	149.0	0.0	149.0	219.0	0.00910	4.7	872	997	*36*	*208*
870.0	149.8	0.0	149.8	220.2	0.00915	4.8	877	1002	*36*	*209*
880.0	150.8	0.0	150.8	221.6	0.00921	4.8	883	1008	*37*	*210*
890.0	151.8	0.0	151.8	223.1	0.00926	4.8	888	1014	*37*	*211*
900.0	152.6	0.0	152.6	224.3	0.00931	4.9	893	1019	*38*	*213*
910.0	153.6	0.0	153.6	225.7	0.00938	4.9	898	1026	*38*	*214*
920.0	154.6	0.0	154.6	227.1	0.00943	4.9	904	1032	*38*	*215*
930.0	155.6	0.0	155.6	228.6	0.00949	5.0	909	1038	*39*	*216*
940.0	156.4	0.0	156.4	229.8	0.00954	5.0	914	1043	*39*	*217*
950.0	157.4	0.0	157.4	231.2	0.00960	5.0	919	1049	*40*	*218*
960.0	158.3	0.0	158.3	232.7	0.00966	5.0	925	1055	*40*	*220*
970.0	159.3	0.0	159.3	234.1	0.00972	5.1	930	1061	*41*	*221*
980.0	160.1	0.0	160.1	235.3	0.00977	5.1	935	1066	*41*	*222*
990.0	82.6	0.0	82.6	121.4	0.00504	2.6	435	567	*41*	*223*
1000.0	83.6	0.0	83.6	122.8	0.00510	2.7	442	574	*42*	*224*
1010.0	84.5	0.0	84.5	124.2	0.00516	2.7	449	581	*42*	*225*
1020.0	85.5	0.0	85.5	125.6	0.00522	2.7	455	589	*43*	*226*
1030.0	86.4	0.0	86.4	127.0	0.00527	2.8	462	596	*43*	*228*
1040.0	85.6	0.0	85.6	125.8	0.00523	2.7	456	590	*43*	*227*
1050.0	82.8	0.0	82.8	121.7	0.00505	2.6	436	568	*44*	*225*
1060.0	156.5	0.0	156.5	230.0	0.00955	5.0	914	1043	*44*	*222*
1070.0	149.6	0.0	149.6	219.9	0.00913	4.8	876	1000	*45*	*217*
1080.0	140.6	0.0	140.6	206.6	0.00858	4.5	823	942	*45*	*210*
1090.0	130.2	0.0	130.2	191.4	0.00795	4.1	760	872	*46*	*202*
1100.0	120.1	0.0	120.1	176.5	0.00733	3.8	695	801	*46*	*194*
1110.0	109.9	0.0	109.9	161.5	0.00671	3.5	628	727	*46*	*186*
1120.0	99.6	0.0	99.6	146.3	0.00608	3.2	556	649	*47*	*178*
1130.0	89.4	0.0	89.4	131.4	0.00546	2.8	484	570	*47*	*170*
1140.0	79.1	0.0	79.1	116.2	0.00483	2.5	409	489	*48*	*162*
1150.0	99.6	0.0	99.6	146.4	0.00608	3.2	556	630	*48*	*154*
1160.0	136.2	0.0	136.2	200.2	0.00832	4.0	780	848	*48*	*146*
1170.0	190.3	0.0	190.3	279.7	0.01162	4.9	1060	1121	*49*	*138*
1180.0	202.3	0.0	202.3	297.2	0.01235	5.0	1114	1168	*49*	*130*
1190.0	168.7	0.0	168.7	247.9	0.01030	4.2	940	988	*50*	*123*
1200.0	103.5	0.0	103.5	152.1	0.00632	2.8	551	592	*50*	*115*
1210.0	58.4	0.0	58.4	85.8	0.00356	1.8	260	295	*51*	*107*
1220.0	57.3	0.0	57.3	84.3	0.00350	1.7	244	272	*51*	*99*
1230.0	41.6	0.0	41.6	61.1	0.00254	1.3	149	171	*51*	*91*
1240.0	29.7	0.0	29.7	43.7	0.00181	0.9	86	102	*52*	*83*
1250.0	25.6	0.0	25.6	37.6	0.00156	0.7	63	72	*52*	*75*
1260.0	10.7	0.0	10.7	15.8	0.00066	0.3	15	18	*53*	*67*
1270.0	0.0	0.0	0.0	0.0	0.00000	0.3	0	0	*53*	*59*

1272.0	0.0	0.0	0.0	0.0	0.00000	0.3	0	0	***53***	***58***

Comments

Hydrofracture - Longitudinal Profile Check

[redacted]

$$Pmax = Pemax + U$$ ***Eqn(1)***

$$Pemax = (Pf + c.cot\emptyset).\left\{\left(\frac{Ro}{Rpmax}\right)^2 + Q\right\}^{\frac{-sin\emptyset}{1+sin\emptyset}} - c.cot\emptyset$$ ***Eqn(2)***

$$Q = \frac{(\sigma o.sin\emptyset + c.cos\emptyset)}{G}$$ ***Eqn(3)***

$$Pf = \sigma o\,(1 + sin\emptyset) + c.cos\emptyset$$ ***Eqn(4)***

$$G = \frac{E}{2}\,(1 + \vartheta)$$ ***Eqn(5)***

Where:

Pmax	maximum allowable mud pressure
U	initial in-situ pore pressure
Pemax	maximum allowable effective mud pressure
σ_o	initial effective stress
ϕ	internal angle of friction
c	cohesion
Ro	internal radius of borehole
Rpmax	maximum allowable radius of plastic zone
G	shear modulus
E	elasticity modulus
N	Poisson's ratio

[redacted]

General variables

Gravity (m/s/s):	**g**	9.81				
Density of water (kg/m3):	**ɣw**	1000				
Density of drilling mud (kg/m3):	**ɣm**	1300				
Soil density (kg/m^3):	**ɣs**	2600				*Ground parameters are informed by results of ground investigation and laboratory testing.*
Cohesion (kN/m^2):	**Coh**	0				
Friction angle (deg):	**Φ**	30	Radians Φr =	0.5236		
Poission's ratio :	**v**	0.3				
Elasticity modulus (kPa):	**Emod**	30000				
Shear modulus (kPa):	Gmod =	11538				
Product pipe OD (m):						
Drill bit diameter (inch):		24.00 inch	**Do**	0.610	m	*Diameters assumed at feasibility stage.*
Drill pipe OD (inch):		12.00 inch	**Di**	0.305	m	
Initial radius of borehole (m):	**Ro**	0.305	*Equal half drill bit diameter*			*Rpmax usually assumed between 1/2 and 2/3 depth, assumed 1/2 as worst case scenario*
Allowable plastic radius factor	**Rpmax**	0.50				
Consider lateral soil pressure:	**No**		***Use drop-down to select Y/N***			
Passive coefficient **ko** =	######					*Conservative to not consider lateral soil pressures*
=	######					
=	**0**					

Annular pressure calculations

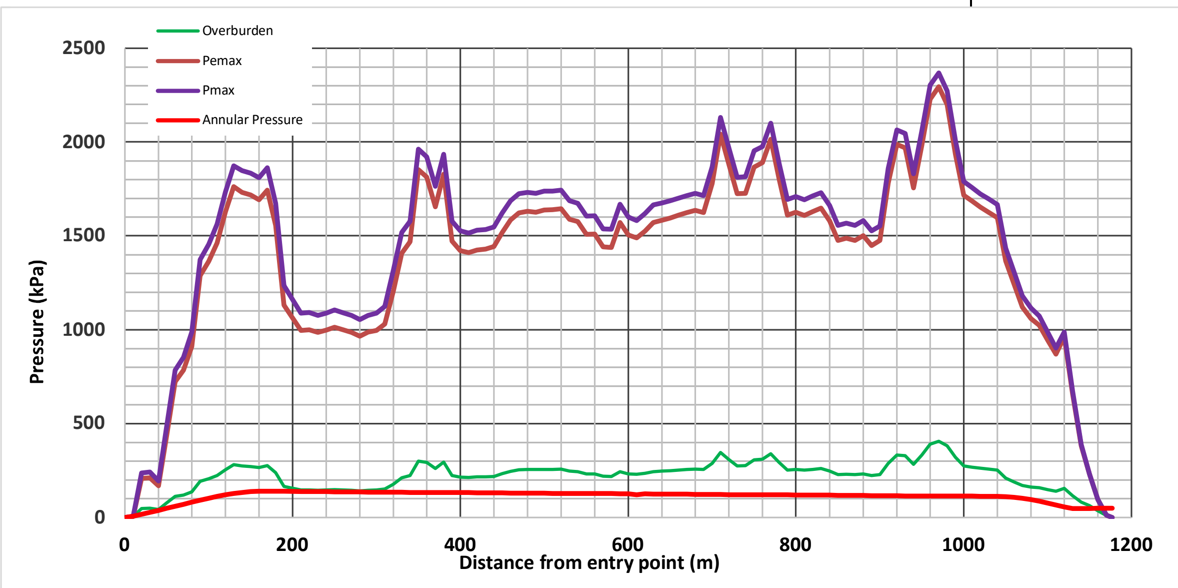
Darcy Weisbach equation for flow in an annulus is: H = f(L/Dh)(V^2/2g), where Dh is the hydraulic diameter, V the flow velocity, L flow pipe length and f is a friction factor. In the case of co-centered circular pipes Dh = Do - Di. The exact drilling operational parameters, such as flow rate are unknown, but some estimated values have been applied - but require verification. The total head is the flow head plus the static head.

Assumed flow velocity (m/s):	V	0.50
Assumed friction coefficient:	f	1.00

The calculations at each chainage location are performed in the frac-out table

Summary Figures

Elevation of entrance hole mOD =	**8.74**	**mOD**		
Elevation of exit hole mOD =	**12.74**	**mOD**	***Diff =***	***-4.00*** m
Maximum cover to HDD borehole =	**18.8**	**m**		
Maximum overburden pressure =	**405.5**	**kN/m^2**		***4.1 Bar***
Maximum safe effective stress **Pemax** =	**2295**	**kN/m^2**		***22.9 Bar***
Maximum safe stress **Pmax** =	**2369**	**kN/m^3**		***23.7 Bar***



Expressions used in hydrofracture calculations

In the tabulation below the following functions are applied

Saturated Layer **Sat'd**: IF (WTL<=HDD, Elevn-HDD, Max(Elevn-WTL, 0))

Bouyant Layer **Bou't**: IF (WTL<=HDD, 0, Min(WTL-HDD, Elevn-HDD))

σv = (ɣs*Satd+(ɣs-ɣw)*Bout)*g/1000

σo = SQRT((ɣs*Satd+(ɣs-ɣw)*Bout)^2 + (ko * (ɣs*Satd + (ɣs-ɣw)*Bout))^2))

Q = (σo*SIN(Φr) + Coh*COS(Φr)) / Gmod

Pf = (σo * (1+SIN(Φr))) + (Coh * COS(Φr))

Pemax = (Pf + Coh*COT(Φr)) * (((Ro/Rpmax)^2 + Q)^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

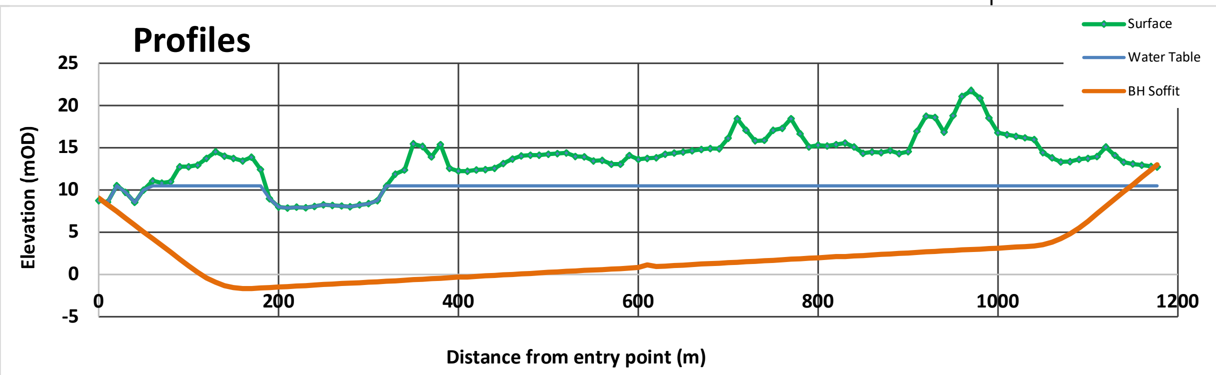
Pelim = (Pf + Coh*COT(Φr)) * (Q^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

WT controls: 10.5

Dist (m)	Elev'n (mOD)	Loc'n	WTL (mOD)	C-Line (mOD)	Soffit (mOD)	Cover (m)	Sat'd (m)	Bou't (m)	U kN/m2	Hs kN/m3
0.00	8.74		8.74	8.76	9.06	0.00	0.00	0.00	0	0
10.00	8.57		8.57	7.96	8.26	0.31	0.00	0.31	3	6
20.00	10.51		10.50	7.15	7.46	3.06	0.01	3.04	30	16
30.00	9.75		9.75	6.35	6.66	3.09	0.00	3.09	30	27
40.00	8.54		8.54	5.55	5.85	2.69	0.00	2.69	26	37
50.00	10.02		10.02	4.75	5.05	4.97	0.00	4.97	49	47
60.00	11.08		10.50	3.94	4.25	6.83	0.58	6.25	61	57
70.00	10.85		10.50	3.14	3.45	7.40	0.35	7.05	69	68
80.00	11.00		10.50	2.34	2.64	8.35	0.50	7.86	77	78
90.00	12.77		10.50	1.54	1.84	10.93	2.27	8.66	85	88
100.00	12.76		10.50	0.74	1.04	11.72	2.26	9.46	93	98
110.00	12.94		10.50	-0.04	0.26	12.68	2.44	10.24	100	108
120.00	13.76		10.50	-0.69	-0.39	14.15	3.26	10.89	107	116
130.00	14.51		10.50	-1.21	-0.91	15.42	4.01	11.41	112	123
140.00	14.02		10.50	-1.60	-1.29	15.32	3.52	11.79	116	128
150.00	13.74		10.50	-1.85	-1.54	15.28	3.24	12.04	118	131
160.00	13.45		10.50	-1.97	-1.66	15.12	2.95	12.16	119	133
170.00	13.89		10.50	-1.96	-1.65	15.54	3.39	12.15	119	133
180.00	12.44		10.50	-1.90	-1.59	14.03	1.94	12.09	119	132
190.00	9.00		9.00	-1.84	-1.53	10.53	0.00	10.53	103	131
200.00	8.00		8.00	-1.78	-1.48	9.47	0.00	9.47	93	130
210.00	7.88		7.88	-1.72	-1.42	9.30	0.00	9.30	91	130
220.00	7.98		7.98	-1.67	-1.36	9.34	0.00	9.34	92	129
230.00	7.91		7.91	-1.61	-1.30	9.21	0.00	9.21	90	128
240.00	8.07		8.07	-1.55	-1.25	9.31	0.00	9.31	91	127
250.00	8.26		8.26	-1.49	-1.19	9.45	0.00	9.45	93	127
260.00	8.20		8.20	-1.44	-1.13	9.33	0.00	9.33	92	126
270.00	8.14		8.14	-1.38	-1.07	9.21	0.00	9.21	90	125
280.00	8.02		8.02	-1.32	-1.02	9.04	0.00	9.04	89	124
290.00	8.26		8.26	-1.26	-0.96	9.22	0.00	9.22	90	124
300.00	8.41		8.41	-1.21	-0.90	9.31	0.00	9.31	91	123
310.00	8.76		8.76	-1.15	-0.84	9.60	0.00	9.60	94	122
320.00	10.49		10.49	-1.09	-0.79	11.27	0.00	11.27	111	122
330.00	11.90		10.50	-1.03	-0.73	12.63	1.40	11.23	110	121
340.00	12.39		10.50	-0.97	-0.67	13.05	1.89	11.17	110	120
350.00	15.46		10.50	-0.92	-0.61	16.07	4.96	11.11	109	119
360.00	15.16		10.50	-0.86	-0.55	15.72	4.66	11.05	108	119
370.00	13.92		10.50	-0.80	-0.50	14.42	3.42	11.00	108	118
380.00	15.37		10.50	-0.74	-0.44	15.80	4.87	10.94	107	117
390.00	12.59		10.50	-0.69	-0.38	12.97	2.09	10.88	107	116
400.00	12.26		10.50	-0.63	-0.32	12.58	1.76	10.82	106	116
410.00	12.22		10.50	-0.57	-0.27	12.49	1.72	10.77	106	115
420.00	12.36		10.50	-0.51	-0.21	12.57	1.86	10.71	105	114
430.00	12.43		10.50	-0.46	-0.15	12.58	1.93	10.65	104	113
440.00	12.58		10.50	-0.40	-0.09	12.67	2.08	10.59	104	113
450.00	13.17		10.50	-0.34	-0.04	13.20	2.67	10.54	103	112
460.00	13.70		10.50	-0.28	0.02	13.67	3.20	10.48	103	111
470.00	14.03		10.50	-0.23	0.08	13.95	3.53	10.42	102	110
480.00	14.14		10.50	-0.17	0.14	14.00	3.64	10.36	102	110
490.00	14.14		10.50	-0.11	0.20	13.94	3.64	10.30	101	109
500.00	14.27		10.50	-0.05	0.25	14.02	3.77	10.25	101	108
510.00	14.31		10.50	0.01	0.31	14.00	3.81	10.19	100	108

520.00	14.39	10.50	0.06	0.37	14.02	3.89	10.13	*99*	*107*
530.00	14.00	10.50	0.12	0.43	13.57	3.50	10.07	*99*	*106*
540.00	13.94	10.50	0.18	0.48	13.45	3.44	10.02	*98*	*105*
550.00	13.46	10.50	0.24	0.54	12.92	2.96	9.96	*98*	*105*
560.00	13.52	10.50	0.29	0.60	12.92	3.02	9.90	*97*	*104*
570.00	13.05	10.50	0.35	0.66	12.39	2.55	9.84	*97*	*103*
580.00	13.07	10.50	0.41	0.71	12.36	2.57	9.79	*96*	*102*
590.00	14.10	10.50	0.47	0.77	13.33	3.60	9.73	*95*	*102*
600.00	13.63	10.50	0.53	0.83	12.80	3.13	9.67	*95*	*101*
610.00	13.74	10.50	0.85	1.16	12.58	3.24	9.34	*92*	*97*
620.00	13.85	10.50	0.64	0.94	12.91	3.35	9.56	*94*	*99*
630.00	14.25	10.50	0.70	1.00	13.25	3.75	9.50	*93*	*99*
640.00	14.37	10.50	0.76	1.06	13.31	3.87	9.44	*93*	*98*
650.00	14.49	10.50	0.81	1.12	13.38	3.99	9.38	*92*	*97*
660.00	14.65	10.50	0.87	1.18	13.47	4.15	9.32	*91*	*97*
670.00	14.80	10.50	0.93	1.23	13.56	4.30	9.27	*91*	*96*
680.00	14.93	10.50	0.99	1.29	13.64	4.43	9.21	*90*	*95*
690.00	14.88	10.50	1.04	1.35	13.53	4.38	9.15	*90*	*94*
700.00	16.15	10.50	1.10	1.41	14.75	5.65	9.09	*89*	*94*
710.00	18.46	10.50	1.16	1.46	16.99	7.96	9.04	*89*	*93*
720.00	17.08	10.50	1.22	1.52	15.56	6.58	8.98	*88*	*92*
730.00	15.81	10.50	1.28	1.58	14.23	5.31	8.92	*88*	*91*
740.00	15.87	10.50	1.33	1.64	14.24	5.37	8.86	*87*	*91*
750.00	17.07	10.50	1.39	1.69	15.37	6.57	8.81	*86*	*90*
760.00	17.30	10.50	1.45	1.75	15.55	6.80	8.75	*86*	*89*
770.00	18.43	10.50	1.51	1.81	16.62	7.93	8.69	*85*	*88*
780.00	16.65	10.50	1.56	1.87	14.78	6.15	8.63	*85*	*88*
790.00	15.13	10.50	1.62	1.93	13.21	4.63	8.57	*84*	*87*
800.00	15.30	10.50	1.68	1.98	13.32	4.80	8.52	*84*	*86*
810.00	15.21	10.50	1.74	2.04	13.17	4.71	8.46	*83*	*85*
820.00	15.41	10.50	1.79	2.10	13.31	4.91	8.40	*82*	*85*
830.00	15.58	10.50	1.85	2.16	13.43	5.08	8.34	*82*	*84*
840.00	15.10	10.50	1.91	2.21	12.89	4.60	8.29	*81*	*83*
850.00	14.36	10.50	1.97	2.27	12.09	3.86	8.23	*81*	*83*
860.00	14.49	10.50	2.02	2.33	12.16	3.99	8.17	*80*	*82*
870.00	14.44	10.50	2.08	2.39	12.05	3.94	8.11	*80*	*81*
880.00	14.67	10.50	2.14	2.44	12.23	4.17	8.06	*79*	*80*
890.00	14.32	10.50	2.20	2.50	11.82	3.82	8.00	*78*	*80*
900.00	14.55	10.50	2.26	2.56	11.99	4.05	7.94	*78*	*79*
910.00	16.95	10.50	2.31	2.62	14.33	6.45	7.88	*77*	*78*
920.00	18.73	10.50	2.37	2.67	16.06	8.23	7.83	*77*	*77*
930.00	18.61	10.50	2.43	2.73	15.88	8.11	7.77	*76*	*77*
940.00	16.85	10.50	2.49	2.79	14.06	6.35	7.71	*76*	*76*
950.00	18.81	10.50	2.54	2.85	15.96	8.31	7.65	*75*	*75*
960.00	21.09	10.50	2.60	2.91	18.18	10.59	7.59	*74*	*74*
970.00	21.76	10.50	2.66	2.96	18.80	11.26	7.54	*74*	*74*
980.00	20.88	10.50	2.72	3.02	17.86	10.38	7.48	*73*	*73*
990.00	18.54	10.50	2.77	3.08	15.46	8.04	7.42	*73*	*72*
1000.00	16.76	10.50	2.83	3.14	13.62	6.26	7.36	*72*	*71*
1010.00	16.55	10.50	2.89	3.19	13.36	6.05	7.31	*72*	*71*
1020.00	16.34	10.50	2.95	3.25	13.08	5.84	7.25	*71*	*70*
1030.00	16.16	10.50	3.01	3.31	12.85	5.66	7.19	*71*	*69*
1040.00	15.99	10.50	3.07	3.37	12.62	5.49	7.13	*70*	*68*
1050.00	14.43	10.50	3.22	3.53	10.90	3.93	6.97	*68*	*66*
1060.00	13.82	10.50	3.52	3.82	10.00	3.32	6.68	*66*	*63*
1070.00	13.33	10.50	3.94	4.24	9.09	2.83	6.26	*61*	*57*
1080.00	13.35	10.50	4.50	4.80	8.55	2.85	5.70	*56*	*50*
1090.00	13.62	10.50	5.19	5.49	8.13	3.12	5.01	*49*	*41*
1100.00	13.76	10.50	6.01	6.31	7.45	3.26	4.19	*41*	*31*
1110.00	13.96	10.50	6.88	7.18	6.78	3.46	3.32	*33*	*20*
1120.00	15.10	10.50	7.75	8.05	7.04	4.60	2.45	*24*	*9*
1130.00	14.11	10.50	8.62	8.93	5.19	3.61	1.57	*15*	*0*
1140.00	13.30	10.50	9.49	9.80	3.50	2.80	0.70	*7*	*0*
1150.00	13.10	10.50	10.36	10.67	2.43	2.43	0.00	*0*	*0*
1160.00	12.95	10.50	11.23	11.54	1.41	1.41	0.00	*0*	*0*
1170.00	12.80	10.50	12.10	12.41	0.39	0.39	0.00	*0*	*0*
1177.00	12.74	10.50	12.69	13.00	0.00	0.00	0.00	*0*	*0*

HDD borehole profile graph based on the above table



Dist (m)	σv (kN/m^2)	σh (kN/m^2)	σo (kN/m^2)	Pf (kN/m^2)	Q	Rpmax (m)	Pemax (kN/m^2)	Pmax (kN/m^2)	Hf (kN/m^2)	H (kN/m^2)
0.0	0.0	0.0	0.0	0.0	0.00000	0.3	0	0	*0*	*0*
10.0	4.9	0.0	4.9	7.3	0.00021	0.2	5	8	*0*	*7*
20.0	48.1	0.0	48.1	72.1	0.00208	1.5	208	238	*1*	*17*
30.0	48.5	0.0	48.5	72.7	0.00210	1.5	211	241	*1*	*28*
40.0	42.2	0.0	42.2	63.3	0.00183	1.3	168	195	*2*	*39*
50.0	77.9	0.0	77.9	116.9	0.00338	2.5	443	491	*2*	*49*
60.0	112.9	0.0	112.9	169.4	0.00489	3.4	723	784	*3*	*60*
70.0	119.6	0.0	119.6	179.4	0.00518	3.7	784	853	*3*	*70*
80.0	136.0	0.0	136.0	204.0	0.00589	4.2	911	988	*3*	*81*
90.0	193.8	0.0	193.8	290.7	0.00840	5.5	1287	1372	*4*	*92*
100.0	206.0	0.0	206.0	309.0	0.00893	5.9	1364	1457	*4*	*102*
110.0	223.0	0.0	223.0	334.5	0.00966	6.3	1462	1562	*5*	*113*
120.0	254.1	0.0	254.1	381.2	0.01101	7.1	1627	1733	*5*	*121*
130.0	281.4	0.0	281.4	422.0	0.01219	7.7	1761	1873	*5*	*128*
140.0	274.9	0.0	274.9	412.4	0.01191	7.7	1732	1848	*6*	*134*
150.0	271.7	0.0	271.7	407.5	0.01177	7.6	1717	1835	*6*	*137*
160.0	266.2	0.0	266.2	399.3	0.01154	7.6	1691	1811	*7*	*139*
170.0	277.1	0.0	277.1	415.6	0.01201	7.8	1744	1863	*7*	*140*
180.0	239.2	0.0	239.2	358.8	0.01036	7.0	1556	1675	*8*	*139*
190.0	165.3	0.0	165.3	247.9	0.00716	5.3	1132	1235	*8*	*139*
210.0	146.0	0.0	146.0	219.0	0.00633	4.7	996	1087	*9*	*138*
220.0	146.5	0.0	146.5	219.8	0.00635	4.7	1000	1092	*9*	*138*
230.0	144.6	0.0	144.6	216.9	0.00627	4.6	986	1076	*10*	*138*
240.0	146.1	0.0	146.1	219.2	0.00633	4.7	997	1089	*10*	*137*
250.0	148.3	0.0	148.3	222.5	0.00643	4.7	1013	1106	*10*	*137*
260.0	146.4	0.0	146.4	219.6	0.00635	4.7	999	1091	*11*	*137*
270.0	144.6	0.0	144.6	216.9	0.00627	4.6	986	1076	*11*	*136*
280.0	141.8	0.0	141.8	212.8	0.00615	4.5	966	1054	*12*	*136*
290.0	144.7	0.0	144.7	217.0	0.00627	4.6	986	1077	*12*	*136*
300.0	146.1	0.0	146.1	219.1	0.00633	4.7	997	1088	*13*	*136*
310.0	150.7	0.0	150.7	226.1	0.00653	4.8	1031	1125	*13*	*135*
320.0	176.9	0.0	176.9	265.4	0.00767	5.6	1208	1319	*13*	*135*
330.0	211.9	0.0	211.9	317.8	0.00918	6.3	1407	1518	*14*	*135*
340.0	223.4	0.0	223.4	335.1	0.00968	6.5	1469	1579	*14*	*134*
350.0	300.9	0.0	300.9	451.3	0.01304	8.0	1852	1961	*15*	*134*
360.0	292.4	0.0	292.4	438.7	0.01267	7.9	1812	1921	*15*	*134*
370.0	259.9	0.0	259.9	389.9	0.01126	7.2	1656	1764	*15*	*133*
380.0	295.8	0.0	295.8	443.7	0.01282	7.9	1828	1935	*16*	*133*
390.0	224.1	0.0	224.1	336.1	0.00971	6.5	1472	1578	*16*	*133*
400.0	214.7	0.0	214.7	322.1	0.00930	6.3	1421	1527	*17*	*132*
410.0	212.9	0.0	212.9	319.3	0.00922	6.2	1410	1516	*17*	*132*
420.0	215.6	0.0	215.6	323.4	0.00934	6.3	1425	1530	*18*	*132*
430.0	216.4	0.0	216.4	324.6	0.00938	6.3	1429	1533	*18*	*131*
440.0	219.2	0.0	219.2	328.9	0.00950	6.3	1444	1548	*18*	*131*
450.0	233.3	0.0	233.3	350.0	0.01011	6.6	1519	1622	*19*	*131*
460.0	245.9	0.0	245.9	368.9	0.01066	6.8	1583	1686	*19*	*130*
470.0	253.7	0.0	253.7	380.5	0.01099	7.0	1622	1725	*20*	*130*
480.0	255.4	0.0	255.4	383.2	0.01107	7.0	1631	1733	*20*	*130*
490.0	254.5	0.0	254.5	381.8	0.01103	7.0	1626	1727	*20*	*129*
500.0	257.0	0.0	257.0	385.5	0.01114	7.0	1638	1739	*21*	*129*
510.0	257.1	0.0	257.1	385.7	0.01114	7.0	1639	1739	*21*	*129*

*The pressure calculations are set out in this table. Note that **Rpmax** varies as it is set to be a proportion of the cover depth.*

Hf is a rough estimate of the drilling mud pressure in the return annular flow.

*The total head **H** is the static head **Hs** (table above) and **Hf**.*

520.0	258.3	0.0	258.3	387.4	0.01119	7.0	1644	1744	*22*	*129*
530.0	247.3	0.0	247.3	371.0	0.01072	6.8	1589	1687	*22*	*128*
540.0	244.8	0.0	244.8	367.2	0.01061	6.7	1576	1674	*23*	*128*
550.0	231.8	0.0	231.8	347.7	0.01005	6.5	1507	1605	*23*	*128*
560.0	232.4	0.0	232.4	348.6	0.01007	6.5	1510	1607	*23*	*127*
570.0	219.5	0.0	219.5	329.2	0.00951	6.2	1441	1537	*24*	*127*
580.0	219.2	0.0	219.2	328.8	0.00950	6.2	1439	1535	*24*	*127*
590.0	244.5	0.0	244.5	366.7	0.01059	6.7	1572	1668	*25*	*126*
600.0	231.6	0.0	231.6	347.4	0.01004	6.4	1505	1600	*25*	*126*
610.0	229.1	0.0	229.1	343.7	0.00993	6.3	1490	1582	*26*	*122*
620.0	235.5	0.0	235.5	353.3	0.01021	6.5	1525	1618	*26*	*125*
630.0	244.7	0.0	244.7	367.0	0.01060	6.6	1572	1665	*26*	*125*
640.0	246.8	0.0	246.8	370.1	0.01069	6.7	1583	1675	*27*	*125*
650.0	249.1	0.0	249.1	373.7	0.01080	6.7	1594	1686	*27*	*124*
660.0	252.1	0.0	252.1	378.2	0.01093	6.7	1609	1701	*28*	*124*
670.0	255.0	0.0	255.0	382.5	0.01105	6.8	1624	1715	*28*	*124*
680.0	257.5	0.0	257.5	386.3	0.01116	6.8	1636	1727	*28*	*123*
690.0	255.3	0.0	255.3	382.9	0.01106	6.8	1625	1714	*29*	*123*
700.0	286.9	0.0	286.9	430.3	0.01243	7.4	1780	1869	*29*	*123*
710.0	344.8	0.0	344.8	517.2	0.01494	8.5	2043	2132	*30*	*123*
720.0	308.7	0.0	308.7	463.1	0.01338	7.8	1881	1969	*30*	*122*
730.0	275.5	0.0	275.5	413.3	0.01194	7.1	1724	1812	*31*	*122*
740.0	276.2	0.0	276.2	414.2	0.01197	7.1	1727	1814	*31*	*122*
750.0	305.7	0.0	305.7	458.6	0.01325	7.7	1867	1953	*31*	*121*
760.0	310.8	0.0	310.8	466.2	0.01347	7.8	1890	1976	*32*	*121*
770.0	338.7	0.0	338.7	508.1	0.01468	8.3	2015	2101	*32*	*121*
780.0	292.2	0.0	292.2	438.3	0.01266	7.4	1803	1888	*33*	*120*
790.0	252.7	0.0	252.7	379.1	0.01095	6.6	1609	1693	*33*	*120*
800.0	256.1	0.0	256.1	384.1	0.01110	6.7	1626	1709	*33*	*120*
810.0	252.8	0.0	252.8	379.2	0.01096	6.6	1609	1692	*34*	*119*
820.0	257.0	0.0	257.0	385.5	0.01114	6.7	1630	1712	*34*	*119*
830.0	260.6	0.0	260.6	390.9	0.01129	6.7	1648	1730	*35*	*119*
840.0	247.5	0.0	247.5	371.2	0.01072	6.4	1580	1662	*35*	*118*
850.0	227.6	0.0	227.6	341.4	0.00986	6.0	1475	1556	*36*	*118*
860.0	230.0	0.0	230.0	345.1	0.00997	6.1	1488	1568	*36*	*118*
870.0	227.9	0.0	227.9	341.8	0.00987	6.0	1475	1555	*36*	*117*
880.0	232.8	0.0	232.8	349.3	0.01009	6.1	1502	1581	*37*	*117*
890.0	222.9	0.0	222.9	334.4	0.00966	5.9	1448	1526	*37*	*117*
900.0	227.9	0.0	227.9	341.9	0.00988	6.0	1475	1553	*38*	*116*
910.0	288.3	0.0	288.3	432.4	0.01249	7.2	1781	1859	*38*	*116*
920.0	332.8	0.0	332.8	499.1	0.01442	8.0	1987	2063	*38*	*116*
930.0	328.7	0.0	328.7	493.1	0.01425	7.9	1968	2045	*39*	*116*
940.0	283.0	0.0	283.0	424.5	0.01226	7.0	1755	1831	*39*	*115*
950.0	332.1	0.0	332.1	498.2	0.01439	8.0	1983	2058	*40*	*115*
960.0	389.3	0.0	389.3	584.0	0.01687	9.1	2228	2303	*40*	*115*
970.0	405.5	0.0	405.5	608.2	0.01757	9.4	2295	2369	*41*	*114*
980.0	382.2	0.0	382.2	573.3	0.01656	8.9	2199	2272	*41*	*114*
990.0	321.5	0.0	321.5	482.3	0.01393	7.7	1935	2008	*41*	*114*
1000.0	275.3	0.0	275.3	412.9	0.01193	6.8	1716	1788	*42*	*113*
1010.0	269.0	0.0	269.0	403.5	0.01166	6.7	1685	1756	*42*	*113*
1020.0	262.6	0.0	262.6	393.9	0.01138	6.5	1652	1723	*43*	*113*
1030.0	257.3	0.0	257.3	385.9	0.01115	6.4	1625	1695	*43*	*112*
1040.0	251.9	0.0	251.9	377.8	0.01092	6.3	1597	1667	*43*	*112*
1050.0	209.6	0.0	209.6	314.4	0.00908	5.5	1365	1434	*44*	*110*
1060.0	189.5	0.0	189.5	284.2	0.00821	5.0	1244	1309	*44*	*107*
1070.0	170.4	0.0	170.4	255.6	0.00738	4.5	1120	1181	*45*	*102*
1080.0	162.2	0.0	162.2	243.3	0.00703	4.3	1060	1116	*45*	*95*
1090.0	158.3	0.0	158.3	237.4	0.00686	4.1	1024	1073	*46*	*87*
1100.0	148.8	0.0	148.8	223.2	0.00645	3.7	946	987	*46*	*77*
1110.0	140.3	0.0	140.3	210.5	0.00608	3.4	870	902	*46*	*66*
1120.0	155.6	0.0	155.6	233.4	0.00674	3.5	963	987	*47*	*56*
1130.0	116.8	0.0	116.8	175.3	0.00506	2.6	658	674	*47*	*47*
1140.0	82.4	0.0	82.4	123.6	0.00357	1.8	382	389	*48*	*48*
1150.0	62.0	0.0	62.0	93.0	0.00269	1.2	231	231	*48*	*48*
1160.0	36.0	0.0	36.0	54.1	0.00156	0.7	94	94	*48*	*48*
1170.0	9.9	0.0	9.9	14.8	0.00043	0.2	11	11	*49*	*49*
1177.0	0.0	0.0	0.0	0.0	0.00000	0.3	0	0	*49*	*49*

Comments

waterman	**Spreadsheet Calcpad** *(Macros must be enabled. Ctrl+Alt+F9 recalculates.)*	**Project**	
		WIE12731-153	
	WIE12731-153_White Cross Phase 2 Landfall HDD Hydrofracture Calculations Revsion 1	**Prepared**	**Date**
		LP	02-Nov-23
		Checked	**Date**
		CG	06-Nov-23

Hydrofracture - Longitudinal Profile Check

[redacted]

$$Pmax = Pemax + U$$ ***Eqn(1)***

$$Pemax = (Pf + c.cot\emptyset).\left\{\left(\frac{Ro}{Rpmax}\right)^2 + Q\right\}^{\frac{-sin\emptyset}{1+sin\emptyset}} - c.cot\emptyset$$ ***Eqn(2)***

$$Q = \frac{(\sigma o.sin\emptyset + c.cos\emptyset)}{G}$$ ***Eqn(3)***

$$Pf = \sigma o\,(1 + sin\emptyset) + c.cos\emptyset$$ ***Eqn(4)***

$$G = \frac{E}{2}\,(1 + \vartheta)$$ ***Eqn(5)***

Where:

Pmax	maximum allowable mud pressure
U	initial in-situ pore pressure
Pemax	maximum allowable effective mud pressure
σ_o	initial effective stress
ϕ	internal angle of friction
c	cohesion
Ro	internal radius of borehole
Rpmax	maximum allowable radius of plastic zone
G	shear modulus
E	elasticity modulus
N	Poisson's ratio

Only enter data into green highlight cells. Other cells may contain calculations and editing them will over-write the formula.

General variables

Gravity (m/s/s):	**g**	9.81			
Density of water (kg/m3):	**ɣw**	1000			
Density of drilling mud (kg/m3):	**ɣm**	1300			
Soil density (kg/m^3):	**ɣs**	2600			
Cohesion (kN/m^2):	**Coh**	0			
Friction angle (deg):	**Φ**	30	Radians Φr =	0.5236	
Poission's ratio :	**v**	0.3			
Elasticity modulus (kPa):	**Emod**	30000			
Shear modulus (kPa):	Gmod =	11538			

Ground parameters are informed by results of ground investigation and laboratory testing.

Product pipe OD (m):					
Drill bit diameter (inch):	44.00	inch	**Do**	1.118	m
Drill pipe OD (inch):	12.00	inch	**Di**	0.305	m

Diameters assumed at feasibility stage.

Initial radius of borehole (m):	**Ro**	0.559	*Equal half drill bit diameter*
Allowable plastic radius factor	**Rpmax**	0.50	

Rpmax usually assumed between 1/2 and 2/3 depth, assumed 1/2 as worst case scenario

Consider lateral soil pressure: **No** ***Use drop-down to select Y/N***

Passive coefficient **ko** = IF(Y_N = "Yes", 1 - SIN(Φr), 0)
= IF(= "Yes", 1 - SIN(0.5236), 0)
= **0**

Conservative to not consider lateral soil pressures

Annular pressure calculations

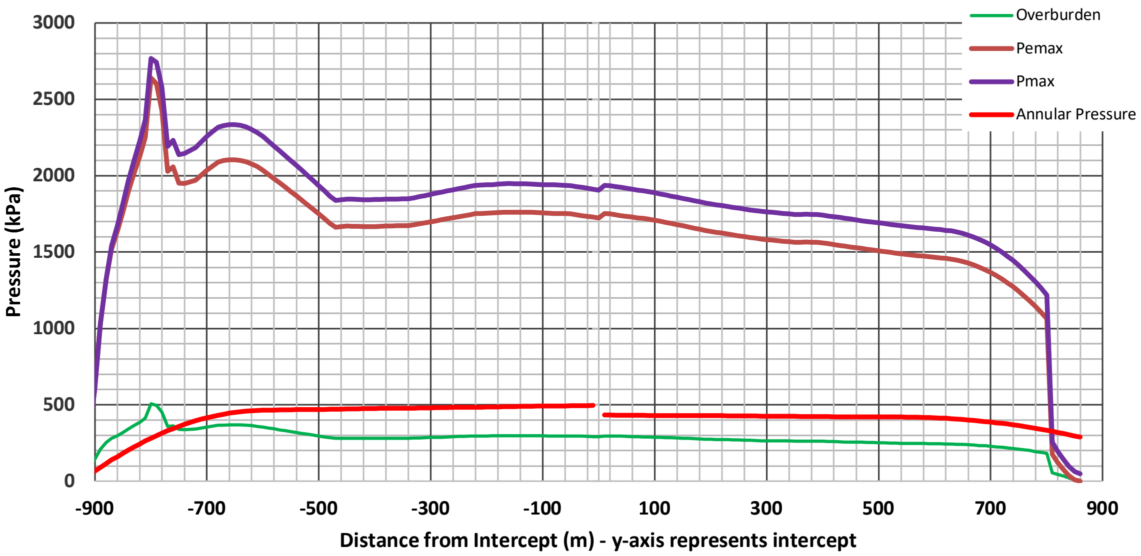
Darcy Weisbach equation for flow in an annulus is: H = f(L/Dh)(V^2/2g), where Dh is the hydraulic diameter, V the flow velocity, L flow pipe length and f is a friction factor. In the case of co-centered circular pipes Dh = Do - Di. The exact drilling operational parameters, such as flow rate are unknown, but some estimated values have been applied - but require verification. The total head is the flow head plus the static head.

Assumed flow velocity (m/s):	V	0.50
Assumed friction coefficient:	f	2.50

The calculations at each chainage location are performed in the frac-out table

Summary Figures

Elevation of entrance hole mOD =	**12.97**	**mOD**		
Elevation of exit hole mOD =	**-9.89**	**mOD**	*Diff =*	*22.86* m
Maximum cover to HDD borehole =	**25.0**	**m**		
Maximum overburden pressure =	**507.8**	**kN/m²**		*5.1 Bar*
Maximum safe effective stress **Pemax** =	**2640**	**kN/m²**		*26.4 Bar*
Maximum safe stress **Pmax** =	**2768**	**kN/m³**		*27.7 Bar*



Expressions used in hydrofracture calculations

In the tabulation below the following functions are applied

Saturated Layer **Sat'd**: IF (WTL<=HDD, Elevn-HDD, Max(Elevn-WTL, 0))

Bouyant Layer **Bou't**: IF (WTL<=HDD, 0, Min(WTL-HDD, Elevn-HDD))

σv = (γs*Satd+(γs-γw)*Bout)*g/1000

σo = SQRT((γs*Satd+(γs-γw)*Bout)^2 + (ko * (γs*Satd + (γs-γw)*Bout))^2))

Q = (σo*SIN(Φr) + Coh*COS(Φr)) / Gmod

Pf = (σo * (1+SIN(Φr))) + (Coh * COS(Φr))

Pemax = (Pf + Coh*COT(Φr)) * (((Ro/Rpmax)^2 + Q)^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

Pelim = (Pf + Coh*COT(Φr)) * (Q^(-SIN(Φr)/(1+SIN(Φr)))) - Coh*COT(Φr)

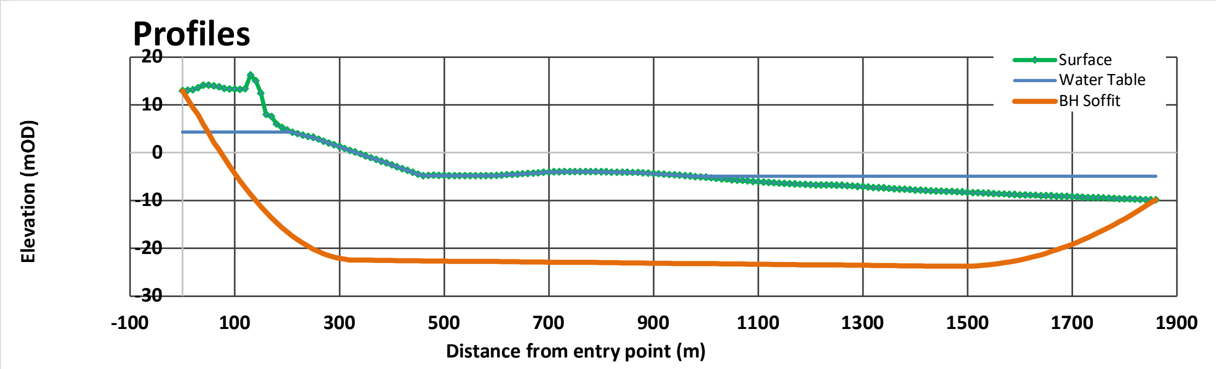
	Onshore	LAT
WT controls:	4.35	-4.89

Dist (m)	Elev'n (mOD)	Loc'n	WTL (mOD)	C-Line (mOD)	Soffit (mOD)	Cover (m)	Sat'd (m)	Bou't (m)	U kN/m2	Hs kN/m3
0.00	12.97	On	4.35		12.97	0.00	0.00	0.00	0	0
10.00	13.08	On	4.35		11.21	1.87	1.87	0.00	0	22
20.00	13.18	On	4.35		9.45	3.73	3.73	0.00	0	45
30.00	13.58	On	4.35		7.96	5.62	5.62	0.00	0	64
40.00	14.12	On	4.35		5.94	8.18	8.18	0.00	0	90
50.00	14.15	On	4.35		4.18	9.97	9.80	0.17	2	112
60.00	13.98	On	4.35		2.15	11.84	9.63	2.20	22	138
70.00	13.74	On	4.35		0.66	13.08	9.39	3.69	36	157
80.00	13.45	On	4.35		-1.06	14.51	9.10	5.41	53	179
90.00	13.36	On	4.35		-2.72	16.08	9.01	7.07	69	200
100.00	13.28	On	4.35		-4.31	17.58	8.93	8.66	85	220
110.00	13.22	On	4.35		-5.83	19.05	8.87	10.18	100	240
120.00	13.37	On	4.35		-7.28	20.66	9.02	11.63	114	258
130.00	16.25	On	4.35		-8.67	24.92	11.90	13.02	128	276
140.00	15.01	On	4.35		-10.00	25.01	10.66	14.35	141	293
150.00	12.46	On	4.35		-11.25	23.71	8.11	15.60	153	309
160.00	8.02	On	4.35		-12.44	20.46	3.67	16.79	165	324
170.00	7.56	On	4.35		-13.56	21.12	3.21	17.91	176	338
180.00	5.96	On	4.35		-14.62	20.58	1.61	18.97	186	352
190.00	5.29	On	4.35		-15.61	20.89	0.94	19.96	196	364
200.00	4.72	On	4.35		-16.53	21.25	0.37	20.88	205	376
210.00	4.30	On	4.35		-17.39	21.69	0.00	21.69	213	387
220.00	3.97		3.97		-18.18	22.15	0.00	22.15	217	397
230.00	3.66		3.66		-18.90	22.56	0.00	22.56	221	406
240.00	3.39		3.39		-19.55	22.95	0.00	22.95	225	415
250.00	3.17		3.17		-20.14	23.32	0.00	23.32	229	422
260.00	2.79		2.79		-20.67	23.46	0.00	23.46	230	429
270.00	2.41		2.41		-21.12	23.53	0.00	23.53	231	435
280.00	2.03		2.03		-21.51	23.54	0.00	23.54	231	440
290.00	1.64		1.64		-21.83	23.48	0.00	23.48	230	444
300.00	1.26		1.26		-22.09	23.35	0.00	23.35	229	447
310.00	0.88		0.88		-22.28	23.16	0.00	23.16	227	449
320.00	0.50		0.50		-22.40	22.90	0.00	22.90	225	451
330.00	0.11		0.11		-22.46	22.57	0.00	22.57	221	452
340.00	-0.27		-0.27		-22.47	22.20	0.00	22.20	218	452
350.00	-0.65		-0.65		-22.48	21.83	0.00	21.83	214	452
360.00	-1.04		-1.04		-22.49	21.46	0.00	21.46	210	452
370.00	-1.42		-1.42		-22.50	21.08	0.00	21.08	207	452
380.00	-1.80		-1.80		-22.51	20.71	0.00	20.71	203	452
390.00	-2.18		-2.18		-22.52	20.34	0.00	20.34	200	453
400.00	-2.57		-2.57		-22.54	19.97	0.00	19.97	196	453
410.00	-2.95		-2.95		-22.55	19.60	0.00	19.60	192	453
420.00	-3.33		-3.33		-22.56	19.23	0.00	19.23	189	453
430.00	-3.72		-3.72		-22.57	18.85	0.00	18.85	185	453
440.00	-4.10		-4.10		-22.58	18.48	0.00	18.48	181	453
450.00	-4.48		-4.48		-22.59	18.11	0.00	18.11	178	453
460.00	-4.79		-4.79		-22.60	17.81	0.00	17.81	175	454
470.00	-4.75		-4.75		-22.61	17.87	0.00	17.87	175	454
480.00	-4.72		-4.72		-22.62	17.91	0.00	17.91	176	454
490.00	-4.74		-4.74		-22.64	17.90	0.00	17.90	176	454
500.00	-4.76		-4.76		-22.65	17.89	0.00	17.89	175	454
510.00	-4.78		-4.78		-22.66	17.88	0.00	17.88	175	454

520.00	-4.80		-4.80	-22.67	17.87	0.00	17.87	*175*	*454*	
530.00	-4.80		-4.80	-22.68	17.88	0.00	17.88	*175*	*455*	
540.00	-4.80		-4.80	-22.69	17.89	0.00	17.89	*176*	*455*	
550.00	-4.80		-4.80	-22.70	17.90	0.00	17.90	*176*	*455*	
560.00	-4.80		-4.80	-22.71	17.91	0.00	17.91	*176*	*455*	
570.00	-4.80		-4.80	-22.72	17.92	0.00	17.92	*176*	*455*	
580.00	-4.80		-4.80	-22.73	17.93	0.00	17.93	*176*	*455*	
590.00	-4.80		-4.80	-22.75	17.95	0.00	17.95	*176*	*455*	
600.00	-4.75		-4.75	-22.76	18.01	0.00	18.01	*177*	*456*	
610.00	-4.68		-4.68	-22.77	18.09	0.00	18.09	*177*	*456*	
620.00	-4.61		-4.61	-22.78	18.17	0.00	18.17	*178*	*456*	
630.00	-4.54		-4.54	-22.79	18.25	0.00	18.25	*179*	*456*	
640.00	-4.48		-4.48	-22.80	18.33	0.00	18.33	*180*	*456*	
650.00	-4.41		-4.41	-22.81	18.41	0.00	18.41	*181*	*456*	
660.00	-4.34		-4.34	-22.82	18.48	0.00	18.48	*181*	*456*	
670.00	-4.27		-4.27	-22.83	18.56	0.00	18.56	*182*	*457*	
680.00	-4.20		-4.20	-22.85	18.64	0.00	18.64	*183*	*457*	
690.00	-4.13		-4.13	-22.86	18.72	0.00	18.72	*184*	*457*	
700.00	-4.07		-4.07	-22.87	18.80	0.00	18.80	*184*	*457*	
710.00	-4.00		-4.00	-22.88	18.88	0.00	18.88	*185*	*457*	
720.00	-3.99		-3.99	-22.89	18.90	0.00	18.90	*185*	*457*	
730.00	-3.98		-3.98	-22.90	18.92	0.00	18.92	*186*	*457*	
740.00	-3.97		-3.97	-22.91	18.94	0.00	18.94	*186*	*458*	
750.00	-3.96		-3.96	-22.92	18.96	0.00	18.96	*186*	*458*	
760.00	-3.95		-3.95	-22.93	18.99	0.00	18.99	*186*	*458*	
770.00	-3.94		-3.94	-22.95	19.01	0.00	19.01	*186*	*458*	
780.00	-3.96		-3.96	-22.96	19.00	0.00	19.00	*186*	*458*	
790.00	-3.97		-3.97	-22.97	18.99	0.00	18.99	*186*	*458*	
800.00	-3.99		-3.99	-22.98	18.99	0.00	18.99	*186*	*458*	
810.00	-4.01		-4.01	-22.99	18.98	0.00	18.98	*186*	*459*	
820.00	-4.04		-4.04	-23.00	18.96	0.00	18.96	*186*	*459*	
830.00	-4.07		-4.07	-23.01	18.94	0.00	18.94	*186*	*459*	
840.00	-4.10		-4.10	-23.02	18.92	0.00	18.92	*186*	*459*	
850.00	-4.12		-4.12	-23.03	18.91	0.00	18.91	*185*	*459*	
860.00	-4.15		-4.15	-23.04	18.90	0.00	18.90	*185*	*459*	
870.00	-4.17		-4.17	-23.06	18.89	0.00	18.89	*185*	*459*	
880.00	-4.22		-4.22	-23.07	18.85	0.00	18.85	*185*	*460*	
890.00	-4.29		-4.29	-23.08	18.79	0.00	18.79	*184*	*460*	
900.00	-4.36		-4.36	-23.09	18.73	0.00	18.73	*184*	*460*	
910.00	-4.43		-4.43	-23.10	18.67	0.00	18.67	*183*	*460*	
920.00	-4.50		-4.50	-23.11	18.61	0.00	18.61	*183*	*460*	
930.00	-4.58		-4.58	-23.12	18.55	0.00	18.55	*182*	*460*	INTERCEPT
940.00	-4.63		-4.63	-23.13	18.51	0.00	18.51	*182*	*397*	
950.00	-4.71		-4.71	-23.14	18.44	0.00	18.44	*181*	*397*	
960.00	-4.79		-4.79	-23.16	18.37	0.00	18.37	*180*	*397*	
970.00	-4.89	sea	-4.89	-23.17	18.28	0.00	18.28	*179*	*397*	
980.00	-4.99	sea	-4.89	-23.18	18.19	0.00	18.19	*179*	*398*	
990.00	-5.09	sea	-4.89	-23.19	18.10	0.00	18.10	*180*	*398*	
1000.00	-5.19	sea	-4.89	-23.20	18.01	0.00	18.01	*180*	*398*	
1010.00	-5.29	sea	-4.89	-23.21	17.92	0.00	17.92	*180*	*398*	
1020.00	-5.39	sea	-4.89	-23.22	17.83	0.00	17.83	*180*	*398*	
1030.00	-5.49	sea	-4.89	-23.23	17.74	0.00	17.74	*180*	*398*	
1040.00	-5.59	sea	-4.89	-23.24	17.65	0.00	17.65	*180*	*398*	
1050.00	-5.69	sea	-4.89	-23.26	17.56	0.00	17.56	*180*	*399*	
1060.00	-5.78	sea	-4.89	-23.27	17.49	0.00	17.49	*180*	*399*	
1070.00	-5.85	sea	-4.89	-23.28	17.43	0.00	17.43	*180*	*399*	
1080.00	-5.93	sea	-4.89	-23.29	17.36	0.00	17.36	*180*	*399*	
1090.00	-6.00	sea	-4.89	-23.30	17.30	0.00	17.30	*181*	*399*	
1100.00	-6.08	sea	-4.89	-23.31	17.23	0.00	17.23	*181*	*399*	
1110.00	-6.16	sea	-4.89	-23.32	17.17	0.00	17.17	*181*	*399*	
1120.00	-6.23	sea	-4.89	-23.33	17.10	0.00	17.10	*181*	*400*	
1130.00	-6.30	sea	-4.89	-23.34	17.04	0.00	17.04	*181*	*400*	
1140.00	-6.37	sea	-4.89	-23.36	16.99	0.00	16.99	*181*	*400*	
1150.00	-6.45	sea	-4.89	-23.37	16.92	0.00	16.92	*181*	*400*	
1160.00	-6.50	sea	-4.89	-23.38	16.88	0.00	16.88	*181*	*400*	
1170.00	-6.55	sea	-4.89	-23.39	16.84	0.00	16.84	*181*	*400*	
1180.00	-6.60	sea	-4.89	-23.40	16.80	0.00	16.80	*182*	*400*	

1190.00	-6.65	sea	-4.89	-23.41	16.76	0.00	16.76	***182***	***401***	
1200.00	-6.70	sea	-4.89	-23.42	16.73	0.00	16.73	***182***	***401***	
1210.00	-6.74	sea	-4.89	-23.43	16.69	0.00	16.69	***182***	***401***	
1220.00	-6.75	sea	-4.89	-23.44	16.70	0.00	16.70	***182***	***401***	
1230.00	-6.75	sea	-4.89	-23.45	16.70	0.00	16.70	***182***	***401***	
1240.00	-6.77	sea	-4.89	-23.47	16.70	0.00	16.70	***182***	***401***	
1250.00	-6.79	sea	-4.89	-23.48	16.68	0.00	16.68	***182***	***401***	
1260.00	-6.85	sea	-4.89	-23.49	16.64	0.00	16.64	***182***	***402***	
1270.00	-6.92	sea	-4.89	-23.50	16.58	0.00	16.58	***183***	***402***	
1280.00	-6.99	sea	-4.89	-23.51	16.52	0.00	16.52	***183***	***402***	
1290.00	-7.06	sea	-4.89	-23.52	16.46	0.00	16.46	***183***	***402***	
1300.00	-7.13	sea	-4.89	-23.53	16.40	0.00	16.40	***183***	***402***	
1310.00	-7.20	sea	-4.89	-23.54	16.34	0.00	16.34	***183***	***402***	
1320.00	-7.27	sea	-4.89	-23.55	16.28	0.00	16.28	***183***	***402***	
1330.00	-7.34	sea	-4.89	-23.57	16.23	0.00	16.23	***183***	***403***	
1340.00	-7.41	sea	-4.89	-23.58	16.17	0.00	16.17	***183***	***403***	
1350.00	-7.47	sea	-4.89	-23.59	16.11	0.00	16.11	***183***	***403***	
1360.00	-7.54	sea	-4.89	-23.60	16.06	0.00	16.06	***184***	***403***	
1370.00	-7.61	sea	-4.89	-23.61	16.00	0.00	16.00	***184***	***403***	
1380.00	-7.67	sea	-4.89	-23.62	15.95	0.00	15.95	***184***	***403***	
1390.00	-7.74	sea	-4.89	-23.63	15.90	0.00	15.90	***184***	***403***	
1400.00	-7.80	sea	-4.89	-23.64	15.84	0.00	15.84	***184***	***404***	
1410.00	-7.85	sea	-4.89	-23.65	15.80	0.00	15.80	***184***	***404***	
1420.00	-7.90	sea	-4.89	-23.67	15.76	0.00	15.76	***184***	***404***	
1430.00	-7.95	sea	-4.89	-23.68	15.72	0.00	15.72	***184***	***404***	
1440.00	-8.00	sea	-4.89	-23.69	15.68	0.00	15.68	***184***	***404***	
1450.00	-8.06	sea	-4.89	-23.70	15.64	0.00	15.64	***185***	***404***	
1460.00	-8.11	sea	-4.89	-23.71	15.60	0.00	15.60	***185***	***404***	
1470.00	-8.16	sea	-4.89	-23.72	15.56	0.00	15.56	***185***	***405***	
1480.00	-8.21	sea	-4.89	-23.73	15.52	0.00	15.52	***185***	***405***	
1490.00	-8.26	sea	-4.89	-23.73	15.47	0.00	15.47	***185***	***405***	
1500.00	-8.31	sea	-4.89	-23.71	15.40	0.00	15.40	***185***	***404***	
1510.00	-8.36	sea	-4.89	-23.67	15.31	0.00	15.31	***184***	***404***	
1520.00	-8.41	sea	-4.89	-23.61	15.20	0.00	15.20	***184***	***403***	
1530.00	-8.46	sea	-4.89	-23.53	15.07	0.00	15.07	***183***	***402***	
1540.00	-8.51	sea	-4.89	-23.44	14.92	0.00	14.92	***182***	***401***	
1550.00	-8.56	sea	-4.89	-23.32	14.75	0.00	14.75	***181***	***399***	
1560.00	-8.61	sea	-4.89	-23.18	14.56	0.00	14.56	***179***	***398***	
1570.00	-8.67	sea	-4.89	-23.02	14.35	0.00	14.35	***178***	***396***	
1580.00	-8.71	sea	-4.89	-22.84	14.12	0.00	14.12	***176***	***393***	
1590.00	-8.76	sea	-4.89	-22.64	13.88	0.00	13.88	***174***	***391***	
1600.00	-8.80	sea	-4.89	-22.42	13.62	0.00	13.62	***172***	***388***	
1610.00	-8.84	sea	-4.89	-22.18	13.34	0.00	13.34	***170***	***385***	
1620.00	-8.88	sea	-4.89	-21.92	13.04	0.00	13.04	***167***	***382***	
1630.00	-8.92	sea	-4.89	-21.64	12.72	0.00	12.72	***164***	***378***	
1640.00	-8.96	sea	-4.89	-21.34	12.38	0.00	12.38	***161***	***374***	
1650.00	-9.00	sea	-4.89	-21.02	12.03	0.00	12.03	***158***	***370***	
1660.00	-9.03	sea	-4.89	-20.68	11.65	0.00	11.65	***155***	***366***	
1670.00	-9.07	sea	-4.89	-20.32	11.25	0.00	11.25	***151***	***361***	
1680.00	-9.12	sea	-4.89	-19.94	10.83	0.00	10.83	***148***	***356***	
1690.00	-9.16	sea	-4.89	-19.55	10.39	0.00	10.39	***144***	***351***	
1700.00	-9.20	sea	-4.89	-19.13	9.92	0.00	9.92	***140***	***346***	
1710.00	-9.25	sea	-4.89	-18.69	9.44	0.00	9.44	***135***	***340***	
1720.00	-9.29	sea	-4.89	-18.23	8.94	0.00	8.94	***131***	***334***	
1730.00	-9.34	sea	-4.89	-17.75	8.41	0.00	8.41	***126***	***328***	
1740.00	-9.38	sea	-4.89	-17.25	7.87	0.00	7.87	***121***	***322***	
1750.00	-9.42	sea	-4.89	-16.73	7.30	0.00	7.30	***116***	***315***	
1760.00	-9.47	sea	-4.89	-16.19	6.72	0.00	6.72	***111***	***308***	
1770.00	-9.51	sea	-4.89	-15.63	6.12	0.00	6.12	***105***	***301***	
1780.00	-9.56	sea	-4.89	-15.05	5.49	0.00	5.49	***100***	***294***	
1790.00	-9.60	sea	-4.89	-14.45	4.85	0.00	4.85	***94***	***286***	
1800.00	-9.64	sea	-4.89	-13.83	4.19	0.00	4.19	***88***	***278***	
1810.00	-9.69	sea	-4.89	-13.19	3.51	0.00	3.51	***81***	***270***	
1820.00	-9.73	sea	-4.89	-12.53	2.80	0.00	2.80	***75***	***262***	
1830.00	-9.77	sea	-4.89	-11.85	2.08	0.00	2.08	***68***	***253***	
1840.00	-9.82	sea	-4.89	-11.16	1.34	0.00	1.34	***61***	***244***	*HDD borehole profile*
1850.00	-9.86	sea	-4.89	-10.45	0.59	0.00	0.59	***55***	***235***	*graph based on the above table*

1860.00	-9.89	sea	-4.89	-9.89	0.00	0.00	0.00	***49***	***228***	*table*
JUB	8.00				8.00	8.00	0.00			



Dist (m)	σv (kN/m²)	σh (kN/m²)	σo (kN/m²)	Pf (kN/m²)	Q	Rpmax (m)	Pemax (kN/m²)	Pmax (kN/m²)	Hf (kN/m²)	H (kN/m²)
0.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*0*	*0*
10.0	47.7	0.0	47.7	71.6	0.00207	0.9	101	101	*0*	*23*
20.0	95.2	0.0	95.2	142.7	0.00412	1.9	314	314	*1*	*46*
30.0	143.3	0.0	143.3	214.9	0.00621	2.8	601	601	*1*	*65*
40.0	208.7	0.0	208.7	313.1	0.00904	4.1	1035	1035	*2*	*91*
50.0	252.6	0.0	252.6	378.9	0.01095	5.0	1323	1324	*2*	*114*
60.0	280.3	0.0	280.3	420.4	0.01215	5.9	1522	1544	*2*	*140*
70.0	297.4	0.0	297.4	446.1	0.01289	6.5	1638	1674	*3*	*160*
80.0	317.1	0.0	317.1	475.6	0.01374	7.3	1762	1815	*3*	*182*
90.0	340.8	0.0	340.8	511.2	0.01477	8.0	1896	1965	*4*	*204*
100.0	363.6	0.0	363.6	545.3	0.01575	8.8	2016	2101	*4*	*224*
110.0	386.1	0.0	386.1	579.1	0.01673	9.5	2127	2227	*4*	*244*
120.0	412.7	0.0	412.7	619.1	0.01789	10.3	2251	2365	*5*	*263*
130.0	507.8	0.0	507.8	761.7	0.02201	12.5	2640	2768	*5*	*281*
140.0	497.2	0.0	497.2	745.8	0.02154	12.5	2602	2743	*5*	*298*
150.0	451.8	0.0	451.8	677.7	0.01958	11.9	2426	2579	*6*	*315*
160.0	357.2	0.0	357.2	535.8	0.01548	10.2	2027	2192	*6*	*330*
170.0	363.0	0.0	363.0	544.5	0.01573	10.6	2058	2233	*7*	*345*
180.0	338.8	0.0	338.8	508.2	0.01468	10.3	1953	2139	*7*	*359*
190.0	337.1	0.0	337.1	505.7	0.01461	10.4	1949	2145	*7*	*372*
210.0	340.4	0.0	340.4	510.6	0.01475	10.8	1970	2183	*8*	*395*
220.0	347.6	0.0	347.6	521.5	0.01506	11.1	2004	2222	*9*	*406*
230.0	354.1	0.0	354.1	531.2	0.01535	11.3	2034	2256	*9*	*415*
240.0	360.2	0.0	360.2	540.3	0.01561	11.5	2062	2287	*9*	*424*
250.0	366.0	0.0	366.0	549.0	0.01586	11.7	2089	2317	*10*	*432*
260.0	368.2	0.0	368.2	552.3	0.01596	11.7	2099	2329	*10*	*439*
270.0	369.3	0.0	369.3	554.0	0.01600	11.8	2104	2335	*11*	*445*
280.0	369.4	0.0	369.4	554.2	0.01601	11.8	2104	2335	*11*	*451*
290.0	368.5	0.0	368.5	552.7	0.01597	11.7	2100	2330	*11*	*455*
300.0	366.5	0.0	366.5	549.7	0.01588	11.7	2091	2320	*12*	*459*
310.0	363.4	0.0	363.4	545.2	0.01575	11.6	2077	2304	*12*	*462*
320.0	359.4	0.0	359.4	539.1	0.01557	11.4	2059	2283	*13*	*464*
330.0	354.2	0.0	354.2	531.3	0.01535	11.3	2035	2256	*13*	*465*
340.0	348.4	0.0	348.4	522.6	0.01510	11.1	2008	2226	*13*	*465*
350.0	342.6	0.0	342.6	513.9	0.01485	10.9	1981	2195	*14*	*466*
360.0	336.8	0.0	336.8	505.1	0.01459	10.7	1953	2163	*14*	*466*
370.0	330.9	0.0	330.9	496.4	0.01434	10.5	1925	2132	*15*	*467*
380.0	325.1	0.0	325.1	487.6	0.01409	10.4	1896	2100	*15*	*467*
390.0	319.3	0.0	319.3	478.9	0.01384	10.2	1868	2067	*15*	*468*
400.0	313.4	0.0	313.4	470.1	0.01358	10.0	1839	2035	*16*	*468*
410.0	307.6	0.0	307.6	461.4	0.01333	9.8	1809	2002	*16*	*469*
420.0	301.8	0.0	301.8	452.6	0.01308	9.6	1780	1968	*16*	*469*
430.0	295.9	0.0	295.9	443.9	0.01282	9.4	1749	1934	*17*	*470*
440.0	290.1	0.0	290.1	435.1	0.01257	9.2	1719	1900	*17*	*471*
450.0	284.2	0.0	284.2	426.4	0.01232	9.1	1688	1865	*18*	*471*
460.0	279.5	0.0	279.5	419.3	0.01211	8.9	1662	1837	*18*	*472*
470.0	280.4	0.0	280.4	420.6	0.01215	8.9	1667	1842	*18*	*472*
480.0	281.1	0.0	281.1	421.6	0.01218	9.0	1670	1846	*19*	*473*
490.0	280.9	0.0	280.9	421.3	0.01217	8.9	1670	1845	*19*	*473*
500.0	280.7	0.0	280.7	421.1	0.01217	8.9	1669	1844	*20*	*474*
510.0	280.6	0.0	280.6	420.9	0.01216	8.9	1668	1843	*20*	*474*
520.0	280.5	0.0	280.5	420.7	0.01215	8.9	1667	1842	*20*	*475*
530.0	280.6	0.0	280.6	420.9	0.01216	8.9	1668	1844	*21*	*475*

*The pressure calculations are set out in this table. Note that **Rpmax** varies as it is set to be a proportion of the cover depth.*

Hf is a rough estimate of the drilling mud pressure in the return annular flow.

*The total head **H** is the static head **Hs** (table above) and **Hf**.*

540.0	280.8	0.0	280.8	421.2	0.01217	8.9	1669	1845	*21*	*476*
550.0	281.0	0.0	281.0	421.5	0.01218	9.0	1670	1846	*22*	*476*
560.0	281.1	0.0	281.1	421.7	0.01218	9.0	1671	1847	*22*	*477*
570.0	281.3	0.0	281.3	422.0	0.01219	9.0	1672	1848	*22*	*477*
580.0	281.5	0.0	281.5	422.2	0.01220	9.0	1673	1849	*23*	*478*
590.0	281.7	0.0	281.7	422.5	0.01221	9.0	1674	1850	*23*	*479*
600.0	282.6	0.0	282.6	424.0	0.01225	9.0	1679	1856	*24*	*479*
610.0	283.9	0.0	283.9	425.8	0.01230	9.0	1686	1863	*24*	*480*
620.0	285.1	0.0	285.1	427.7	0.01236	9.1	1692	1871	*24*	*480*
630.0	286.4	0.0	286.4	429.6	0.01241	9.1	1699	1878	*25*	*481*
640.0	287.6	0.0	287.6	431.4	0.01246	9.2	1706	1885	*25*	*481*
650.0	288.9	0.0	288.9	433.3	0.01252	9.2	1712	1893	*25*	*482*
660.0	290.1	0.0	290.1	435.2	0.01257	9.2	1719	1900	*26*	*482*
670.0	291.4	0.0	291.4	437.1	0.01263	9.3	1726	1908	*26*	*483*
680.0	292.6	0.0	292.6	438.9	0.01268	9.3	1732	1915	*27*	*483*
690.0	293.9	0.0	293.9	440.8	0.01273	9.4	1739	1922	*27*	*484*
700.0	295.1	0.0	295.1	442.7	0.01279	9.4	1745	1930	*27*	*484*
710.0	296.3	0.0	296.3	444.4	0.01284	9.4	1751	1936	*28*	*485*
720.0	296.6	0.0	296.6	444.9	0.01285	9.4	1753	1938	*28*	*485*
730.0	297.0	0.0	297.0	445.4	0.01287	9.5	1755	1940	*29*	*486*
740.0	297.3	0.0	297.3	446.0	0.01288	9.5	1757	1942	*29*	*487*
750.0	297.7	0.0	297.7	446.5	0.01290	9.5	1758	1944	*29*	*487*
760.0	298.0	0.0	298.0	447.0	0.01291	9.5	1760	1946	*30*	*488*
770.0	298.3	0.0	298.3	447.5	0.01293	9.5	1762	1948	*30*	*488*
780.0	298.2	0.0	298.2	447.3	0.01292	9.5	1761	1948	*31*	*489*
790.0	298.1	0.0	298.1	447.2	0.01292	9.5	1761	1947	*31*	*489*
800.0	298.1	0.0	298.1	447.1	0.01292	9.5	1760	1947	*31*	*490*
810.0	297.9	0.0	297.9	446.8	0.01291	9.5	1760	1946	*32*	*490*
820.0	297.6	0.0	297.6	446.4	0.01290	9.5	1758	1944	*32*	*491*
830.0	297.3	0.0	297.3	445.9	0.01288	9.5	1756	1942	*33*	*491*
840.0	297.0	0.0	297.0	445.5	0.01287	9.5	1755	1941	*33*	*492*
850.0	296.8	0.0	296.8	445.2	0.01286	9.5	1754	1939	*33*	*492*
860.0	296.6	0.0	296.6	444.9	0.01285	9.4	1753	1938	*34*	*493*
870.0	296.5	0.0	296.5	444.7	0.01285	9.4	1752	1938	*34*	*493*
880.0	295.9	0.0	295.9	443.9	0.01282	9.4	1749	1934	*34*	*494*
890.0	294.9	0.0	294.9	442.4	0.01278	9.4	1744	1929	*35*	*495*
900.0	294.0	0.0	294.0	441.0	0.01274	9.4	1739	1923	*35*	*495*
910.0	293.0	0.0	293.0	439.5	0.01270	9.3	1734	1917	*36*	*496*
920.0	292.1	0.0	292.1	438.1	0.01266	9.3	1729	1912	*36*	*496*
930.0	291.1	0.0	291.1	436.7	0.01262	9.3	1724	1906	*36*	
920.0	296.5	0.0	296.5	444.7	0.01285	9.4	1752	1938	*36*	*433*
910.0	295.9	0.0	295.9	443.9	0.01282	9.4	1749	1934	*36*	*433*
900.0	294.9	0.0	294.9	442.4	0.01278	9.4	1744	1929	*35*	*433*
890.0	294.0	0.0	294.0	441.0	0.01274	9.4	1739	1923	*35*	*432*
880.0	293.0	0.0	293.0	439.5	0.01270	9.3	1734	1917	*34*	*432*
870.0	292.1	0.0	292.1	438.1	0.01266	9.3	1729	1912	*34*	*432*
860.0	291.1	0.0	291.1	436.7	0.01262	9.3	1724	1906	*34*	*432*
850.0	290.5	0.0	290.5	435.7	0.01259	9.3	1721	1902	*33*	*431*
840.0	289.4	0.0	289.4	434.1	0.01254	9.2	1715	1896	*33*	*431*
830.0	288.3	0.0	288.3	432.4	0.01249	9.2	1709	1889	*33*	*431*
820.0	286.9	0.0	286.9	430.4	0.01243	9.1	1702	1881	*32*	*431*
810.0	285.5	0.0	285.5	428.2	0.01237	9.1	1694	1874	*32*	*430*
800.0	284.1	0.0	284.1	426.1	0.01231	9.0	1687	1866	*31*	*430*
790.0	282.7	0.0	282.7	424.1	0.01225	9.0	1679	1859	*31*	*430*
780.0	281.3	0.0	281.3	421.9	0.01219	9.0	1672	1851	*31*	*430*
770.0	279.9	0.0	279.9	419.8	0.01213	8.9	1664	1844	*30*	*429*
760.0	278.5	0.0	278.5	417.7	0.01207	8.9	1657	1837	*30*	*429*
750.0	277.1	0.0	277.1	415.6	0.01201	8.8	1649	1829	*29*	*429*
740.0	275.7	0.0	275.7	413.5	0.01195	8.8	1641	1821	*29*	*429*
730.0	274.5	0.0	274.5	411.7	0.01190	8.7	1635	1815	*29*	*428*
720.0	273.5	0.0	273.5	410.3	0.01185	8.7	1629	1810	*28*	*428*
710.0	272.5	0.0	272.5	408.7	0.01181	8.7	1624	1804	*28*	*428*
700.0	271.5	0.0	271.5	407.2	0.01176	8.6	1618	1799	*27*	*428*
690.0	270.5	0.0	270.5	405.7	0.01172	8.6	1612	1793	*27*	*427*
680.0	269.4	0.0	269.4	404.2	0.01168	8.6	1607	1788	*27*	*427*
670.0	268.4	0.0	268.4	402.7	0.01163	8.6	1601	1782	*26*	*427*
660.0	267.5	0.0	267.5	401.2	0.01159	8.5	1596	1777	*26*	*427*
650.0	266.6	0.0	266.6	400.0	0.01156	8.5	1591	1772	*25*	*426*
640.0	265.5	0.0	265.5	398.3	0.01151	8.5	1585	1766	*25*	*426*
630.0	264.9	0.0	264.9	397.3	0.01148	8.4	1581	1763	*25*	*426*
620.0	264.3	0.0	264.3	396.5	0.01145	8.4	1578	1759	*24*	*426*
610.0	263.7	0.0	263.7	395.6	0.01143	8.4	1575	1756	*24*	*425*
600.0	263.1	0.0	263.1	394.7	0.01140	8.4	1571	1753	*24*	*425*
590.0	262.5	0.0	262.5	393.8	0.01138	8.4	1568	1750	*23*	*425*
580.0	262.0	0.0	262.0	392.9	0.01135	8.3	1565	1747	*23*	*425*
570.0	262.0	0.0	262.0	393.1	0.01136	8.3	1565	1747	*22*	*424*

560.0	262.2	0.0	262.2	393.3	0.01136	8.4	1566	1748	*22*	*424*
550.0	262.0	0.0	262.0	393.1	0.01136	8.3	1565	1747	*22*	*424*
540.0	261.8	0.0	261.8	392.8	0.01135	8.3	1564	1746	*21*	*424*
530.0	261.1	0.0	261.1	391.7	0.01132	8.3	1560	1742	*21*	*423*
520.0	260.2	0.0	260.2	390.3	0.01128	8.3	1555	1737	*20*	*423*
510.0	259.3	0.0	259.3	388.9	0.01124	8.3	1549	1732	*20*	*423*
500.0	258.3	0.0	258.3	387.5	0.01120	8.2	1544	1727	*20*	*423*
490.0	257.4	0.0	257.4	386.1	0.01116	8.2	1539	1722	*19*	*422*
480.0	256.5	0.0	256.5	384.7	0.01111	8.2	1533	1716	*19*	*422*
470.0	255.5	0.0	255.5	383.3	0.01107	8.1	1528	1711	*18*	*422*
460.0	254.7	0.0	254.7	382.0	0.01104	8.1	1523	1706	*18*	*422*
450.0	253.8	0.0	253.8	380.7	0.01100	8.1	1518	1701	*18*	*421*
440.0	252.9	0.0	252.9	379.4	0.01096	8.1	1513	1696	*17*	*421*
430.0	252.1	0.0	252.1	378.1	0.01092	8.0	1508	1691	*17*	*421*
420.0	251.2	0.0	251.2	376.8	0.01089	8.0	1503	1686	*16*	*421*
410.0	250.4	0.0	250.4	375.5	0.01085	8.0	1498	1682	*16*	*420*
400.0	249.5	0.0	249.5	374.3	0.01081	7.9	1493	1677	*16*	*420*
390.0	248.7	0.0	248.7	373.0	0.01078	7.9	1488	1672	*15*	*420*
380.0	248.0	0.0	248.0	372.0	0.01075	7.9	1484	1668	*15*	*420*
370.0	247.4	0.0	247.4	371.1	0.01072	7.9	1481	1665	*15*	*419*
360.0	246.8	0.0	246.8	370.2	0.01069	7.9	1477	1661	*14*	*419*
350.0	246.2	0.0	246.2	369.2	0.01067	7.8	1473	1658	*14*	*418*
340.0	245.5	0.0	245.5	368.3	0.01064	7.8	1469	1654	*13*	*416*
330.0	244.9	0.0	244.9	367.4	0.01061	7.8	1466	1650	*13*	*415*
320.0	244.3	0.0	244.3	366.4	0.01059	7.8	1462	1647	*13*	*413*
310.0	243.6	0.0	243.6	365.5	0.01056	7.8	1458	1643	*12*	*412*
300.0	242.9	0.0	242.9	364.3	0.01052	7.7	1454	1638	*12*	*409*
290.0	241.8	0.0	241.8	362.6	0.01048	7.7	1447	1632	*11*	*407*
280.0	240.4	0.0	240.4	360.5	0.01042	7.7	1439	1623	*11*	*404*
270.0	238.6	0.0	238.6	357.9	0.01034	7.6	1428	1612	*11*	*401*
260.0	236.6	0.0	236.6	354.9	0.01025	7.5	1416	1599	*10*	*398*
250.0	234.2	0.0	234.2	351.3	0.01015	7.5	1401	1583	*10*	*395*
240.0	231.5	0.0	231.5	347.3	0.01003	7.4	1385	1566	*9*	*391*
230.0	228.6	0.0	228.6	342.8	0.00990	7.3	1366	1546	*9*	*387*
220.0	225.3	0.0	225.3	337.9	0.00976	7.2	1346	1524	*9*	*383*
210.0	221.7	0.0	221.7	332.5	0.00961	7.1	1323	1499	*8*	*378*
200.0	217.8	0.0	217.8	326.7	0.00944	6.9	1299	1473	*8*	*374*
190.0	213.7	0.0	213.7	320.6	0.00926	6.8	1272	1444	*7*	*369*
180.0	209.4	0.0	209.4	314.1	0.00907	6.7	1244	1414	*7*	*363*
170.0	204.6	0.0	204.6	307.0	0.00887	6.5	1213	1380	*7*	*358*
160.0	199.6	0.0	199.6	299.4	0.00865	6.4	1179	1344	*6*	*352*
150.0	194.3	0.0	194.3	291.5	0.00842	6.2	1143	1305	*6*	*346*
140.0	188.7	0.0	188.7	283.1	0.00818	6.0	1105	1263	*5*	*340*
130.0	182.8	0.0	182.8	274.3	0.00792	5.8	1064	1219	*5*	*333*
120.0	55.0	0.0	55.0	82.5	0.00238	1.8	175	257	*5*	*327*
110.0	44.0	0.0	44.0	66.0	0.00191	1.4	121	196	*4*	*320*
100.0	32.6	0.0	32.6	49.0	0.00141	1.0	74	142	*4*	*312*
90.0	21.0	0.0	21.0	31.5	0.00091	0.7	36	97	*4*	*305*
80.0	9.3	0.0	9.3	14.0	0.00040	0.3	9	64	*3*	*297*
70.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	49	*3*	*289*
60.0	204.0	0.0	204.0	306.1	0.00884	4.0	1004	1004	*2*	*281*
50.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*2*	*272*
40.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*2*	*263*
30.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*1*	*254*
20.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*1*	*245*
10.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*0*	*236*
0.0	0.0	0.0	0.0	0.0	0.00000	0.6	0	0	*0*	*228*

Comments

C. Factual Report

Appendix C: Ground Investigation Factual Report (April 2024)

is presented in:

Annex 1: Onshore Ground Investigation Factual Report of **Appendix T: Onshore Ground Investigation Interpretative Report** of the **ES Addendum**.